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CLIMATE CHANGE AND THE RACE TO SAVE BIODIVERSITY

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Climate change refers to the long-term changes in temperature and weather due to human activities. Enormous increase in the emission of greenhouse gases (CO_2, methane and nitrous oxide) due to burning of coal and fossil fuels, mining activities, intensive farming practices, waste disposal, over-exploitation of natural resources and deforestation are the main drivers of climate change. Marked increase in the frequency and intensity of natural disasters, permafrost/ice melting, rise in sea level, decrease in crop productivity, poverty, displacement of species and loss of biodiversity are the main consequences of climate change. Declining biodiversity poses a significant threat and is a pressing issue now-a-days.

Climate Change as Accelerated by Biodiversity Loss

Other human-induced environmental changes such as habitat loss and degradation, overexploitation of bioresources and introduction of alien species interact with climate change and affect biodiversity and ecosystems. 519 studies on ecological responses to extreme climate events (cyclones, droughts, floods, cold waves and heat waves) between 1941 and 2015 was studied by Maxwell *et al.*, 2019, covering amphibians, birds, fish, invertebrates, mammals, reptiles and plants.

Healthy ecosystems like forests, wetlands and coastal mangroves, absorbs carbon dioxide from the atmosphere and act as carbon sinks but biodiversity loss can no longer perform this function and release their stored carbon, primarily as CO_2 and disrupts natural climate regulation. For example, the degradation of coastal ecosystems is estimated to release 0.45 billion tons of CO_2 annually. The loss of even one species can have a cascading effect on the entire ecosystem, impairing its ability to regulate the climate, control weather patterns, and purify water.

Also, the faunal species like bees and other pollinators are crucial for plant life, and their decline can lead to a collapse of plant populations, impacting the entire food web and reducing the planet's ability to sequester carbon. As climate change intensifies, it further accelerates biodiversity loss. When biodiversity is lost, the ecosystem becomes more vulnerable to climate impacts, creating a vicious cycle.

Impact of Climate Change on Shifting of Species

The disruptions like habitat loss and fragmentation, altering ecological cycles and species interactions, and increasing extreme weather events force species to migrate, fail to reproduce, or starve, while also creating conditions that favor invasive species and increase the spread of diseases, ultimately leading to species extinction. Due to increase in temperature, a shift in distributional range of species and phenological events occur. The timing of crucial ecological events, such as flowering or egg-laying, becomes out of sync with the species that depend on them, like pollinators and birds.

As the temperature gets warmer in their native habitat, species tend to move to higher altitudes and towards the poles in search of suitable temperature and other environmental conditions. For example, many fish and shellfish populations, such as Pacific cod and surf clams shifting their historic ranges toward the poles (northward in the Northern Hemisphere) in search of cooler water. Polar bears rely on sea ice to hunt seals; as the ice melts earlier and forms later, their hunting grounds diminish, leading to starvation and their population declines.

Extinct Species Due to Climate Change

Bramble Cay melomys: This rodent, found on Bramble Cay in Australia, is considered the first mammal to go extinct as a direct result of climate change. Rising sea levels destroyed its habitat and the resulting storms and sea surges wiped out its population.

Golden toad: Native to Costa Rica, this toad's extinction is linked to climate change-driven alterations in its environment. Changing weather patterns led to its breeding pools drying up, which prevented successful reproduction.

Coral reefs: Numerous coral species are declining rapidly worldwide due to climate change. The reasons behind their mass extinction is due to mass bleaching and ocean acidification.

Snow crabs**:** In the Bering Sea, a massive die-off of snow crabs occurred between 2018 and 2021, potentially linked to climate change causing a lack of food and starvation.

Humpback whales**:** A large number of humpback whales in the northern Pacific Ocean have died from marine heatwaves in recent years.

Climate-adaptive Conservation Practices

Assisted migration, habitat corridors, and genetic diversity preservation practices help species and ecosystems to adjust with rapid environmental changes.

Assisted migration involves the human-supported deliberate translocation of species to habitats, enabling them to adapt to changing environmental conditions. When intermediate habitats along the migration routes are lacking, these practices can be found effective. (Szamosvári *et al*., 2025). The species facing severe barriers to migration, such as urban development or vast agricultural land can be prevented from extinction by this approach.

Habitat or wildlife corridors are strips of natural habitat that connect isolated patches of land, allowing animals and plants to move between them. These structures facilitate natural movement, seasonal migration, and dispersal, which helps species access food, water, and mates. Genetic exchange can be assured which may be helpful for maintaining healthy and resilient gene pools.

Genetic diversity preservation ensures long-term health and adaptive potential. In situ conservation involves gene flow within and between existing populations and ex-situ methods include seed banks, botanical gardens, and captive breeding programs.

