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लोकहितार्थ सत्यनिष्ठा
Dedicated to Truth in Public Interest

GREEN FILES
VOLUME- 50

THEME: - Agriculture with a Focus on Environment Volume II

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Acknowledgement

We thank all the contributors for their immensely valuable contributions and for making this endeavour a success.

Foreword

In the 50th edition of *The Green Files*, iCED's quarterly journal, we delve into the crucial relationship between agriculture and the environment. This volume brings together a series of articles and features that provide a comprehensive perspective on the subject. With over a decade of expertise in environmental audits and SDG-related initiatives, iCED continues to offer valuable insights into agriculture's role in promoting sustainability.

This edition highlights multiple sectors and perspectives on Agriculture with a focus on the environment. The article titled "Soil Health and Sustainability" sheds light on the crucial role of soil health in sustainable land management in India, linking it to agricultural productivity and environmental quality. The article on "Sustainable Agriculture" delves into the critical role of agriculture in India. The focus is on sustainable Agriculture, highlighting practices that enhance productivity while minimizing environmental impact.

Furthermore, the article on "Supply Chain Management in Farming (Storage, transportation and distribution channel) highlights the importance of efficient supply chain management in India's agriculture, addressing challenges like logistics, storage, and high intermediary costs. It also discusses government initiatives aimed at improving infrastructure, reducing wastage, and enhancing supply chain efficiency to support farmers and consumers.

In addition, our publication highlights an article on "Assessment of Groundwater and Surface Water Status, Challenges, and Solutions in the City of Jaipur" The article assesses the evolving water crisis in Jaipur, highlighting the growing gap between

water supply and demand. The article proposes solutions such as water conservation awareness, reducing water losses, installing floating solar panels, improving drainage, and exploring new water sources to address these challenges and ensure sustainable water management for the future.

Another article on “Importance of Agro-biodiversity”, explores the critical importance of agro-biodiversity for food security and agriculture. It also highlights how diverse genetic resources and cropping practices enhance productivity, improve nutrition, and support ecosystem health.

On behalf of the entire team of “Green Files” at iCED, we look forward to your suggestions to make Green Files as informative and user friendly as possible. Your contributions within the broad scope of this quarterly journal will be highly appreciated, including any feedback you may like to share on the featured articles.

(Dr. Abhishek Gupta)

Additional Dy. Comptroller and Auditor General and Director General,
iCED, Jaipur

Message from the Director (Training & Research)

iCED's quarterly journal, "Green Files," offers insights into environmental and sustainable development issues from the perspective of public sector auditing. Additionally, it provides snapshots of the capacity-building and research activities undertaken at iCED during the covered period. The last four volumes have highlighted issues related to Climate Change, the Blue Economy and Agriculture with a focus on environment. The current volume also focuses on the theme of Agriculture Volume II, with an emphasis on the Environment.

This 50th volume of "Green Files" brings out, inter alia, articles highlighting multiple dimensions of Agriculture with a focus on Environment to help understand these dimensions, from the perspectives of Audit. Spanning various facets of agriculture, the 50th Volume covers the critical aspects such as Soil Health and Sustainability, Opportunities and Challenges in Sustainability of Vertical Farming, Supply chain management in Farming, Budget allocation for Agriculture infrastructural development, Importance of Agro biodiversity and Agri- Tourism.

We hope that this edition will prove to be valuable in enhancing comprehension of the diverse facets of the Agriculture Section focused on environment, especially for their relevance to the auditing professionals.

December 2024

Jaipur

Shri. Mehul Grover

Director (Training & Research),

iCED, Jaipur

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Soil Health and Sustainability

By: Shri Kailash Chand Bajya AAO and Shri Mohan Meena, Asst Supervisor

Definition of Soil Health

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Healthy soil gives us clean air and water, bountiful crops and forests, productive grazing lands, diverse wildlife, and beautiful landscapes (NRCS USDA n.d.). This definition highlights two primary aspects: the soil's ongoing ability to fulfil its roles and the recognition of soil as a living ecosystem, which includes a diverse array of organisms that facilitate nutrient cycling, suppress diseases, and improve overall soil structure. The concept of soil health encompasses biological, chemical, and physical properties, underscoring the significance of soil biodiversity and the interactions among various soil components. In conclusion, soil health is essential for maintaining ecosystem services, ensuring food security, and enhancing environmental resilience. It is a fundamental element of sustainable land management practices (U.S. Department of Agriculture 2024).

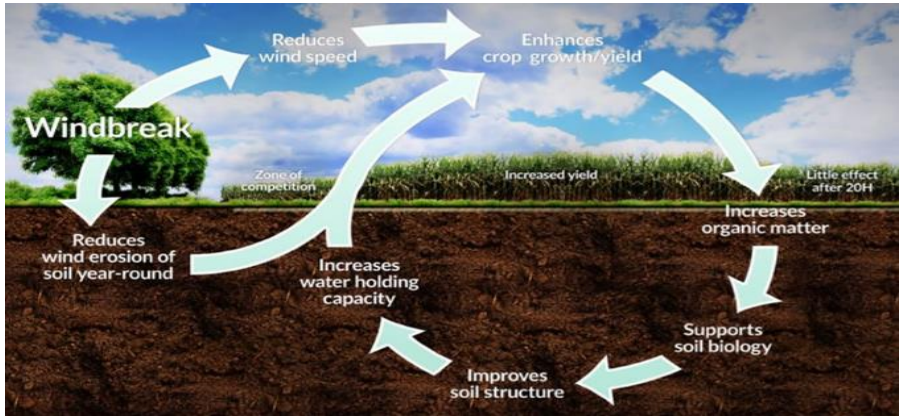

Image 1 Agroforestry's Role in Soil Health Source: - (Forest Service USDA n.d.)

Importance of the Soil Health

Soil health is of paramount importance in India for several reasons, particularly in the context of agriculture, environmental sustainability, and food security. Soil health can also be defined as the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health. This holistic definition emphasizes the soil's ability to provide essential services while maintaining a sound physical, chemical, and biological condition (New Mexico

State University 2019). Healthy soil is essential for maintaining the delicate balance of ecosystems and supporting various land-use practices. It plays a crucial role in providing essential services such as:

- Production of crops and other agricultural products.
- Retention and filtration of water.
- Habitat for diverse organisms.
- Recycling of nutrients.

By emphasizing the sustained ability of soil to provide these services, the definition of soil health underscores its importance as a vital living system that supports the overall health and well-being of the environment and the organisms that depend on it.

Soil Health Impact on Water Quality (Soilquality 2024)**:** Soil health plays a crucial role in maintaining water quality in India, as the two systems are intricately linked. Soil functions as a natural filter, safeguarding the quality of water, air, and other resources. It has the ability to degrade toxic compounds or excess nutrients, rendering them unavailable to plants and animals. The filtering capacity of soil can be evaluated by measuring or observing the following indicators:

Toxicity Indicators: These include substances such as arsenic, copper, pesticides, and zinc.

Organic Matter Indicators: Key metrics include the carbon-to-nitrogen (C:N) ratio, decomposition rates, microbial biomass carbon, particulate organic matter, soil organic matter, total organic carbon, and total organic matter.

Soil Reaction Indicators: This category primarily involves measuring soil pH.

Salinity and Sodicity Indicators: Important metrics include electrical conductivity, exchangeable sodium percentage, sodium levels, and the sodium adsorption ratio.

Biological Activity and Diversity Indicators: These indicators encompass active fungi, earthworms, potentially mineral nitrogen, respiration rates, soil enzymes, and diversity indices for organisms such as bacteria, macro and micro arthropods, nematodes, and plants.

The minerals and microorganisms present in soil play a crucial role in filtering, buffering, degrading, immobilizing, and detoxifying both organic and inorganic materials, including industrial and municipal by-products as well as atmospheric deposits. Soil has the capacity to absorb contaminants from both water and air. Some of these harmful compounds are broken down by soil microorganisms, while others are securely retained in the soil, preventing contamination of air and water resources.

Sustainable Practices (Gajjela Indira 2023)

Sustainable agriculture practices are essential for reducing the negative effects of conventional farming methods on soil health. Some of the sustainable agricultural practices are as under:-

a) Conservation Tillage: Conservation tillage minimizes soil disturbance, helping to maintain soil structure and reduce erosion. This protects valuable topsoil from wind and water erosion. Additionally, this practice improves moisture retention and boosts microbial activity, which promotes nutrient cycling and the decomposition of organic matter.

b) Crop rotation and Diversification: This strategy involves rotating different types of crops in a specific field across successive seasons. By doing so, it disrupts the life cycles of pests and diseases, helping to minimize their accumulation in the soil.

Image 2 Source- (Gajjela Indira 2023)

c) Cover Cropping: Cover crops are primarily planted to safeguard and enhance soil health during the times when main cash crops are not growing. Their extensive root systems help prevent soil erosion, while the above-ground biomass contributes valuable organic matter as it decomposes.

d) Precision Agriculture: Precision agriculture uses advanced technologies like GPS, remote sensing, and variable rate application systems to optimize resource use and reduce environmental impacts. By tailoring inputs such as water, fertilizers, and pesticides to the specific needs of different areas within a field, it minimizes waste and decreases chemical runoff.

e) Agroforestry and Agro ecological Approaches: Agroforestry incorporates trees and woody perennials into agricultural landscapes. This approach boosts biodiversity, enhances nutrient cycling, and stabilizes soil structure.

f) Integrated Nutrient Management: Integrated Nutrient Management (INM) is a sustainable agricultural practice that optimizes nutrient utilization for healthy crop growth. It blends organic sources such as compost and manure with chemical fertilizers to improve soil fertility while minimizing environmental impacts. (Gajjela Indira 2023)

Challenges in Soil Management

There are some challenges in soil management. The same are summarized below.

- **Soil degradation**:- Soil degradation in India is estimated to be occurring on 147 million hectares (Mha) of land, including 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, 9 Mha from wind erosion, 6 Mha from salinity, and 7 Mha from a combination of factors. (al 2015)
- **Unsustainable Agricultural Practices**: (al 2015) - Unsustainable agricultural practices are farming methods that deplete or degrade natural resources, leading to long-term damage to the environment and the productivity of the land. Some of the key unsustainable practices includes Excessive Use of Chemical Fertilizers and Pesticides, Low and Imbalanced Fertilization, Excessive Tillage and Use of Heavy Machinery, Crop Residue Burning and Inadequate Organic Matter Inputs, Monoculture and Loss of Biodiversity, Soil Degradation and Erosion, Deforestation and Habitat Loss, Unsustainable Water Use, Waste and Pollution etc.

- **Climate Change Impacts** (National Library of MEdicine, Institute of US, 2018): - Soil is essential for ensuring food security and providing various ecosystem services. Climate change impacts soil function both directly and indirectly. Direct effects include alterations in temperature, precipitation patterns, and moisture regimes. Indirect effects arise from adaptations such as changes in irrigation practices, crop rotations, and tillage methods. Agricultural management practices can help mitigate the impacts of climate change, such as by enhancing soil organic carbon (SOC) sequestration.

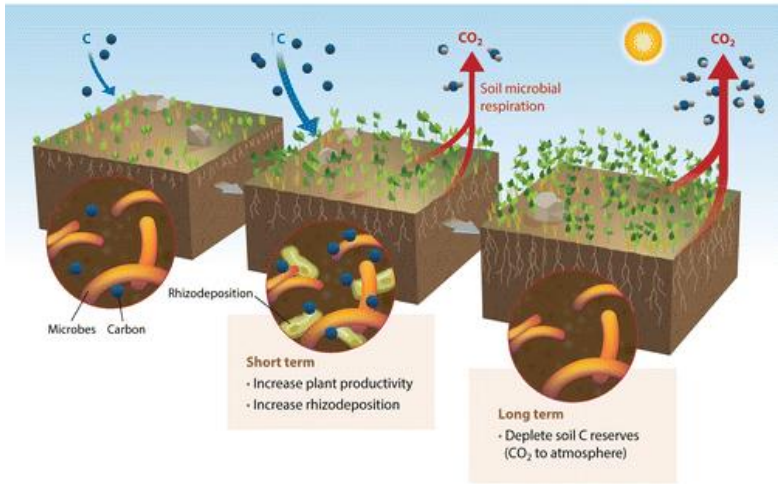

Image 3 Impact of elevated CO2 on soil carbon reserves (Source: Wikimedia Commons)

- An increase in global temperatures accelerates the loss of carbon from soils, leading to higher concentrations of carbon dioxide in the atmosphere. Additionally, shifts in rainfall patterns will further exacerbate erosion in vulnerable soils, which frequently already have low organic matter content. (Chinchmalatpure, 2024).
- **Policy and Implementation Gaps:** - While policies and programs exist, their implementation is lacking. Lack of awareness among farmers, inadequate soil testing facilities, and insufficient incentives for adopting sustainable practices are key challenges.

Soil governance: existing schemes and programmes in India (Stephanie Katsir, 2024).

- According to the 7th Schedule of the Constitution of India, agriculture and soil conservation fall under the jurisdiction of state governments. However, several national, state, and local schemes support soil governance in India. Over the years, the Indian government has made significant investments in soil health through various development programs, including the Integrated Watershed Management Programme (IWMP), the National Watershed Development Project for Rainfed Areas, the Drought Prone Areas Programme (DPAP), and the Desert Development Programme (DDP).

- The National Mission for Sustainable Agriculture (NMSA), launched in 2010 as part of the National Action Plan on Climate Change (NAPCC), is a key initiative aimed at making agriculture more productive, sustainable, and climate-resilient. It focuses on conserving natural resources, promoting soil health management practices, and optimizing water use. Soil Health Management (SHM) is a core component of NMSA.
- Additionally, the Soil Health Card scheme, introduced by the Government of India in the financial year 2014–15, was designed to address the issue of declining soil health. It encourages farmers to apply fertilizers based on soil test results, thereby promoting better soil management practices (Stephanie Katsir, 2024).

Conclusion: - In conclusion, maintaining soil health is vital for sustaining agricultural productivity, environmental balance, and overall food security. Embracing sustainable practices and addressing issues like soil degradation and climate change are key to ensuring the long-term vitality of our soils. Through continued efforts in soil management and awareness, we can secure a healthier and more resilient future for both the environment and society.

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Sustainable Agriculture – New Pathway by India

By: Shri Rohan Sharma, AAO and Shri Akesh Kumar Yadav, Sr.Ar

Introduction: - Agriculture, contributing 18 per cent to India's GVA (Gross Value Added) in FY24, remains a cornerstone of the economy. Despite challenges like the global health crisis and climate variability, the sector showed resilience, aiding economic recovery. In FY23, food grain production reached 329.7 million tonnes, up 14.1 million from the previous year, with an annual average of 289 million tonnes from FY15-FY23. India leads globally in milk, pulses, and spices, and ranks second in producing fruits, vegetables, wheat, and rice. Agricultural exports surged to ₹4.2 lakh crore in FY23, setting new records (Ministry of Information & Broadcasting, 2024).

Sustainable agriculture practices and systems (SAPSs)	
System	Practice
Permaculture*	Vermicompost*
Organic farming*	Drip irrigation/sprinkler*
Natural farming*	Crop rotation*
System of rice intensification (SRI) *	Intercropping*
Biodynamic agriculture*	Cover crops*
Conservation agriculture*	Mulching*
Integrated farming system (IFS) *	Contour farming*
Agroforestry*	Rainwater harvesting-artificial recharge of groundwater *
Integrated pest management (IPM) *	Floating farming*
Precision farming*	Plastic mulching
Silvipastoral systems	Shade net house
Vertical farming	Alternative wet and drying technique (for rice)
Hydroponics/Aeroponics	Saguna rice technique
Crop-livestock-fisheries farming system	Farm pond lined with plastic film
	Direct seeding of rice
	Canopy management
	Mangrove and non-mangrove bio-shields

Image 1, Source: (Council on Energy, Environment and Water, n.d.)

State of Sustainable Agriculture in India

In a research study, it has been identified that a total of 30 sustainable agriculture practices (SAPs) are prevalent in India. Some of these practices focus on specific aspects of agriculture, which are classified as individual practices, while others take a more holistic approach, addressing multiple facets of agricultural systems, and are categorized as systems. These are collectively referred to as sustainable agriculture practices and systems (SAPSs). It is noteworthy that several of these practices overlap, and some individual practices are also integrated within broader systems, as detailed in Image at the left.

The research reveals that sustainable agriculture is not yet widespread in India. With a few exceptions, most sustainable agriculture practices and systems (SAPSs) are adopted by fewer than five million farmers, accounting for less than four percent of the total farming population. For many practices, the number of farmers implementing them is less than one percent of the overall farming community in India. (Council on Energy, Environment and Water, n.d.)

Promoting Sustainable Farming Practices

Sustainable agriculture in India encompasses practices that aim to enhance productivity while minimizing environmental impact. Sustainable and organic farming is crucial for environmental health, soil fertility, and long-term food security. It reduces the use of synthetic chemicals, fosters biodiversity, and helps combat climate change. The Government of India has introduced major schemes to support organic agriculture, enhance production quality, and boost farming resilience nationwide.

Image 2 Promoting Sustainable Farming. Source: (Ministry of Agriculture & Farmers' Welfare, 2024)

To address climate change, the Indian government is implementing the National Mission for Sustainable Agriculture (NMSA), a key component of the National Action Plan on Climate Change (NAPCC).

The NMSA enhances agricultural climate resilience through schemes like Rain-fed Area Development (RAD), On-Farm Water Management (OFWM), and Soil Health Management (SHM). It has since expanded to include initiatives such as Soil Health Cards, Parampragat Krishi Vikas Yojana (PKVY), and the National Bamboo Mission. The Mission Organic Value Chain Development in the North Eastern Region (MOVCDNER), launched in 2015-16 with an initial budget of ₹400 crore, focuses on creating certified organic production clusters in eight North-Eastern states. By June 2024, the scheme had disbursed ₹1,150.09 crore, established 379 FPOs(Farmer Producer Organisation)/FPCs(Farmer Producer Company)

covering 189,039 farmers and 172,966 hectares, and set up 394 collection units, 123 processing facilities, and provided 145 vehicles (Ministry of Agriculture & Farmers' Welfare, 2024).

The Indian government has launched several programs to support sustainable agriculture:

1. National Food Security Act: It aims to provide subsidized food grains to disadvantaged households, ensuring food security while promoting sustainable practices.

2. KisanMitr and mKisan Portals: These are digital platforms that provide farmers with access to information on sustainable practices, weather updates, and market prices, thereby enhancing their decision-making capabilities.

3. **Jaivik-Kheti Portal**: This is a dedicated online platform, Jaivik-Kheti, which has been created to enable direct sales of organic products from farmers to consumers. The portal currently has 623,000 registered farmers.

4. **Clean Plant Programme (CPP):** In August 2024, the Union Cabinet approved the Clean Plant Programme (CPP), proposed by the Ministry of Agriculture and Farmers Welfare, with a substantial investment of ₹1,765.67 crore. The CPP will provide virus-free, high-quality planting material to boost crop yields and enhance farmer incomes. By streamlining certification and supporting nursery infrastructure, the program promotes sustainable growth. It will also deliver superior, virus-free produce with better taste, appearance, and nutritional value for consumers (Ministry of Agriculture & Farmers' Welfare, 2024).

4. PM-PRANAM: In Union Budget, 2023-24 , the government introduced the "PM Programme for Restoration, Awareness, Nourishment, and Amelioration of Mother Earth" (PM-PRANAM) Scheme. The initiative aims to incentivize states and union territories to encourage the use of alternative fertilizers and promote the balanced application of chemical fertilizers. The program will incentivize state governments with 50 per cent of the savings from reduced fertilizer subsidies to promote organic farming and fertilizers. Additionally, the government has introduced a

Market Development Assistance of ₹1,500/MT for the use of Fermented Organic Manure and Liquid Fermented Organic Manure (Ministry of Agriculture & Farmers' Welfare, 2024).

Challenges to Agricultural Sustainability

The sustainability of agriculture faces several challenges that can be examined across three primary farming systems: traditional production systems, modern agricultural systems, and sustainable agriculture systems. These challenges can be analyzed through three key dimensions: ecological, economic, and social sustainability.