Conclusion

Climate change is indeed a formidable global threat. Human interventions for biodiversity conservation amid climate change involve mitigating greenhouse gas emissions through renewable energy and efficiency, and implementing adaptive conservation strategies, which aim to protect and restore ecosystems that serve as natural carbon sinks, allow species to adapt to shifting ranges, and protect vulnerable habitats from the impacts of a changing climate.

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INTEGRATED MULTI-TROPHIC AQUACULTURE

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Food demand is rising due to the world's expanding population. In the past two to three decades, the aquaculture industry has made substantial advances despite population growth, advancements in human welfare, and a decline in natural aquatic resources (Tang et al., 2024). Biofilter organisms from the different trophic levels in the aquaculture plant are used in an integrated multi-trophic aquaculture (IMTA) system to remove animal waste from the water. Through an ecosystem-oriented methodology, the IMTA aims to improve sustainability in intensive aquaculture by combining fed aquaculture species with both organic and inorganic extractive species to create an equilibrium system that promotes social acceptance, financial viability, and environmental sustainability (Biswas et al., 2020; Sanz-Lazaro and Sanchez-Jerez, 2020). The IMTA technique was created to use excess nutrients from organisms at a higher trophic level to generate economically valuable lower trophic level commodities. The IMTA systems provide the best possible answer to the problems aquaculture faces, such as resource inefficiency, environmental contamination, aquaculture hazards, and model development obstacles. Thus, the application of IMTA systems in aquaculture is highly recommended (Troell et al., 2009; Zhang et al., 2022). The three primary issues facing aquaculture—pollution, feed input, and space—are addressed by IMTA. According to Chopin et al. (2001); Troell et al., 2003, integrated multi-trophic aquaculture (IMTA) is the practice of cultivating aquatic species of varying trophic levels close to one another in a way that recycles waste, by-products, or uneaten feed from one species and uses it as energy, fertilizer, or feed for another crop. This allows the crops to benefit from their synergistic interactions.

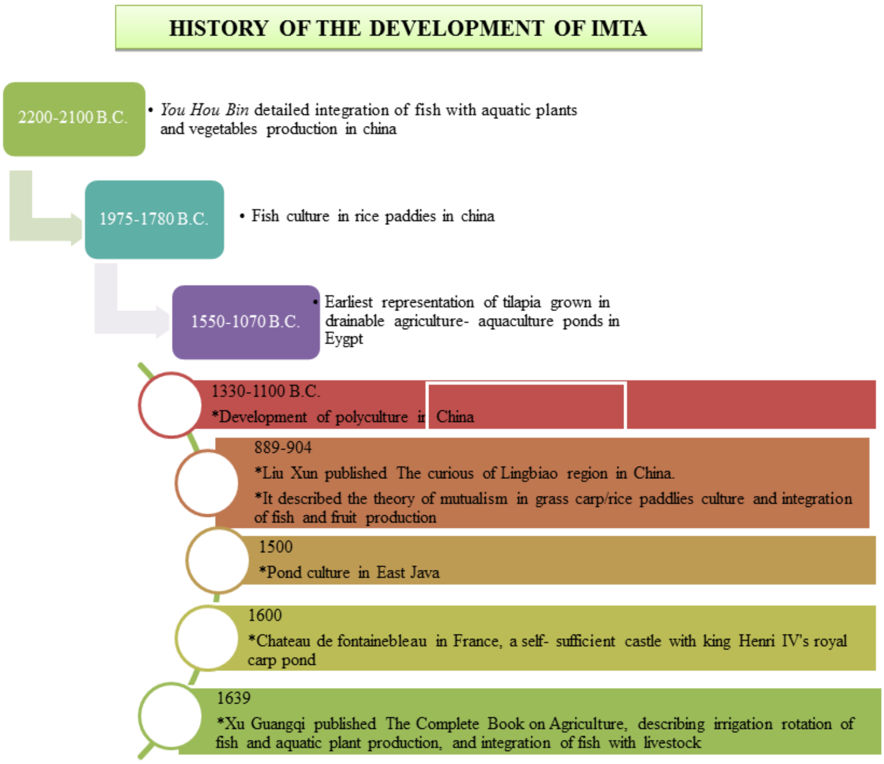
A Standard IMTA Configuration Consists of Three Main Parts (Troell et al., 2009)

1. Fed aquaculture species (finfish/shrimp) - Finfish contribute to the economy of an IMTA setup, form the upper trophic level, and provide nutrients to other system components (Sasikumar and Viji, 2015). Environmental is likely to have a predatory finfish as a fed species, but the choice of fed aquaculture species is only chosen after a thorough economic, environmental, and dietary review. Carp, a lower trophic level fish, are more energy efficient than salmon, a top predatory fish, yet salmon has higher feed requirements and eventually excretes more nutrients.