1. **Ecological Sustainability Challenges:**
   - **Soil Fertility:** Conventional farming leads to continuous soil fertility decline, while sustainable agriculture improves soil structure and fertility.
   - **Water:** Over-reliance on irrigation and contamination of water resources from fertilizers and pesticides. Sustainable agriculture enhances water retention and reduces dependency on irrigation.
   - **Biodiversity:** Traditional practices often lack biodiversity. Sustainable agriculture promotes mixed cropping, increasing crop diversity and benefiting surrounding ecosystems.
   - **Health & Pollution:** Chemicals and pesticides harm local ecology and public health. Sustainable agriculture reduces chemical use, promoting safer pest control.
   - **Land Use Patterns:** Over-exploitation of land leads to erosion and decreased productivity. Sustainable practices focus on soil conservation and efficient land use.
2. **Economic Sustainability Challenges:**
   - **Economic Viability:** Conventional agriculture involves higher risks and costs. Export-focused systems often undermine domestic food security. Policies should balance export trade and domestic food needs for long-term economic sustainability.
   -

3. **Social Sustainability Challenges:**

- **Social Justice:** Agricultural development must benefit all, particularly the rural poor. Social injustice occurs when some groups are excluded from development opportunities. (Swaraj Meher, 2020)
- **Technology Adoption:** New agricultural technologies often fail due to lack of local acceptance. Sustainable agriculture aligns with local traditions and knowledge, fostering easier adoption and greater community involvement. (Swaraj Meher, 2020)

Conclusion:-, Sustainable agriculture is key to India's long-term food security and environmental resilience. While progress has been made through various government initiatives, challenges like climate change and resource depletion persist. Continued support for sustainable practices and farmer empowerment will be vital for a secure agricultural future.

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Supply chain management in farming (Storage, transportation and distribution channel) with a focus on Planning, Implementation, Coordination and Control

By: Shri Maneesh Mangal, AAO and Shri. Ashutosh Goyal, Sr.Ar

Introduction:

Supply chains focus on managing the flow of products and information between member organizations, encompassing the procurement of raw materials, the transformation of these materials into finished goods, and the distribution of those goods to end customers. In today's information-driven and integrated supply chains, organizations can reduce inventory and operational costs, enhance product value, optimize resources, speed up time to market, and improve customer retention. (Fernando, 2024)

A Graphical Presentation of Post-Harvest Supply Chain:

The real measure of supply chain success is how well activities coordinate across the supply chain to create value for consumers, while increasing the profitability of every link in the supply chain.

Image 1 Post-Harvest Supply Chain Chain (DMCA)

Supply Chain Management involves following processes:

- Integrated Planning
- Implementation
- Coordination
- Control

Supply Chain Management in agriculture involves the comprehensive planning, implementation, coordination, and control of all processes and activities required to produce and deliver agricultural products in the most efficient way possible, ensuring they meet consumer preferences and standards.

Challenges in Agricultural Supply chain management in India

a) **Issues related to Logistics**:-Logistics in India faces significant challenges due to its vast size, uneven geography, large population, lack of infrastructure, and frequent natural calamities. The absence of professional communities to implement an integrated systems approach hampers effective logistics management. Although government organizations like the Central Warehousing Corporation (CWC) and Food Corporation of India (FCI) have been established to improve agro-supply chain performance, they suffer from inefficiencies. For instance, the cost of procuring wheat by FCI rose from Rs 1,411.9 per quintal in 2015-16 to Rs 2,181.7, while the cost of rice rose from Rs 2,039 to Rs 3,038.9 per quintal during the same period. Additionally, leakage in the Public Distribution System (PDS) results in the diversion of grains into the open market, where they are sold at higher prices due to involvement from corrupt officials, transporters, and ration shop owners. (Nitu Ranjan Agarwal, 2018)

b) **Inefficiencies in Grain Management**: - The current grain management system in India faces significant inefficiencies, particularly within government storage facilities. The country's food grain production is 311 Million metric tonnes (MMT), but storage capacity is only 145 MMT, resulting in a shortfall of 166 MMT. While other countries have a 131per cent surplus in storage capacity, India has a 47per cent shortfall (Cooperation, Ministry of, n.d.).

Critics argue that the Food Corporation of India (FCI) often holds grains beyond the prescribed buffer stock limits, resulting in high holding costs. Furthermore, due to inadequate storage facilities, a substantial portion of the grains deteriorates, leading to wastage.

Deloitte's study reveals that the Indian agricultural industry faces several challenges, including inefficient storage facilities, inadequate power supply, and a lack of sufficient cold storage. As a result, nearly 40per cent of fruits and vegetables are wasted during transportation to the markets. This wastage has increased to around 30-35per cent of total production, amounting to a loss of approximately Rs 85,000 crores.

This highlights the urgent need for a renewed focus on logistics and supply chain management in India's agricultural sector, an area that has long been neglected. (Nitu Ranjan Agarwal, 2018)

c) **Agricultural Transportation**:- Transportation faces significant challenges as fruits and vegetables are transported over long distances from farms to markets (mandis) in open trucks and tractors. Poor road conditions lead to the loss of quality, weight, water content, and overall quantity during transit. (Nitu Ranjan Agarwal, 2018)

d) **Knowledge Access for farmers**: - Farmers often face deliberate restrictions in accessing fundamental knowledge about marketing, logistics, and new technologies. This lack of access prevents them from actively responding to evolving market conditions. (Nitu Ranjan Agarwal, 2018)

e)**High Intermediary Costs**:- The agricultural supply chain in India is long, involving at least 5-6 intermediaries, including village consolidators, commission agents, wholesalers, sub-wholesalers, and retailers. This complex chain significantly raises the final price of agricultural products. For example, consumers often pay 3-4 times the price received by farmers, whereas in developed countries, consumers typically pay only 1.5 to 2 times the farmer's price. In many cases, farmers receive only about 35per cent of the market price for their produce. Additionally, middlemen often delay payments to farmers, charge commissions on both the seller and the buyer, and contribute to artificial supply shortages, further driving up costs for consumers. (Nitu Ranjan Agarwal, 2018)

Schemes and initiatives by Government of India

a) **National Agricultural Market: -** To streamline the supply chain and reduce intermediaries, the government has introduced initiatives like the National Agriculture Market (e-NAM), a unified electronic platform allowing farmers to sell their produce directly. This platform connects markets across India, with 585 Agricultural Produce Market Committees (APMCs) currently linked to it. (Nitu Ranjan Agarwal, 2018)

b) **AMUL's Anand Pattern: A Model for Direct Farmer Cooperation and Fair Pricing**: An example of an efficient supply chain model is the Gujarat Cooperative Milk Marketing Federation (GCMMF), popularly known as AMUL, which follows the Anand Pattern. In this system, farmers directly sell their milk to village cooperative societies without any intermediaries. The cooperative is managed by a Milk Supply Officer and operates under a district-level cooperative dairy union. Farmers, even those with just 2-3 cows, can become members by paying a nominal fee.

This eliminates traditional middlemen, reducing procurement costs and ensuring fair prices for farmers, who receive up to 90per cent of the market price. (Nitu Ranjan Agarwal, 2018)

c) **Cost Savings Through Irradiation:-** The Bhabha Atomic Research Centre (BARC) in Mumbai has been using irradiation techniques for several years. Irradiating potatoes helps reduce sprouting and spoilage to just 10per cent. This allows potatoes to be stored at 15 degrees Celsius, significantly higher than the usual 2 degrees Celsius required. This results in direct cost savings. Since 92per cent of cold storage in India is used for potatoes, the potential savings from this technique are substantial. (Nitu Ranjan Agarwal, 2018)

d) **Improvement in Agricultural Storage Infrastructure**:- The government has implemented the Agricultural Marketing Infrastructure (AMI) scheme to address storage issues, supporting 41,452 projects and adding 725.7 Lakh MT of storage capacity since 2001. The Agriculture Infrastructure Fund (AIF), with a budget of ₹1,00,000 Crore, has sanctioned ₹7618 Crore for 9516 warehouse applications. Additionally, the Ministry of Cooperation launched the "World's Largest Grain Storage Plan in the Cooperative Sector," aiming to transform Primary Agricultural Credit Societies (PACS) into multifunctional entities with infrastructure like warehouses and processing units to reduce wastage, improve food security, and increase farmers' incomes. This initiative targets over 100,000 PACS across 24 states and UTs. (Cooperation, Ministry of, n.d.)

e) **Transportation**: - The Government of India has launched several initiatives to improve agricultural logistics. The "Kisan Rath" mobile app helps farmers and traders hire transport vehicles, integrated with the e-NAM portal. Indian Railways operates 208 Kisan Rail services across 24 routes for perishables, and temperature-controlled storage facilities have been set up in key locations. Infrastructure projects like PM-Gram Sadak Yojana, Kisan Rail, Krishi UDAN, and the Transport and Marketing Assistance scheme enhance connectivity and reduce wastage. Additionally, the National Civil Aviation Policy and Krishi Udaan Scheme support air cargo logistics, with cold storage facilities at major airports, including Mumbai's world-largest cold storage for perishables. (Ministry of Agriculture & Farmers Welfare, 2021)

Conclusion: In conclusion, efficient supply chain management is vital for improving the Indian agricultural sector. Despite challenges like poor logistics, inadequate storage, and high intermediary costs, government initiatives like e-NAM, better infrastructure, and direct farmer models such as AMUL's Anand Pattern are helping address these issues. Continued focus on infrastructure, technology, and farmer support is key to building a more efficient and sustainable agricultural supply chain in India.

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Budget allocation for Agriculture infrastructural development in India

By: Shri Saurabh Sharma AAO and Shri Ram Niwas Sharma, Sr.Ar

Overview and importance of Agriculture infrastructure in India

Agriculture plays a vital role in India's economy. 54.6 per cent of the total workforce is engaged in agriculture and allied sector activities (Census 2011). Agriculture and Allied sector accounts for 18.4 per cent of India's Gross Value Addition (GVA) at current prices during 2022-23 (Department of Agriculture & Farmers Welfare, 2023-24).

Infrastructure plays a vital role in driving agricultural development and enhancing production capabilities. A robust infrastructure network is essential not only for improving on-farm productivity but also for ensuring the efficient post-harvest handling of agricultural produce. By focusing on the development of post-harvest infrastructure viz. storage facilities, cold chains and processing units, the agricultural sector can significantly reduce wastage and improve quality and create opportunities for value addition. By this way, we can ensure that farmers receive fair prices for their produce and could improve their livelihoods. Moreover, well-developed agricultural infrastructure can mitigate the challenges posed by natural uncertainties, such as unpredictable weather patterns and climate change. Further, the infrastructure development can bridge regional disparities by enabling remote and underdeveloped areas to access markets and modern agricultural technologies.

Therefore, it is essential for any country to prioritize these critical factors and invest in robust infrastructure development to ensure food security, fostering rural prosperity and driving overall economic growth.

Key insights of budget allocation for Agricultural Infrastructure in India

In last two decades, the Government has substantially enhanced the budget allocation of Ministry of Agriculture & Farmers Welfare from Rs. 27,662.67 crore BE during 2013-14 to Rs. 1,25,035.79 crore BE during 2023-24 (Ministry of Agriculture & Farmers Welfare, 2024). In budget 2024-25, there is also kept provision of ₹ 1.52 lakh crore for agriculture and allied sector announced (Ministry of Finance, 2024). Out of the total budget, a substantial portion has been earmarked for the development of agricultural infrastructure in India. Now the emphasis is given to increase capital expenditure on key sectors such as irrigation, rural roads, storage, cold chains and market linkages to sustain the agriculture and thereby increasing

the farmers' income. A brief overview of the significant steps taken by the government to improve agricultural infrastructure in India is outlined in the succeeding paragraphs,

Significant initiatives taken to improve Agriculture infrastructure in India

Infrastructure is crucial to agriculture at every stage, from the supply of inputs and crop sowing to post-harvest management. In India, post-harvest losses are notably high due to gaps in fundamental infrastructure such as inadequate storage facilities, pack houses and the lack of an efficient supply chain. Addressing these deficiencies through planned investments can greatly enhance the efficiency and sustainability of the agricultural sector. Some of the flagship schemes are given below:

a) **Agricultural Infrastructure Fund(AIF):** Government of India has formulated a Central Sector Scheme of financing facility under 'Agriculture Infrastructure Fund' which was launched on 9th August 2020 for creating adequate pre and post-harvest management infrastructures. This Fund has provision to provide a medium/long term debt financing facility till 2025-2026 through 3 per cent interest subvention and credit guarantee (Ministry of Agriculture & Farmers Welfare, 2021). In August 2024, the cabinet has approved a significant expansion of the Agricultural Infrastructure Fund (AIF) scheme and introduced a series of measures designed to make the scheme more attractive, impactful, and inclusive. Till end of August-2024, a total of ₹47,575 crore has been sanctioned for 74,508 projects under this scheme. (Ministry of Agriculture & Farmers Welfare, 2024).

b) **Agricultural Marketing Infrastructure (AMI):** To improve storage facilities, the government has launched Agricultural Marketing Infrastructure (AMI) scheme, which is a component of the Integrated Scheme for Agricultural Marketing (ISAM). This scheme provides assistance for the construction or renovation of godowns and warehouses in rural areas to boost agricultural storage capacity. Under this scheme, subsidies of 25per cent and 33.33per cent are offered on the capital costs of projects, depending on the beneficiary category. (Ministry of Agriculture & Farmers Welfare, 2024).

c) **Digital Agriculture Mission**: Recently on 2nd September, 2024, the Cabinet approved this mission with an outlay of Rs. 2817 Crore, including the central share of Rs. 1940 Crore. The Mission is an umbrella scheme to support digital agriculture initiatives, such as creating Digital Public Infrastructure, implementing the Digital General Crop Estimation Survey (DGCES), and taking up other IT initiatives by the Central Government, State Governments, and Academic and Research Institutions (Ministry of Agriculture & Farmers Welfare, 2024).

Several other flagship schemes such as the Mission Organic Value Chain Development for North Eastern Region, Pradhan Mantri Matsya Sampada Yojana, and the Micro Irrigation Fund (MIF) have been launched to address the different facets of agricultural growth.

Way forward

Agricultural infrastructure development is critical for enhancing productivity and reducing post-harvest losses for farmers in India. Regardless of the significant government efforts and increased budget allocations, agriculture sector faces several challenges. The limited private sector participation is also a major concerns.

To overcome these challenges, a multifaceted approach is essential and it is much needed that institutions like NABARD, SIDBI and rural banks promote more aggressive investment in crucial infrastructure viz. irrigation, storage, and transport. Further, necessary steps could be taken to expand the affordable credit through public-private partnerships (PPPs). By issuing agriculture bonds, the government and financial institutions can secure the capital needed to invest in large-scale infrastructure projects. To attract more capital investment, the government can consider issuing agricultural bonds, which would provide a reliable means for securing the necessary funds to invest in large-scale infrastructure projects.

Additionally, there is also a need of policy reforms to streamline regulatory processes and also to simplify land acquisition as of today for speeding up the infrastructure projects according to ever increasing needs. India has the potential to significantly boost agricultural productivity, enhance rural livelihoods and drive overall economic progress and same could be achieved only with coordinated and concerted efforts at both the individual and government levels.

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Importance of Agro Forestry- Combining Trees and Crops

By Shri Kamal Kumar Sahal, Consultant & Shri Rajesh Meena, Sr.Ar

1. Introduction

Agroforestry refers to both traditional and modern land-use practices where woody perennials like trees, shrubs, bamboos, and palms are deliberately integrated with crops and/or livestock on the same land in various spatial or temporal arrangements. As defined by the World Agroforestry Centre, it is the practice and science of managing the interactions between agriculture and forestry, involving farmers, trees (woody perennials), forests, and livestock at different scales (Council on Energy, Environment and Water).

2. Importance of the Agroforestry

Agroforestry, plays a crucial role in promoting sustainable agricultural practices and enhancing environmental resilience. This method not only increases farm productivity by optimizing the interactions among different species but also provides numerous ecosystem services that are vital for food security and nutrition. For instance, agroforestry systems can improve soil fertility, reduce erosion, and enhance biodiversity, which collectively contribute to healthier ecosystems and agricultural sustainability (Adeyemi, 2024). Furthermore, agroforestry practices are particularly beneficial in addressing climate change challenges. They enhance carbon sequestration and mitigate greenhouse gas emissions, thus playing a significant role in climate change adaptation strategies. By diversifying agricultural outputs, agroforestry also helps secure farmers' incomes and food availability, making it a valuable approach for rural communities, especially in developing regions like sub-Saharan Africa (Gurdeep Singh Malhi, 2021). In addition to environmental benefits, agroforestry fosters economic resilience by providing multiple sources of income, such as timber, fruits, and medicinal plants. This diversification is crucial for smallholder farmers who face economic uncertainties and environmental shocks. Overall, agroforestry represents a holistic approach to land management that aligns agricultural productivity with ecological sustainability (N. R. Gangadharappa).

3. Types of Agroforestry Systems

Agroforestry systems come in various forms, each tailored to specific environmental conditions, cultural practices, and economic goals. Here are some common types of agroforestry systems:

I. Agri silvicultural Systems (crops and trees including shrubs/vines and trees)

In this system, agricultural crops are intercropped between tree rows in the spaces between the trees. Agricultural crops can be cultivated for up to two years in irrigated conditions and up to four years in rain fed conditions.. (A Arunachalam, 2020).

II. Silvipastoral systems (trees + pasture and/or animals)

The practice of combining the cultivation of woody plants with pasture is known as the silvopasture system. In this system, trees and shrubs can be grown mainly to provide fodder for livestock or for producing timber, fuel wood, and fruit, or to improve soil quality. This system is categorised into three types:

(a) Protein bank- In this silvipastoral system, various multipurpose trees, which are rich in protein, are planted in or around farmlands and rangelands to produce cut-and-carry fodder. (D.B.V.RAMANA).

(b) Livefence of fodder trees and hedges- In this system, different fodder trees and hedges are planted as living fences to protect the property from stray animals and other biotic influences (Dinesh Jinger, 2023).

(c) Trees and shrubs on pasture- In this system, various tree and shrub species are either scattered irregularly or arranged in a specific pattern to enhance forage production.

III. AgroSilvopastoral Systems (trees + crops+pasture/animals)

The agrisilvopastoral system combines the cultivation of woody perennials with annual crops and pastures. This system is classified into two categories:

(a) Home gardens- Home gardens involve the intentional management of multipurpose trees, shrubs, vegetables, and herbaceous plants, closely integrated with annual and perennial crops and livestock within individual households. (S. Viswanath, 2018).

(b) Woody Hedgerows- In this system, various woody hedges, particularly fast-growing and coppicing fodder shrubs and trees, are planted for purposes such as browsing, mulching, providing green manure, and conserving soil.

(iv) Other Systems

(a) Apiculture with trees- In this system, various nectar-producing trees that are frequently visited by honeybees are planted along the boundaries of agricultural fields (Dara A. Stanley, 2024).

(b) Aquaforestry- In this system, various trees and shrubs that are favoured by fish are planted along the boundaries and around fish ponds.

(c) Mixed wood lots- In this system, location-specific multipurpose trees (MPTs) are grown either in mixed arrangements or separately for various uses, including wood, fodder, soil conservation, and soil reclamation.

3. Agroforestry in the context of India

Agroforestry is a traditional land-use practice in India that contributes to livelihoods, nutrition, energy, and environmental security. Agroforestry supplies nearly half of India's fuelwood, two-thirds of small timber, 70-80 per cent of plywood, 60 per cent of paper pulp raw materials, and 9-11 per cent of green fodder needed for livestock. It also meets subsistence needs for households, providing food, fruit, fiber, medicine, and other resources (Basu, 2014). The Indian Council of Agricultural Research (ICAR) initiated the All India Coordinated Research Project (AICRP) on

Agroforestry in 1983, which has grown to 37 centres across all agro-climatic zones. The National Agroforestry Policy (NAP) in 2014 formalised the sector and removed legislative barriers, transforming agroforestry from a forestry sector to an integral part of agriculture. Other government initiatives, such as the National Forest Policy of 1988, the National Agriculture Policy of 2000, the Planning Commission Task Force on Greening India (PCTFGI), the National Bamboo Mission, the National Policy on Farmers 2007, and the Green India Mission 2010, also highlight the role of agroforestry (Council on Energy, Environment and Water).