2. Inorganic extractive species (seaweeds)- Since algae are an essential part of IMTA because of their capacity to absorb nutrients, the selection of algae should be based on their capacity to eliminate phosphate and nitrogen in addition to their ideal temperature range (Skriptsova and Miroshnikova, 2011). Along the Atlantic coast, it has been common practice to use *Gracilaria bursa-pastoris, G. gracilis, Chondrus crispus, Palmaria palmata, Porphyra dioica, Asparagopsis armata, Gracilariopsis longissima, Ulva rotundata*, and *U. intestinalis* as biofilters in conjunction with sea bass and turbot (Barrington et al., 2009). Algal growth modeling in the finfish-sea urchin-sea-seaweed system showed that nutrients, radiation, and ambient temperature typically operate as growth-limiting factors. Temperature and radiation shouldn't be limiting considerations in an algae farm; instead, nutrients could be one (Lamprianidou et al., 2015).

3. Organic extractive species (suspension and deposit feeders)- Many organisms, such as crustaceans and echinoderms, have been tested for their suitability for open water IMTA setups (Barrington et al., 2009; Nelson et al., 2012). However, macroalgae and bivalves have been found to be suitable for the setup because they are grown in the down current area of fed aquaculture cages, which makes it easier for farm waste to flow towards these suspension extractive species or SES. There are two primary types of organisms in the SES group: bivalves, which use organic waste, and macroalgae, which use inorganic waste. Particulate fish waste serves as an extra food source for suspension-feeding bivalves, which are generalist consumers that take a wide variety of particles of various sizes and types (Troell et al., 2003). Echinoderms are the top prospect for the deposit extractive species, which is the group that occupies the bottom of the culture site. The garbage that the suspension feeders miss is what they eat.

Evolution: Modern IMTA, also known as Polyculture, emerged gradually over a long period of time, starting with integrated fish farming through polyculture and ultimately incorporating ecological engineering into aquaculture. The organic and inorganic extractive aquaculture species (bivalves, aquatic plants) and the fed-aquaculture organisms (fish, shrimp) are grown independently in designated production units in intensive monoculture or polyculture systems, which clearly result in notable environmental changes. IMTA involves the cultivation of fed species that require nourishment from feed supplementation, while extractive species utilize the organic and inorganic waste generated in the production unit for maintenance and growth metabolisms. A deeper understanding of IMTA principles and practices is crucial to the creation of harmonious systems that support ecological sustainability (by mitigation), financial viability (through diversified products and risk elimination), and social acceptance (via improved management procedures) (Pinak et al., 2023). From a conceptual standpoint, the IMTA is an evolving agricultural method that entails growing two or more organisms together while considering the trophic levels, feeding preferences, and recycling byproducts from one species as inputs for another.



John ryther et al., 1975	Integrated waste recycling marine polyculture systems
Marilyn Harlin et al., 1979	Seaweeds in closed system fish culture
M.E. McDonald, 1985	Biological removal of nutrients in algal fish systems
Amir Neori, 1991	Seaweed biofilters for intensive mariculture
Muki Shpigel et al., 1991	Oysters in fish aquaculture ponds
Alejandro Buschmann et al., 1994	Seaweed cultivation with land-based salmon effluents
Max Troell et al., 1999	Aquaculture ecological engineering
Thierry Chopin and Jack Taylor, 2004	Integrated multi-trophic aquaculture

Selection Criteria for Species

IMTA prioritizes environmental sustainability, which influences the selection criterion for species. Because of this, the selection of species is determined by an understanding of the constraints that are inherent in the natural ecosystem. It is crucial to carefully assess each species' compatibility with the habitat and culture unit when deciding which ones are appropriate for incorporation inside an IMTA system. Farmers must understand the compatibility of the species and its possible impacts on the ecosystem to guarantee both good growth and economic viability. For nutrition, organisms that need to be fed—such as carnivorous fish and shrimp—rely on outside supplies like pellets or abandoned fish. On the other hand, organisms that are extractive obtain their nourishment from their surroundings. This includes seaweed and bivalves, two economically important cultural groups.

Carefully choosing co-cultured species combinations requires consideration of several factors and situations.

1. **Complementary functions in the system with other species:** On various levels of trophic structure, select species that are complementary to one another. To enhance water quality and promote efficient growth, for instance, newly integrated species need to be able to consume the waste products of other species.

2. **Adaptability about the habitat:** Native species can be utilized for which technology is accessible and within their typical geographic range.

3. The **possibility that invasive species will damage the surrounding ecosystem** and possibly interfere with other commercial endeavors. Moreover, native species have developed strong adaptations to the local environment.

4. **Culture technologies and site environmental conditions:** When selecting a farm site, particulate organic matter, dissolved inorganic nutrients, and particle size range should all be taken into account.

5. Utilize species that can produce a sizable biomass to mitigate problems effectively and continuously. Another possibility is to have a species that is highly valuable, in which case smaller volumes can be produced. Nevertheless, the latter lessens the bio mitigating role.

6. **Pricing and market demand for the species** as a raw material or for products made from these organisms: Make use of species whose market worth is known or thought to exist.

7. **Potential for commercialization:** Make use of species for which legislators and regulators will allow the exploration of new markets without putting further regulatory barriers in the way of commercialization.

Benefits and Challenges

One advantage of IMTA is that it allows for the mitigation of wastewater by biological methods. This is accomplished by using bio-filters that are compatible with the ecological conditions of the aquaculture site.

- **Increased financial rewards from trading commercially generated by-products**: Increased profits through diversification. The farm can obtain additional products that surpass the costs of starting and maintaining an IMTA farm by utilizing the extractive potential of co-cultivated lower trophic level species. In integrated aquaculture, the excess nutrients are used as a resource to support bio-filters.
- **Enhancing the local economy:** Promoting economic expansion by creating jobs both directly and indirectly, as well as by processing and distributing goods.
- **Inherent risk mitigation strategy:** Product diversification can provide financial stability and lessen economic susceptibilities to price swings, crop losses from disease, or unfavorable weather.
- **Disease management:** Because of their antibacterial qualities against fish-pathogenic microorganisms, some seaweed species can help prevent or lessen fish infections.
- **Increased revenue through premium pricing**; the ability to set IMTA products apart through eco-labeling programs or obtaining organic certification.

Conclusion

With an innovative framework for creating the most effective food production system, IMTA systems are crucial to the sustainable growth of aquaculture operations within a balanced ecosystem approach in response to the growing global demand for seafood. The benefits of IMTA include disease prevention, bioremediation, increased carrying capacity, and a variety of products. IMTAs are still being developed in many countries, at least at full commercial scales, despite their immense potential. In various regions of the world, there are a few prospective open-ocean IMTA demonstration facilities that could serve as models for further development. Nevertheless, more effort is required to modify these designs for other species and circumstances. Demonstration research sites, with cost-sharing arrangements to lessen the expensive nature of offshore research, will be able to offer the aquaculture industry invaluable information as designs are scaled up to commercial production levels. Therefore, this sustainable and environmentally friendly choice needs to be further pushed to provide coastal fishermen with a reliable source of income, mitigate the negative effects of climate change, and earn precious carbon credits for our nation.

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IMPACT OF PRADHAN MANTRI FASAL BIMA YOJANA (PMFBY) ON FARMERS OF TRIPURA

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Agriculture in Tripura is predominantly rain-fed and characterised by small and marginal landholdings, making farmers highly vulnerable to climatic uncertainties such as erratic rainfall, floods, dry spells, pest outbreaks, and cyclonic disturbances. These risks often result in crop failure, income instability, and growing indebtedness among farming households. To address these challenges and provide a safety net against crop losses, the Government of India launched the Pradhan Mantri Fasal Bima Yojana (PMFBY) in 2016.

PMFBY aims to provide affordable crop insurance coverage to farmers, ensuring financial protection against yield losses due to natural calamities, pests, and diseases. In a state like Tripura, where agriculture remains a key livelihood source and climate variability is increasing, PMFBY holds significant relevance for stabilising farm income and encouraging farmers to continue agricultural activities with reduced risk.

Overview of PMFBY

The Pradhan Mantri Fasal Bima Yojana is a comprehensive crop insurance scheme implemented across India with the active participation of State Governments, insurance companies, banks, and local institutions. Under PMFBY, farmers pay a nominal premium—2% for Kharif crops, 1.5% for Rabi crops, and 5% for commercial and horticultural crops—while the remaining premium is shared by the Central and State Governments.

The scheme covers yield losses due to natural calamities, prevented sowing, post-harvest losses, and localized risks such as landslides and inundation. PMFBY uses an area-based approach supported by Crop Cutting Experiments (CCEs) and digital platforms for enrolment and claim settlement, aiming to ensure transparency and timely compensation.

Adoption of PMFBY in Tripura

Since its implementation, PMFBY has been adopted in various districts of Tripura, covering major crops such as paddy, maize, pulses, and oilseeds. Enrollment levels vary across districts depending on awareness, institutional support, and accessibility to banking and digital services. Farmers associated with cooperative societies, Farmer Producer Organizations (FPOs), and institutional credit systems show relatively higher participation.

However, adoption among remote tribal areas and marginal farmers remains inconsistent due to limited awareness, procedural complexities, and inadequate extension support. Despite these challenges, PMFBY has gradually gained recognition among farmers as a formal risk-management tool in Tripura.