Challenges of Agroforestry in India

a) There is a significant shortage of high-quality planting materials and improved seed varieties (Verma et al., 2017). Only about 10% of planting materials meet high-quality standards, with the remainder lacking any assurance of quality. Additionally, there is a lack of sufficient research on agroforestry models that are tailored to the diverse agro-climatic regions.

b) Another concerning issue in India is that agroforestry research has largely been confined to small plots at research stations or within laboratory settings. There has been limited research conducted at the ecosystem or landscape level, and most studies are short-term in nature.

c) In most parts of the country, marketing infrastructure for agroforestry products is lacking, with only a few states having such facilities. As a result, the market is predominantly driven by buyers, and middlemen often capture the largest share of the profits. Institutional finance and insurance coverage for agroforestry have not reached their full potential, largely due to a lack of awareness regarding the technical and economic data associated with various agroforestry models.

d) Additionally, complex, costly, and frustrating legislation surrounding tree felling, wood transportation, processing, and marketing significantly deters farmers from adopting agroforestry. Furthermore, taxes are imposed at multiple stages of processing by various agencies, causing domestic agroforestry products to struggle against imported materials. (Prashant Sharma 2017)

4. Impact of Agroforestry on soil health

Agroforestry significantly enhances soil health and nutrient availability through several key mechanisms:

(i) Increased Soil Organic Carbon- Agroforestry systems enrich soil organic carbon (SOC) more than monocropping systems. (Jeanne Dollinger, 2018).

(ii) Improved Soil Fertility- The presence of trees in agroforestry systems improves soil nutrient availability and overall soil fertility (Jeanne Dollinger, 2018). Nitrogen-fixing trees and cover crops enrich the soil with nitrogen, increasing fertility and providing essential nutrients (tracextech.com, 2023).

(iii) Enhanced Soil Microbial Dynamics- Agroforestry enhances soil microbial dynamics, which positively influences soil health. (Rachel C. Pinho, 2012).

(iv) Reduced Soil Erosion- Trees and shrubs in agroforestry systems act as windbreaks and barriers, preventing soil erosion caused by water runoff. Their root systems help bind soils, reducing compaction and enhancing structure (Rivest, 2023). Agroforestry can reduce soil erosion rates by 50 per cent compared to monocultures due to higher infiltration rates and lower runoff (Lai Wang, 2015).

(v) Increased Organic Matter- Fallen leaves, branches, and organic debris from trees in agroforestry contribute to increased soil organic matter content. This improves soil structure, water retention, and nutrient availability for microorganisms to thrive (Salma, 2024).

5. Environmental Benefits of Agroforestry

Agroforestry provides numerous environmental benefits that make it a sustainable land management practice. The key environmental benefits of agroforestry include:

- Climate Change Mitigation through Carbon Sequestration
- Biodiversity Conservation
- Soil Health Enrichment
- Air and Water Quality Improvement
- Microclimate Modification

- Pest and Disease Regulation

6. Conclusion

Agroforestry is a sustainable land management approach that integrates trees, crops, and livestock, enhancing agricultural productivity and environmental resilience. It supports soil health through improved organic matter, nutrient cycling, and reduced erosion, leading to more fertile land. Agroforestry also plays a crucial role in climate change mitigation by sequestering carbon and reducing greenhouse gas emissions. In India, agroforestry is vital for rural communities' subsistence needs and environmental sustainability goals. Various agroforestry systems cater to different ecological and economic contexts, making it an essential strategy for sustainable development in agriculture.

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Assessment of Groundwater and Surface Water Status, Challenges, and Solutions in the City of Jaipur

By: Mr. Jayant Sharma, Consultant

Introduction, Background and History

In the early months of 2024, the news about the severe water crises in the IT hub Bengaluru captured widespread attention. The situation was so terrible that the city's residents were struggling for every drop of water. Like Bengaluru, almost 17 per cent of notified towns and cities in our country are facing extreme scarcity of water. Jaipur, the capital of Rajasthan (the State with the Thar Desert), is among the hardest hit (Sharma M. A., Estimation of future population and water demand of urban centers , 2023).

Jaipur is part of the semi-arid zone of the country. In the 19th century, when erstwhile ruler of Jaipur, Swai Ram Singh II, perceived that the city did not have enough water to meet its needs, he built the "**Ramgarh Lake**" in 1876. The lake served as the main source of drinking water for the people until it dried up completely in mid-2006. (Amit Dass) (Jaipur Nagar Nigam (Greater), n.d.) (The Hindu, 2024). A seasonal river called "**Dravyavthi**" also flows through Jaipur. Unfortunately, this river had been choked by the unplanned expansion of the city over the past few decades. Despite efforts by the state-government to revive the river, it does not provide drinking water for the residents. Currently, the majority of domestic water demand is met through pipelines connected to the **Bisalpur Dam**, located over 125 km from the city. The remaining needs are being met through groundwater extraction from wells, bore-wells, and bawarees, etc. As of December 31, 2021, both sources supplied a total of 672.48 million liters per day (MLD) of water (470 MLD (*69.9per cent*) from the Bisalpur Dam and 202.48 MLD (*30.1per cent*) from groundwater), excluding industrial and irrigation requirements (Rajasthan Government, PHED, 2022-23).

Difference Between Actual Demand And Surface Availability Of Domestic Water (Water Used By People For Drinking And Household Purposes)

The population of Jaipur is 4.25 million (Rajasthan Government, PHED, 2022-23) and is projected to reach 77 million by 2050. Considering the huge population size, the city requires the domestic water demand of a metropolitan city, which is 733.13 mld, whereas the actual water supply to

the city is only 672.48 mld (i.e., 60.65 mld short). By 2050, the demand for drinking water is expected to rise to approximately 1328 MLD (Rajasthan Government, PHED, 2022-23). Consequently, the gap between water demand and supply will continue to widen over time.

Challenges Of Future Severity

Both the water sources (groundwater and water from Bisalpur Dam) are limited in their capacity to supply additional water and cannot meet the city's actual demand. This is further explained more in the following paragraphs:

- **Water supply from Bisalpur**

By the end of 2022, several other cities, including Ajmer, Tonk, Malpura, Jairana, and Dausa, as well as 3,000 villages in Rajasthan State, have been connected to the Bisalpur water supply chain. This additional demand places extra pressure on the dam, limiting its ability to supply more water to meet the actual demand of Jaipur (Sharma P. , An Analytical Study Of Water Production, Demand, Supply).

- **Groundwater**

Rainfall is the main source of groundwater recharge in the State, with 90 per cent of it occurring during the southwest monsoon (June to September). Interestingly, from 2012 to 2021, rainfall was 108.72 per cent of the average 526.8 mm recorded from 1901 to 1970. In spite of this, the groundwater level in the city has declined. In 2020, 28.31 per cent of wells had water available at a depth of 2-10 meters, but this percentage dropped to 1.46 per cent by 2022. Meanwhile, the proportion of wells with water available at depths of 10 to 40 meters and beyond increased from 71.69 per cent to 73.15 per cent. Additionally, wells with water available at depths greater than 40 meters accounted for over 41 per cent of the total number of wells surveyed in 2020, 2021, and 2022, highlighting the dire situation of the groundwater shortage (Central Ground Water Board, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Government of India, 2019-20, 2020-21 and 2021-22). **Table 1** below provides a detailed picture of this situation:

Table 1
Categorisation of depth to water level – Jaipur

Month and Year	No. of well analysed	DTWL mbgl		No. of well in different Ranges					
		Min	Max	0 to 2(m)	2 to 5(m)	5 to 10(m)	10 to 20(m)	20 to 40(m)	>40(m)
01/2022	108	1.59	89.4	2	11	16	16	17	46
				1.85per cent	10.19per cent	14.81per cent	14.81per cent	15.74per cent	42.59per cent
01/2021	108	1.18	87.8	1	7	18	17	17	47
				1.85per cent	6.48per cent	16.67per cent	15.74per cent	15.74per cent	43.52per cent
01/2020	113	2	93.18	1	10	21	16	18	47
				0.88per cent	8.85per cent	18.58per cent	14.16per cent	15.93per cent	41.59per cent

Source: (Central Ground Water Board, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Government of India, 2019-20, 2020-21 and 2021-22)

Grim Situation of Groundwater Extraction in Jaipur:

The Central Ground Water Board (CGWB) has defined the status of groundwater based on extraction levels as follows (Central Ground Water Board, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, GoI):

Categories of Groundwater extraction

Stage of Groundwater Extraction	Category
≤ 70%	Safe
> 70% and ≤90%	Semi-critical
> 90% and ≤100%	Critical
> 100%	Over Exploited

Source: (Central Ground Water Board)

Based on the groundwater status, **Table 2** below, presents a comparative analysis of groundwater extraction over the past 20 years (2004-2023) for the country, Rajasthan State, and Jaipur District. The data reveals that the average groundwater extraction in the country was 58-63 per cent, categorizing them as safe. In contrast, groundwater extraction in Rajasthan State was 148.77 per cent, and in Jaipur, it reached 225.93 per cent, indicating an extremely over-exploited situation:

Table 2
Status of groundwater resources and extraction

GROUND WATER RESOURCES, 2023 [in Billion Cubic Meters (BCM)]											
S. No.	Area	Total Annual Ground Water Recharge	Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
					Irrigation	Industrial	Domestic	Total			
1	2	3	4	5	6	7	8	9	10	11	12
1.	Country	449.08	41.89	407.21	209.74	4.01	27.57	241.34	30.82	195.03	59.26

	wide										
2.	Rajasthan	12.45	1.2	11.25	14.3	0.13	2.31	16.74	2.31	0.9	148.77
3.	Jaipur	.72	.07	.65	1.07	.02	.39	1.48	.39	0	225.93

By the year 2019, all 16 blocks of Jaipur district (Phagi, Jalsoo, Govindgarh, Sanganer Rural, Jhotwara Rural, Kotputli, Amber Rural, Bassi, Jamwa Ramgarh, Sambhar, Chaksu, Viratnagar, Shahpura, Dudu, Jaipur Urban, and Paota) had come under **Over-Exploited Assessment Units** and had been declared as **dark zones** as per a survey by the Central Ground Water Board. This situation persists and has reached an alarming level, leading to water supply disruptions in many areas of the city occurring every two or three days (Rajasthan Government, PHED, 2022-23) (Sharma M. A., Estimation of future population and water demand of urban centers , 2023).