Impact of PMFBY on Farmers of Tripura

1. Income Security and Risk Reduction: One of the most significant impacts of PMFBY in Tripura has been the provision of financial relief during crop loss years. Farmers who received timely claim settlements reported reduced dependence on informal credit sources and better capacity to reinvest in the next cropping season. The assurance of compensation has helped farmers cope with weather-induced crop failures and maintain livelihood stability.

2. Encouragement for Continued Farming: PMFBY has played a role in sustaining farmers' confidence in agriculture, especially among small and marginal farmers. The presence of insurance coverage encourages farmers to continue cultivation even after adverse seasons, thereby reducing distress-driven migration and crop abandonment in vulnerable areas.

3. Access to Institutional Credit: Enrollment under PMFBY is often linked with crop loans, which has improved farmers' access to institutional credit. Insured farmers are more likely to receive bank loans, enabling timely purchase of inputs such as seeds, fertilizers, and plant protection chemicals, contributing to improved crop management.

4. Behavioural and Extension Impacts: From an extension perspective, PMFBY has increased interactions between farmers and extension agencies, banks, and insurance representatives. Awareness programmes, village meetings, and enrolment camps have enhanced farmers' understanding of risk management and formal financial systems. However, expectation gaps related to claim assessment methods continue to influence farmers' perceptions.

Constraints Observed in Tripura

Despite its benefits, several challenges limit the effectiveness of PMFBY in Tripura. Delays in claim settlement, lack of clarity on loss assessment procedures, and limited transparency in Crop Cutting Experiments are frequently reported concerns. The area-based assessment approach often fails to reflect individual farmer losses, particularly in heterogeneous and fragmented landholdings common in the state.

Digital barriers, limited grievance redressal at the local level, and inadequate extension manpower further restrict farmers' full utilisation of the scheme. These constraints highlight the need for stronger institutional coordination and farmer-centric implementation.

Role of Agricultural Extension

Agricultural extension plays a crucial role in improving the impact of PMFBY in Tripura. Extension personnel can bridge information gaps by conducting targeted awareness campaigns, training farmers on enrolment and claim procedures, and facilitating digital access. Strengthening Farmer Producer Organizations, SHGs, and community-based institutions can also improve collective enrolment and grievance redressal.

Participatory monitoring of crop loss assessment and regular feedback mechanisms can enhance farmers' trust in the scheme. Integrating PMFBY awareness with climate advisory services and crop planning programmes can further strengthen risk management at the grassroots level.

Conclusion

The Pradhan Mantri Fasal Bima Yojana has emerged as an important risk-mitigation tool for farmers in Tripura, offering income protection and psychological assurance against crop losses. While the scheme has positively influenced income stability, credit access, and farming continuity, its full potential is yet to be realised due to operational and awareness-related challenges.

Strengthening extension support, improving transparency in loss assessment, and enhancing local grievance mechanisms are essential for maximising the benefits of PMFBY. With effective implementation and farmer-centric reforms, PMFBY can significantly contribute to sustainable agriculture and livelihood security in Tripura.

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TANK BASED AQUACULTURE SYSTEM

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Traditional aquaculture methods require significant amounts of land and water, which may not be available in all regions. Maintaining optimal and constant water quality conditions throughout the culture period is a challenge in traditional aquaculture. Traditional methods may not support the high-density rearing of species like catfish and tilapia, limiting production. Tank systems in aquaculture are transformative solutions that address key challenges in traditional fish farming methods. They provide a controlled environment for fish rearing, allow for high-density stocking, and require less land and water resources. These systems not only boost agricultural income by allowing for intensive fish production but also align with global sustainability objectives. They reduce the environmental footprint of aquaculture, promote efficient use of resources, and can contribute to food security.

Tank

A fish holding structure, usually above ground, typically with a high-water turnover rate; highly controlled environment.

Types of Tanks

Based on Material

Wooden tank

- Wooden tanks are lightweight and cost-effective compared to other materials, making them an affordable option for aquarium construction.
- Plywood is a suitable material for construction, as it is easy to work with and can be easily shaped to form the tank.
- Treated wood should be avoided, as it may release toxic chemicals that can harm fish and other aquatic life.
- All exterior surfaces of the tank should be painted with non-toxic, fish-safe paints; avoid paints containing lead to prevent contamination of the water.
- The interior of the tank should be coated with non-toxic, water-resistant materials like epoxy or fiberglass resin, which cure within 48 hours to form a durable, smooth surface.

Concrete tank

- Concrete is used for large tanks or pools.
- Tanks can also be made from gunite which is strong, durable, compact, but is more expensive than liners.

Plastic tanks

- Plastic includes polypropylene, polyethylene, poly butylene, polyvinyl chloride (PVC), acrylics, and vinyl.
- Each one has its own bad and good qualities.

Fiberglass

- Fiberglass is mostly chosen for tank construction because of its light-weight, strong, durable, inert, and can withstand the effects of UV rays.