Way Forward

The need for immediate and crucial action to recharge and conserve both ground and surface water is paramount. It is imperative to devise and implement effective strategies for sustainable water management. Here are some steps that could prove beneficial for recharging and conserving water:

1. **Raising awareness:** The lack of awareness among the public regarding water conservation is a leading cause of water depletion. Many people are unaware of its limited availability of water and use it carelessly, disregarding future implications. There is a need to bear collective responsibility by the governments, educational institutions, social organisations, and civil societies to educate every citizen about harvesting as well as conservation of water.
2. **Public engagement in water conservation:** Collective and collaborative actions, where everyone participates in the campaign to preserve water in the form of good practices such as rainwater harvesting, can also be used during the monsoon season. When individuals actively participate in water conservation, they gain a deeper understanding of its importance and value. To encourage participation, incentives such

as rebates on water and electricity bills, urban development taxes, etc., can be offered. Additionally, rewards, prizes, certificates, etc., can be given to those who actively contribute to water conservation efforts.

3. **Reduce Non-Revenue Water (NRW):** NRW refers to water that has been produced but is lost before reaching the customer, resulting in no revenue for the government. It encompasses both real losses, such as leaks and bursts in the water supply network, and apparent losses, including theft, illegal connections, and free water. High levels of NRW have serious financial implications for water supply providers, leading to lost revenues and increased operational costs, ultimately affecting service quality (Ministry of Housing and Urban Affair, GOI). NRW often means that water is either unused or accessed by only a few individuals.
4. **Installation of floating solar panels over water bodies such as the Bisalpur Dam, Dravyavthi River, and other reservoirs:** The intense heat in Rajasthan worsens water scarcity, with evaporation being a major contributing factor. A news published on June 9, 2024, in a leading newspaper highlighted that the amount of water evaporated from the Bisalpur Dam in May 2024 exceeded the quantity supplied to cities and villages in the State during the same period. In May 2024, the Public Health Engineering Department (PHED) supplied 1,005.6 million litres of water per day, while 1,008 million litres of water per day evaporated. The quantity of water lost to evaporation in a year could meet the needs of citizens dependent on the Bisalpur Dam for five months. This significant loss of valuable water underscores the urgent need for effective conservation measures. Installing FSPS on water bodies like the Bisalpur Dam, Dravyavthi

संडे बिग स्टोरी गर्मी पी गई हमारे हिस्से का पानी; जलस्तर 2-3 सेंटीमीटर रोज घटा

मई में बीसलपुर से 10,056 लाख लीटर पानी की रोज सप्लाई, इतना ही गर्मी से भाप बन उड़ा

नरेश परिहार/ इमरान खान | जयपुर

इस साल पड़ी रिकॉर्ड तोड़ गर्मी से जहां आमजन हीटवेव का शिकार हो रहे हैं, वहीं बांध भी तेजी से सूख रहे हैं। जयपुर की लाइफलाइन बीसलपुर बांध का पानी भी तेजी से सिमट रहा है। मई माह में पारा सामान्य से ज्यादा होते ही बांध का पानी तेजी से भाप होना शुरू हो गया। ऐसे में जलदाय विभाग जितना पानी सप्लाई कर रहा है, उतना ही भाप बनकर उड़ रहा है। बीसलपुर से जयपुर, अजमेर और टोंक के लिए रोजाना 10 हजार 56 लाख लीटर पानी वितरण के लिए लिया जा रहा है और 10 हजार 80 लीटर भाप बनकर उड़ रहा है। यानी हमारे एक महीने की सप्लाई जितना पानी सिर्फ मई माह में उड़ गया। इसके चलते बीसलपुर का जल स्तर एक से डेढ़ सेंटीमीटर की जगह 2 से 3 सेंटीमीटर रोजाना घट रहा है।

44 डिग्री पर 9619 और 46 डिग्री पर 10,128 लाख लीटर पानी वाष्प

बांध से हर दिन 2 से 3 सेंटीमीटर पानी घट रहा है। 20 मई को बांध का जल स्तर 310.51 सेंटीमीटर था। 21 को यह घटकर 310.49 रह गया। बांध से सबसे अधिक पानी भाप बनकर उस दिन उड़ रहा है, जिस दिन पारा ज्यादा है। 44 डिग्री पर 9619 और 46 डिग्री पर 10,128 लाख लीटर पानी उड़ा।

मई के 14 दिन पारा 45 से 47 डिग्री रहा, इसी बीच सर्वाधिक पानी उड़ा

तारीख	बांध का स्तर	सप्लाई	वाष्पीकरण	तापमान
20 मई	310.51	10,056	10,080	46.0
21 मई	310.49	10,788	10,129	46.0
22 मई	310.47	10,533	10,111	46.0
23 मई	310.45	10,513	10,128	46.0
24 मई	310.42	10,473	10,147	46.0
25 मई	310.40	10,490	10,124	46.0
26 मई	310.38	10,607	9,908	45.0
27 मई	310.35	10,253	10,228	47.0
28 मई	310.32	10,431	10,250	47.0
29 मई	310.30	10,313	10,148	46.0
30 मई	310.27	10,675	10,118	45.0
31 मई	310.24	10,488	9,619	44.0

नोट : जल स्तर मीटर, सप्लाई-वाष्पीकरण लाख लीटर और पारा डिग्री सेल्सियस में टोंक का।

मई महीने में टोंक जिले के आसपास केवल दो दिन 1 और 2 मई को पारा 40 डिग्री से नीचे रहा। इसके बाद लगातार 40 डिग्री से ऊपर रिकॉर्ड हुआ। 16 मई के बाद भीषण लू चली और 14 दिन तक तापमान 45 डिग्री से ज्यादा रहा। सर्वाधिक 47 डिग्री तक पारा पहुंचा। इस दौरान बांध से सर्वाधिक पानी उड़ा।

जून में हर दिन औसतन 9328 लाख लीटर पानी भाप बन कर उड़ेगा

भाप बनकर पानी उड़ने का सिलसिला जून, जुलाई, अगस्त, सितंबर तक जारी रहेगा। विभाग के अनुसार जून माह के बाद पानी उड़ना आधा हो जाएगा। जल संसाधन विभाग के अधिकारियों ने जून महीने में रोजाना औसतन 9 हजार 328 लाख लीटर पानी उड़ने की संभावना जताई है। जुलाई माह में 4101, अगस्त में 2403 और सितंबर में 2103 लाख लीटर पानी उड़ने की संभावना जताई है। विभाग के अनुसार एक साल में जितना पानी वाष्पीकरण होता है, उससे करीब 5 महीने सप्लाई की जा सकती है। पिछले तीन महीने में जलदाय ने कुल 3 लाख 10 हजार 404 लाख लीटर पानी सप्लाई किया और 3 लाख 09 हजार 807 लाख लीटर पानी उड़ गया।

तीन साल पहले फॉमिंग से पानी को उड़ने से रोकने का प्लान बना था : बीसलपुर बांध से हर साल 9 टीएमसी पानी भाप बनकर उड़ता है। इसे रोकने के लिए जल संसाधन विभाग ने तीन साल पहले बैलून और फॉमिंग तकनीक से पानी को रोकने का प्लान तैयार किया था। लेकिन बांध का एरिया बड़ा होने से प्रोजेक्ट को प्रारंभिक स्तर पर ही रोक दिया गया।

Figure 1 Source: (The Dainik Bhaskar, Jaipur (Print Media), 2024)

River, Jal Mahal Lake, Mavtha Lake (Amer), and others would not only mitigate water evaporation but also alleviate electricity shortages to some extent. Additionally, it would contribute to India's commitment to generating 500 gigawatts of renewable energy by 2030.

5. **Control the rapid and high-volume flow of rainwater on city roads:** The eastern and northern parts of Jaipur are bordered by the Aaravli Hills, from which rainwater cascades swiftly onto roads, particularly in areas like Raja Park, Jawahar Nagar, Rambagh Circle, SMS Hospital, and Narayan Singh Circle. This results in a rapid flooding situation even with minimal rainfall due to the inadequate drainage system in the city. Measures could be taken to enhance the drainage infrastructure and more importantly develop techniques for direct diverting rainwater from hill areas to water conservation and harvesting facilities. Implementing these solutions will not only alleviate the aforementioned issues but also ensure proper conservation of rainwater.
6. **Development of new water supply sources for the city:** Given the inadequacy of current domestic water supply sources, there is a need to explore new sources of water for the city. Diverting water from the Chambal River through canals/pipelines, could be beneficial for the city. Additionally, during the monsoon season, surplus water from the Bisalpur Dam is often flushed into the river and eventually lost to the sea. Constructing a new dam to collect this excess water during monsoons could provide a valuable resource for the city's residents.

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Invasive Species and Agro-biodiversity with a focus of followings: (a) Impact of invasive species on agro bio-diversity and (b) Strategies to mitigate the effect of invasive species

By Shri Manoj Kumar, AAO and Shri Ram Niwas Sharma, Sr. Auditor

Introduction

Agro-biodiversity refers to the variety of life forms that contribute to food production, shaped by natural processes and human innovation over time. It includes harvested resources like crop varieties, livestock breeds, fish species, and wild resources. Supporting species, such as soil microorganisms and pollinators, are crucial for ecosystem health. Additionally, non-harvested species in broader environments play a key role in sustaining agricultural systems. Maintaining agro-biodiversity is essential for food security and adapting to climate change[1]. (organisation)

Invasive species are non-native organisms that cause significant environmental and economic harm when introduced into new ecosystems. Unlike many non-native species, such as food crops, invasive species rapidly adapt and reproduce, often displacing native species and disrupting local ecosystems. Their impact on agro-biodiversity is particularly concerning as it threatens food security and ecosystem health.. Effective management involves early detection and control measures to protect native habitats and species.