Shape of The Tank

Circular tanks are commonly used for nursery and grow out purposes also used. It has a better hydraulic characteristic. The self-cleaning action and oxygen distribution of circular tanks hold specific benefits. The circulation of water will cause a better mixing of oxygen, food distribution, and higher stock densities.

Square and Rectangular tanks have efficient use of space. It contributes to savings on construction costs. The main disadvantage of square and rectangular tanks is that wastes tend to collect in the corners. The corners of square or rectangular tanks are often rounded to improve the hydraulics and flow patterns.

Oval tanks are an effort to combine the advantages of circular tanks and rectangular tanks. It has efficient water use and self-cleaning action of the circular tank and the space efficiency of rectangular tanks. It is found in intensive indoor and outdoor systems, where aeration technology is applied.

Application

- Hatcheries and Larval Rearing
- Grow-Out Systems
- Brood stock Management
- Food fish ready for sale
- Aquarium fish production
- A public display aquaria
- Research and Development
- Quarantine and Disease Control

Types of Tank Culture System

I. **Recirculatory aquaculture systems (RAS):** Closed systems that reuse water after treatment.

II. **Flow-through systems:** Continuously introduce fresh water and discharge treated wastewater.

I. RAS (Recirculatory aquaculture system): Recirculatory Aquaculture System (RAS) is a technology wherein water is recycled and reused After filtration and removal of suspended matter and metabolites. It utilizing minimum land area and water. It is an intensive high density fish culture unlike other aquaculture production systems. Instead of the traditional method of growing fish outdoors in open ponds and raceways, in This system fish are typically reared in indoor/outdoor tanks in a controlled environment .New water is added to the tanks only to make

Up for splash out, evaporation and that used to flush out waste materials. The reconditioned Water circulates through the system and not more than 10% of the total water volume of The system is replaced daily.

Fig. 1: Components of RAS

SNo	Name of the component	Material/ Capacity	Design
1	Tanks	Cement, Fiber, Metal	Circular, Rectangular, Raceways
2	Pipelines	PVC, UPVC and Metal	NA
3	Sedimentation tank	Cement, Fiber, Metal	Conical, cylindrical or in a combination of both
4	Mechanical filters	Drum filters, Rapid Sand Filters (RSF)	Fiber and Metal
5	Storage sump	Cement, Fiber	As per the convenience
6	Pumping system	Centrifugal pump of assorted capacity	NA
7	Biological filter	Cement, Fiber, Metal	Cone shape, cylindrical or combination of both
8	Protein skimmers	Fiber and Metal	Cone shape, cylindrical or combination of both
9	Degassing unit	Fiber and Metal	
10	Oxygen generator/ Aeration System	5 LPM, 10 LPM and 15 LPM	Air blowers, Oxygen concentrators and Nanobubblers
11	Disinfestation		UV and Ozone

Species Suitable for RAS

- Baramundi/ Asian Seabass/Bhetki (*Lates calcarifer*)
- Cobia (*Rachycentron canadum*)
- Silver/Indian Pompano (*Trichinotus Blochii / Trichinotus mookalee*)
- Tilapia (*Oreochromis niloticus*)
- Pearl spot/Karimeen (*Etroplus suratensis*)
- Pangasius (*Pangasianodon hypophthalmus*)
- Rainbow Trout (*Oncorhynchus mykiss*), especially in Hilly/cold water Region
- Pacific whiteleg shrimp (*Littopenaeus vannamei*)

Dimension

Sl.No.	Particulars	Unit
1	Total Land Area required	Maximum of 100 m^2
2	Tank Area	44.89 m^2
3	Tank Dimension	6.7 x 6.7 x 2 m
4	Tank Volume	90 m^3 (90,000 litre)
5	Effective Depth	2.0 m
6	Bottom Shape	Conical with a slope of 18° and a central slurry accumulating pit
7	Maximum Depth	3.3 m (Centre of the tank)
8	Pump	0.5 HP, Centrifugal Pump
9	Venturi Aeration System	0.5 HP, 4 Systems in a tank
10	Bio-filters	Trickling, Nitrifying Bioreactor

Shape

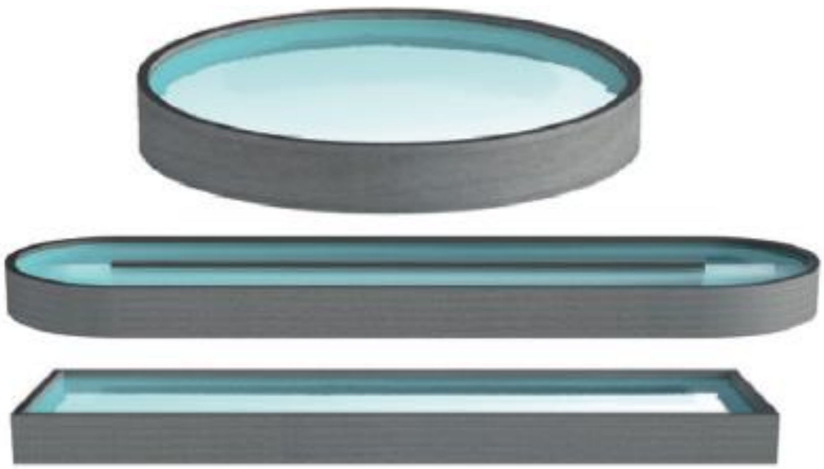

Fig. 2: Circular tank, D-ended raceway, and raceway type

Status

Our country ranks good in freshwater fish production as even traditional methods of fish farming are able to produce anywhere between 2–10 tonne per hectare per year. But, a Recirculation Aquaculture System may produce up to 500 tonne fish per year in same area.

Flowthrough System

Raceways are designed to provide a flow-through system to enable rearing of much denser population of fishes. Raceway culture is defined as raising of fish in running water.

Types of Raceways

I. Series Raceway: In series raceways, water from one raceways flows to the next one. In this case, outflow of the first raceway is inflow to the second raceway and so on. All raceways have the same elevation. In addition to providing mild slope to a particular raceway, all the subsequent raceways have slightly lower elevation than the previous one. This not only facilitate the flow but also helps in aeration of the following water. as fish in a particular raceway depletes some oxygen, it is necessary to aerate the water before it enters the next raceway.

II. Parallel Raceway: In parallel Raceway, water flows parallel to that in the other raceway. In the parallel raceway design, the following problems are minimized:

loss of head between the raceway
development of pollutant concentration and
deplition of DO

Fig. 3: Series Raceway

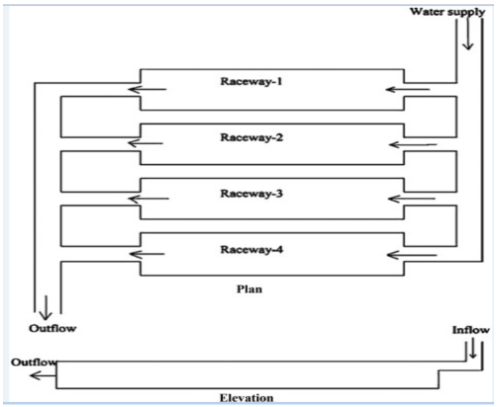

Fig. 4: Parallel Raceway

Candidate Species

- Trout
- Salmonid
- Catfish
- Tilapia
- Yellow perch
- Seabass

Dimension

The depth of water in the raceway may vary from 0.90 to 1.75m with an average of about 1.0 m. The length may vary from 15 to 30m depending upon the topographical condition of the land in the area. Otherwise, concrete raceways or raceways lined with other lining materials may be constructed.

Shape

A raceway usually consists of rectangular basins or canals constructed of concrete and equipped with an inlet and outlet.

Model Technical Specification for Trout culture in raceways

Title	Description
Name of Species	Rainbow Trout (*Oncorhynchus mykiss*)
Raceway Size	17m x 2m x 2m
Effective water volume	50 m^3/raceway
No. of raceways	4
Effective water depth	1.5m
Stocking size	10gm
Stocking density	100/ m^3
Stocking no.	5000/Raceway
Survival rate	80%
FCR	1:1.5
Culture period/crop duration	8-10 months
Cost of Seed	Rs.10/seed
Cost of feed (crude protein >40%)	Rs.110/kg
Total feed required	6 MT
Size at the time of Harvest	250 gm
Expected Total Biomass	4 MT
Sale price	Rs.500 / kg

Conclusion

Tank based aquaculture is an efficient and sustainable method of fish and aquatic organism production, offering advantages such as controlled environments, biosecurity, reand optimized water usage. By utilizing recirculatory aquaculture system (RAS) or flow through systems, farmers can enhance productivity while minimizing environmental impacts.

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DE-NOVO DOMESTICATION OF WILD PLANTS: A NEW FRONTIER IN CROP IMPROVEMENT

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Domestication of plants is one of the most significant milestones in human civilization. Over thousands of years, early farmers selected wild plants with desirable traits such as larger seeds, non-shattering spikes, reduced dormancy, and improved taste, gradually transforming them into modern crops. While this traditional domestication process laid the foundation of global agriculture, it was slow, imprecise, and often accompanied by the loss of valuable traits such as stress tolerance and disease resistance.

In the present era, agriculture faces unprecedented challenges including climate change, increasing population pressure, shrinking arable land, and the emergence of new pests and diseases. Many modern crops possess a narrow genetic base due to repeated selection and breeding, making them vulnerable to environmental stresses. In contrast, wild plant species harbor rich genetic diversity and inherent resilience to adverse conditions. However, their poor agronomic traits limit direct cultivation.