Ecological perturbations from biotic invasions pose a significant threat to global sustainability, with invasive alien plant species (IAPS) being major contributors to biodiversity loss. These species alter ecosystem services and socio-economic conditions through various mechanisms.

[1] https://www.fao.org/4/y5609e/y5609e01.htm#:~:text=per cent5BBoxper cent202per cent5Dper cent20Aper cent20DEFINITIONper cent20OF,per cent2Cper cent20livestockper cent2Cper cent20forestryper cent20andper cent20fisheries.

Impact of Invasive Species on Agro-biodiversity

Many alien species successfully adapt to new environments, often causing disruption to native species and contributing to the homogenization of ecosystems. This can lead to changes in hydrological characteristics and the degradation of gene pools through hybridization with native species ultimately resulting in a loss of biodiversity.

It has been identified that alien species are major contributors to biodiversity decline, including the extinction of native populations and economic losses. In island habitats worldwide, invasive species pose significant threats to both human well-being and habitat integrity. Invasive species can dramatically alter their ecosystems by releasing chemical compounds, influencing abiotic factors, or exhibiting herbivorous behaviors, which may have either positive or negative effects on other organisms.

Certain species, like *Kalanchoe daigremontana*, produce allelopathic substances that inhibit the growth of competitive organisms and disrupt soil processes such as carbon cycling and nitrogen mineralization . On the other hand, species like *Stapelia gigantea* can attract seedlings from arid habitats by creating favorable microclimate conditions and reducing herbivory during the early stages of growth (Kabita Kumari Shah 2020)

Rule Position about Biological Diversity in India

The Biological Diversity Act of 2002 was indeed a significant step for India in aligning with the objectives of the United Nations Convention on Biological Diversity (CBD) from 1992. This legislation emphasizes the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising from genetic resources.

The Act establishes the National Biodiversity Authority (NBA) in Chennai, which plays a crucial role in regulating access to biological resources and ensuring that local communities and indigenous people benefit from the use of their biological knowledge and resources. The NBA also

facilitates the documentation and preservation of traditional knowledge related to biodiversity, thus contributing to both conservation and sustainable development goals.

By recognizing the sovereign rights of states over their biological resources, the Act aims to balance conservation efforts with the need for economic development, ensuring that benefits from biodiversity are shared fairly. This holistic approach is vital for protecting India's rich biodiversity while supporting the livelihoods of local communities. (Environment)

Strategies to Mitigate the Effects of Invasive Species

Mitigating the effects of invasive species indeed requires a comprehensive approach. Here's a more detailed look at the Strategies to mitigate the effect of invasive species such as:

i. **Prevention and Early Detection**: Public Awareness such as launch programs aimed at schools, community centres, and local organizations to inform people about the ecological and economic impacts of invasive species. Use workshops, informational brochures, and social media to reach a broad audience. Events such as "Invasive Species Awareness Days" or local clean-up initiatives can be organized where participants can learn about invasive species first-hand and how to identify them. Providing accessible materials, such as identification guides and online resources etc., can help individuals recognize invasive species in their area.

ii. **Collaboration and Partnerships**: A coordinated approach involving government agencies, NGOs, academia, and local communities can improve invasive species management. By developing comprehensive action plans at local, state, and national levels, stakeholders can ensure funding and responsibilities are clearly defined.

iii. **Engagement and Incentives**: Encouraging community involvement through volunteer programs for monitoring, removal, and habitat restoration fosters a sense of ownership. Providing incentives for landowners and businesses to adopt invasive species management practices can also support prevention efforts.

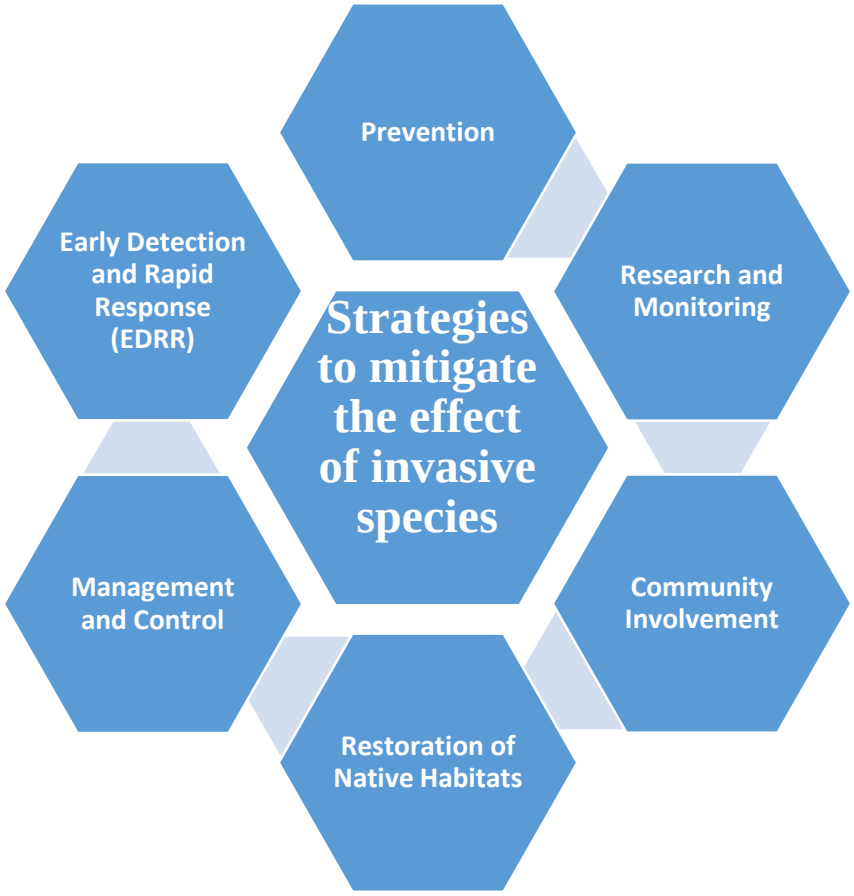

Figure 1 Compiled by Author

Conclusion

Invasive species pose a significant threat to agro-biodiversity by altering ecosystems, displacing native species, and reducing agricultural productivity. The Biological Diversity Act of 2002 provides a legislative framework to address these issues in India, but effective mitigation requires a multi-faceted approach. Prevention, regulation, public awareness, and collaboration across sectors are essential to protect agro-biodiversity and ensure the sustainability of agricultural systems.

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Importance of Agro- Biodiversity

By : - Shri Vikas Dhir, AAO

Introduction: - Agro-biodiversity, encompassing the variety of plants, animals, and microorganisms used in agriculture, is crucial for food security, farming productivity, and ecosystem health. This article explores its importance in sustaining agricultural systems, enhancing pest control, improving nutrition, and supporting ecosystem services. It also stresses the need for conservation through in situ and ex situ methods.

The intention behind this article is to raise awareness about the value of agro-biodiversity and advocate for sustainable agricultural practices and policies that prioritize biodiversity conservation to ensure food security and environmental sustainability.

What is Agro-biodiversity: - According to the Food and Agriculture Organization FAO (CIHEAM n.d.), Agro-Biodiversity is defined as the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems. (FAO).

Types of Agrobiodiversity:-

a) **Genetic Agrobiodiversity:-** It encompasses all domesticated species and their wild relatives used in agriculture, including newly developed man-made varieties and animals. It also includes wild species that provide significant genetic diversity.

b) **Species Agrobiodiversity**: - It includes all species whether wild or domesticated that are dependent on agricultural practices.

c) **Ecosystem Biodiversity:-** It encompasses the ecological habitats of plants, animals, and microorganisms that are adapted to specific time and spatial conditions, at the levels of farm, field, or landscape. (Fidanka Trajkova, 2021)

Importance of Agrobiodiversity:

a) Agro biodiversity as a Basis of Production:-Agrobiodiversity includes genetic resources (plants, animals, soil organisms), crops (traditional varieties and hybrids), livestock, beneficial microorganisms, and agro-ecosystem components (polyculture, monoculture). It supports nutrient cycling, stability, and productivity in farming systems. (Lori Ann Thrupp 2000)

b) Crop Biodiversity and Production Stability: Diverse ecosystems and genetic variation in crops increase productivity and reduce crop failure risks. Smallholder farmers often grow traditional varieties to maintain genetic diversity and food security. (Srivastava 2022).

d) Better Nutrition and Health through Biodiversity: Agricultural biodiversity improves diets by providing essential micronutrients, fiber, and better nutrition. In India, growing minor millets enhances yields, income, and nutrition, particularly benefiting women and improving food security (Srivastava 2022).

Vital Role of Agrobiodiversity in Ecosystem Regulation: Enhancing Pollination, Pest Control, and Carbon Sequestration:

Pollination: -. Agrobiodiversity supports pollination by providing habitats for bees, butterflies, and other pollinators, improving crop yields and food quality. This boosts crop yields, improves food quality, and supports the survival of over 75per cent of plant species reliant on pollination.

Pest Control:-. Diverse species contribute to natural pest control, reducing the need for chemical pesticides. Beneficial insects, such as ladybugs, help control pests like aphids, while practices like crop rotation and using resistant varieties further reduce pest populations.

Image 2: Insect Pollinator, Source: *(Fidanka Trajkova, 2021)*

Carbon Sequestration: Furthermore, agro-biodiversity enhances soil health and structure, facilitating carbon sequestration through improved organic matter content and root biomass. This not only mitigates climate change but also enhances soil fertility, creating a resilient agricultural system that benefits both ecosystems and farmers. (Fidanka Trajkova, The Role and Importance of agrobiodiversity for agriculture, 2021)

Bio diversity Conservation: - Brütting et al. (2013) has identified two primary conservation approaches for existing biodiversity:

1. **In situ conservation**: This method focuses on protecting species, genetic varieties, and habitats within their natural environments. This method is especially important for species that are challenging to conserve outside their habitats, as it maintains genetic variation in the wild or within traditional farming systems. (Fidanka Trajkova, 2021)
2. **Ex situ conservation**: Ex situ conservation involves preserving all levels of biodiversity outside their natural habitats through various methods, including zoos, aquariums, botanical gardens, and gene banks (Borokini et al., 2010). This approach is crucial for raising awareness, communicating conservation challenges, and garnering public and political support for the protection and breeding of endangered species. (Fidanka Trajkova, 2021)

Challenges in Agro biodiversity

a) Human activities like deforestation, land-use change, and urbanization disrupt habitat structure, affecting species survival by reducing population growth, altering species interactions, and hindering foraging, breeding, and dispersal
b) The introduction of invasive species can harm ecosystem biodiversity by outcompeting native species, disrupting the food web, and altering nutrient cycling, leading to an accelerated loss of biodiversity.
c) Over-exploitation of biological resources, such as overhunting, overfishing, and excessive plant collection, poses a significant challenge to agro-biodiversity. These practices threaten species survival, disrupt ecosystems, contribute to the spread of pathogens, and can lead to reduced food security and economic losses.

d) Pollution, impacting local, regional, and global scales, affects biodiversity by reducing the biological fitness of organisms. It can alter genetic diversity, impair reproductive potential, decrease the production of crops or wild species, and disrupt ecosystem structure and function.
e) Climate change, through shifts in temperature and precipitation, poses severe threats to biodiversity. Species at risk of extinction may not survive increased abiotic stress, leading to changes in species distribution and potential extinctions. (Mario X. RUIZ-GONZÁLEZ, 2023)

Regulations and Frameworks for Agro Biodiversity

The Convention on Biological Diversity[2] (CBD) provides a global framework for the conservation and sustainable use of biodiversity, while the Food and Agriculture Organization's (FAO) Commission on Genetic Resources for Food and Agriculture serves as a permanent intergovernmental forum for discussing and negotiating matters related to agricultural biodiversity. Key international agreements like the International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA), alongside national policies such as the National Policy on Agroforestry (2014), the Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA, 2001), and the Biological Diversity Act (2002), all play vital roles in addressing agricultural biodiversity concerns. Additionally, the FAO's Plant Genetic Resources (PGRs) initiative facilitates the conservation, sustainable use, and equitable sharing of benefits derived from PGRs. The Nagoya Protocol, a legally binding framework, aims to enhance the effective implementation of access and benefit-sharing principles at the regional, national, and local levels. In India, the National Agricultural Policy (2000), National Policy for Farmers (2007), National Biodiversity Action Plan 2008, National Seed Policy (2002), and other policies continue to guide the sustainable management of agricultural and food resources.

[2]https://www.researchgate.net/publication/350547021_Conservation_of_India's_agrobiodiversity_towards_increasing_food_nutritional_and_livelihood_security/link/6065b20892851c91b194e7ec/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

Conclusion:-

Agro-biodiversity is essential for the sustainability and resilience of agriculture, supporting food security, nutrition, and resistance to pests and diseases. To safeguard agro-biodiversity, we must embrace inclusive policies that promote diverse cropping systems, honor traditional farming practices, and integrate biodiversity into modern agriculture, ensuring that all farmers, especially marginalized communities, have access to resilient and sustainable food systems.

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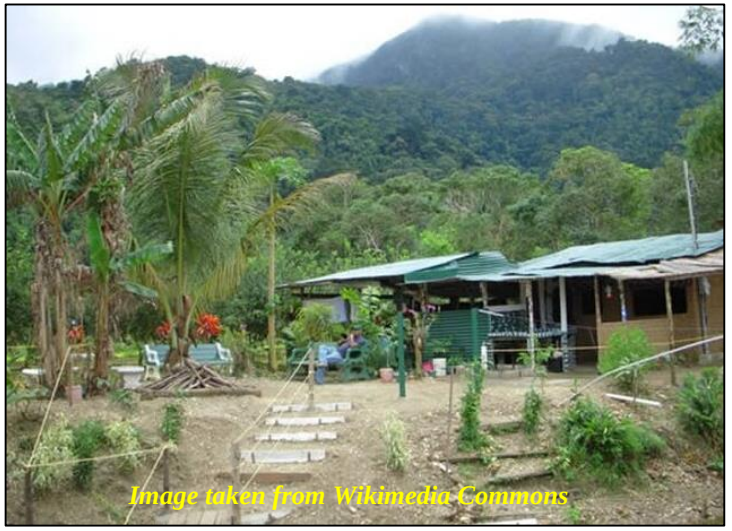
Agri-Tourism

By :- Dr Mahesh Kumar Saini (Research Associate)

Introduction:

Agri-tourism, is also known as agricultural tourism or farm tourism, involves attracting visitors to agricultural areas for recreation, education, and enjoyment. The purposes of agri-tourism include diversifying and stabilizing rural economies, creating jobs, and increasing community income. It supports local businesses by broadening their market base and attracts tourists to rural areas, fostering the growth of small tourism industries. Additionally, agri-tourism provides training and support for farmers, enhancing their livelihoods. It also encourages the appreciation of traditional arts and music in rural communities. Both urban Indians and foreign tourists gain opportunities to discover and value Indian agricultural traditions through these experiences.



Status in the world:

Agri-tourism, integrating agriculture and tourism, has gained significant traction worldwide, reflecting a growing interest in sustainable rural development and authentic experiences. In North America, particularly in the United States and Canada, agri-tourism is well-established, with farms offering fruit picking, farm tours, and educational workshops. States like California and Florida are particularly known for their diverse agri-tourism offerings, including vineyards and citrus groves (Roth, 2016). In Europe, countries like France, Italy, and the Netherlands have embraced agri-tourism, promoting rural heritage and local produce. The European Union has supported agri-tourism initiatives as part of its rural development policies, encouraging sustainable practices and economic diversification (European Committee commision for natural resources, 2024). Australia

is also experiencing a flourishing agri-tourism sector, with many farms providing unique experiences such as wine tasting, farm stays, and wildlife encounters. The Australian government recognizes agri-tourism as a means to enhance rural economies and promote sustainable farming (Govt of South Australia, 2024). In Asia, countries like India and Thailand are emerging as agri-tourism destinations, focusing on educating urban populations about agriculture and promoting local cultures. Initiatives often emphasize organic farming and sustainable practices, appealing to environmentally conscious travellers (Damnet, 2024; Valuechain Asia, 2023). Meanwhile, agri-tourism is still developing in Africa but shows promise, particularly in South Africa, where wineries and safari farms attract tourists. Efforts are being made to integrate agri-tourism with conservation and community development (Brighton Nyagadza, 2024).

Status in India:

The Agro Tourism Villa Scheme, part of Meghalaya's Chief Minister's Elevate Program, promotes youth entrepreneurship by supporting the development of luxury tourist accommodations. The government offers financial aid, including a 35 per cent subsidy, for villa projects ranging from ₹50 lakhs to ₹1.5 crore. The scheme aims to boost high-value tourism, attract discerning travelers, and stimulate rural development by building villas in scenic areas. Thirty individuals or registered entities are eligible for the scheme in its first year. The government collaborates with banks for loans and covers design costs, emphasizing sustainability and local cultural aesthetics (Prime Meghalaya, 2023).

Additionally, the Swadesh Darshan Scheme offers financial assistance for enhancing tourism infrastructure, while the Pradhan Mantri Fasal Bima Yojana (PMFBY) protects farmers from production risks and encourages crop diversification. Together, these initiatives aim to promote sustainable tourism, enhance agricultural competitiveness, and contribute to the overall economic development of the region.

Challenges related to Agri-Tourism in India:

Agri-tourism in India faces several challenges, including a lack of proper training, weak communication skills, and poor coordination between the agriculture and tourism departments. There is limited awareness among both farmers and tourists, along with a low entrepreneurial culture in rural areas. Additionally, cooperation among rural communities is lacking, and there is insufficient funding for agri-tourism centers. The absence of insurance for tourists, high bank loan interest rates, and expensive electricity bills further discourage investment in agri-tourism, limiting its growth potential (S. N. Wanole, 2020).

Conclusion:

Agri-tourism, which integrates agriculture and tourism, provides visitors with immersive experiences in rural farm life. This sector enhances understanding of agricultural practices while promoting sustainable tourism and rural development. By connecting tourists with nature and local culture, agri-tourism diversifies farmers' income and bolsters local economies. Visitors can participate in farm activities, learn about organic farming, and enjoy eco-friendly accommodations, all of which raise awareness about food production and conservation. Furthermore, agri-tourism strengthens the relationship between urban and rural communities, facilitating cultural exchange and environmental education. This fosters appreciation for sustainable farming practices, ultimately contributing to the preservation of agricultural traditions and promoting ecological sustainability.

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Bio-diversity at iCED

By: Vikas Dhir, AAO and Shri. Rajesh Kumar Meena, Sr.Ar

Heliocopris Hamadryas found in iCED Campus,

Photo Credits: - Shri. Vikas Dhir, AAO (Research) iCED, Jaipur

Heliocopris Hamadryas

Heliocopris hamadryas measures approximately 39 to 53 millimeters (1.5 to 2.1 inches) in length. Its body is glossy, with colors ranging from dark brown to black. These beetles create dung balls, where females lay their eggs. The larvae develop and pupate inside these dung balls before emerging as adult beetles. (iNaturalist n.d.)

Darkling Beetle found in iCED Campus

Photo Credits: - Shri. Vikas Dhir, AAO (Research) iCED, Jaipur

Darkling Beetle (Tenebrionids)

Darkling beetles belong to a large family of beetles characterized by their generally dull black or brown coloration. Typically crawling along the ground, they serve as scavengers. Some can fly and may be drawn to lights at night, while many are flightless, with some species having their elytra (the protective forewings) fused together, resulting in no visible split down the back.. Like other beetles, darkling beetles undergo a life cycle that begins with eggs hatching into grublike larvae, which then grow and molt several times before entering the pupal stage. (Missouri Department of Conservation)

Flower Plants at iCED Campus

Photo Credits: - Shri. Vikas Dhir, AAO (Research) iCED, Jaipur

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