Recent advances in plant biotechnology, especially genome editing technologies like CRISPR/Cas systems, have enabled a revolutionary approach known as de-novo domestication. This strategy aims to rapidly domesticate wild plants by precisely editing key domestication-related genes, thereby combining the resilience of wild species with the productivity and uniformity required for agriculture. De-novo domestication represents a promising pathway for developing climate-resilient and sustainable crops for the future.

Concept of De-novo Domestication

De-novo domestication refers to the rapid and targeted domestication of wild plant species using modern genome editing and molecular breeding tools. Unlike conventional breeding, which relies on crossing wild relatives with cultivated varieties over many generations, de-novo domestication directly modifies specific genes responsible for domestication traits while retaining the beneficial stress-adaptive characteristics of wild plants.

The concept is based on the understanding that many domestication traits—such as seed size, plant architecture, flowering time, fruit shape, and loss of seed shattering—are controlled by a relatively small number of genes. With the availability of whole-genome sequences and functional genomics data, these key genes can be identified in wild species. Genome editing tools, particularly CRISPR/Cas9, base editing, and prime editing, are then used to alter these genes in a precise manner.

For example, genes controlling seed shattering, apical dominance, or fruit size can be edited to mimic domesticated forms, while genes responsible for abiotic stress tolerance, pest resistance, and nutrient efficiency are preserved. Importantly, de-novo domestication can be achieved without introducing foreign DNA, resulting in genome-edited plants that are often indistinguishable from naturally mutated varieties.

Thus, de-novo domestication represents a shift from the traditional "domestication first, improvement later" model to a modern approach of "retain wild strength, add domestication traits."

Discussion

Advantages of De-novo Domestication

One of the major advantages of de-novo domestication is the speed of crop development. Traditional domestication and breeding may take decades, whereas genome editing can achieve similar outcomes within a few generations. This is particularly important in the context of rapidly changing climates and emerging agricultural challenges.

Another key benefit is the retention of genetic diversity. Modern crops often suffer from genetic bottlenecks, but de-novo domestication allows direct utilization of wild species with broad genetic variation. This can result in crops with enhanced tolerance to drought, salinity, heat, flooding, and poor soils.

De-novo domestication also expands the crop portfolio. Many wild species that were previously neglected or underutilized can be transformed into new crops. These "neo-crops" may be better adapted to marginal environments and can contribute to food and nutritional security.

Examples and Case Studies

Several successful examples demonstrate the potential of de-novo domestication. In wild tomato (Solanum pimpinellifolium), researchers have edited genes related to fruit size, shape, and plant architecture, creating lines with improved yield while retaining stress tolerance. Similarly, wild rice species have been targeted to modify traits like seed shattering and flowering time, opening possibilities for developing climate-resilient rice varieties.

In orphan crops and wild relatives of cereals, legumes, and oilseeds, de-novo domestication is being explored to address region-specific agricultural needs. This approach is particularly relevant for regions like the North Eastern and rainfed areas of India, where wild and semi-domesticated species are abundant but underutilized.

Challenges and Limitations

Despite its promise, de-novo domestication faces several challenges. A major limitation is the lack of genomic and functional information for many wild species. Without high-quality genome sequences and gene annotations, identifying domestication-related genes becomes difficult.

Another challenge is transformation and regeneration efficiency. Many wild species are recalcitrant to tissue culture and genetic transformation, which can limit the application of genome editing.

Regulatory and public acceptance issues also play a crucial role. Although genome-edited crops without foreign DNA are increasingly treated differently from transgenic GM crops, regulatory frameworks vary across countries. Clear guidelines and public awareness are essential for the successful deployment of de-novo domesticated crops.

Future Prospects

The integration of de-novo domestication with other emerging technologies such as speed breeding, artificial intelligence, genomic selection, and microbiome engineering will further enhance its impact. As sequencing costs decline and editing tools become more efficient, de-novo domestication is expected to become a mainstream strategy in crop improvement programs, especially in public-sector research.

Conclusion

De-novo domestication of wild plants represents a paradigm shift in plant biotechnology and crop improvement. By combining the resilience and genetic diversity of wild species with the precision of genome editing, this approach offers a powerful solution to the limitations of conventional breeding and traditional domestication.

In the face of climate change, food insecurity, and sustainability concerns, de-novo domestication provides an opportunity to develop novel, climate-resilient crops tailored to diverse agro-ecological conditions. Although challenges related to genomics, transformation, regulation, and public perception remain, continued research and supportive policies can unlock the full potential of this innovative strategy.

Overall, de-novo domestication is not merely a technological advancement but a strategic tool for ensuring future food and nutritional security while conserving valuable plant genetic resources.

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