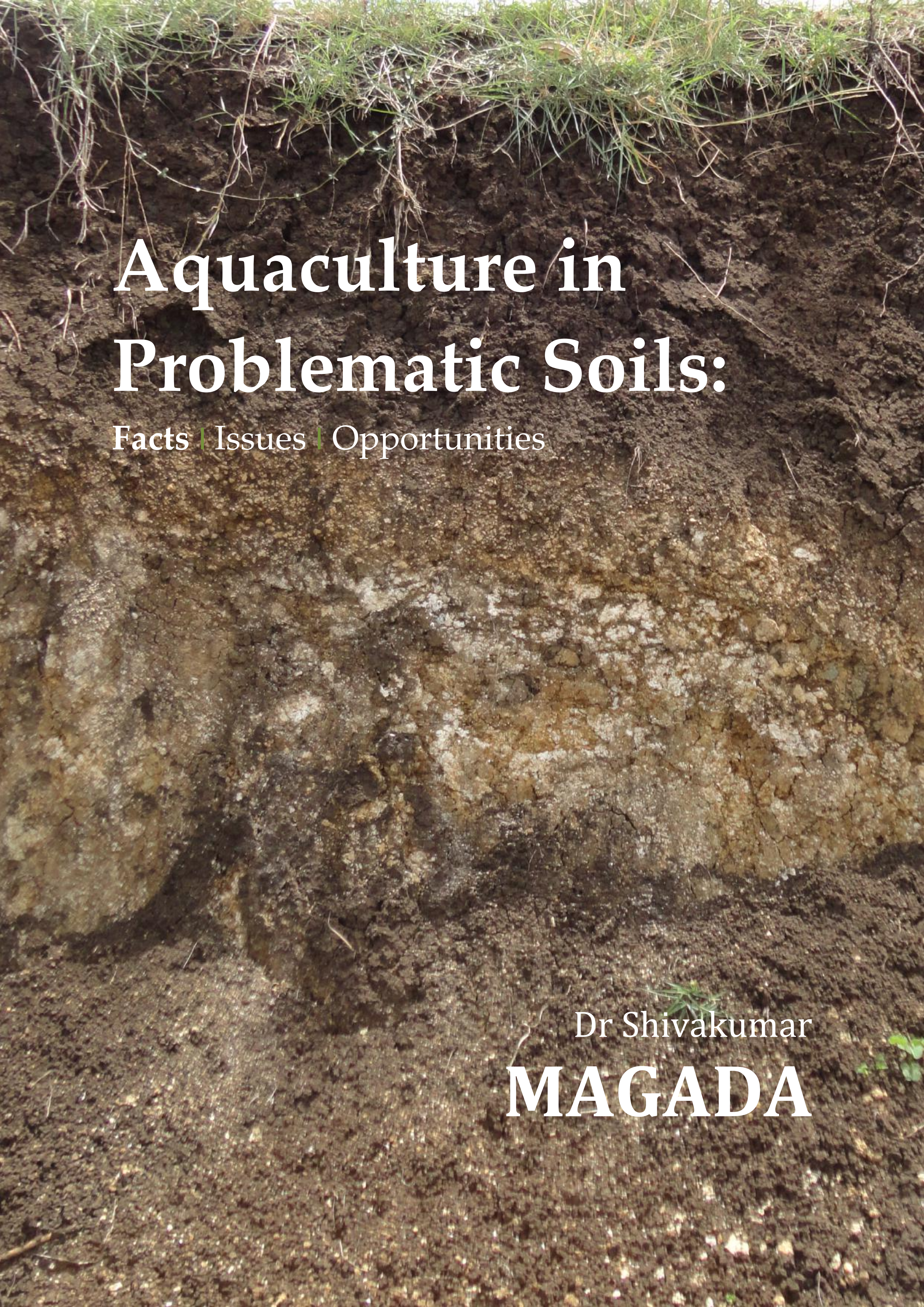

Aquaculture in Problematic Soils:

Facts | Issues | Opportunities

Dr Shivakumar
MAGADA

“**Aquaculture in Problematic Soils: Facts I Issues I Opportunities**” written by Dr Shivakumar Magada, Director General, Sea=MC^2 and published by Arabian Sea Fisheries Management Coordination Committee (Sea=MC^2), India in the year 2025 on the occasion of ‘National Consultation Meeting’

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Foreword

It is with great pleasure and academic pride that I present this important handbook titled *"**Aquaculture in Problematic Soils: Facts, Issues and Opportunities**."* The publication comes at a crucial time when sustainable utilization of natural resources is not just an environmental necessity but also an economic imperative.

India, with its vast agro-climatic diversity, is home to large tracts of problematic soils—saline, alkaline, waterlogged, and acidic. These lands, often marginalized in agriculture, hold untapped potential for aquaculture-based interventions. Transforming these low-productive and derelict lands into high-yielding aquatic farming systems not only addresses food and nutritional security but also contributes to inclusive rural development and employment generation.

This book thoughtfully compiles scientific insights, ground realities, and practical case studies related to aquaculture in such challenging environments. It explores the intricacies of soil chemistry, water quality, crop compatibility, and adaptive strategies, while also highlighting successful models and policy interventions that can guide researchers, planners, and progressive farmers.

I commend the author for the clarity of thought and scientific depth with which the subject has been approached. The book reflects a fine balance between academic rigor and field-level pragmatism, and it rightly positions aquaculture not merely as an alternative, but as a viable solution for land use diversification and resource optimization.

As the Vice Chancellor of KVAFSU, I am proud that such scholarly contributions are emerging from our academic ecosystem. I believe this handbook will serve as a valuable resource for students, scientists, policymakers, and entrepreneurs alike.

Let us envision a future where even the most 'problematic' soils become part of the solution in our collective journey towards sustainability and resilience.

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Preface...

There are over 80 documented definitions of soil, depending on the discipline (agronomy, geology, ecology, engineering, etc.) and context. According to me it is "Soil is a living biological entity in nature, inherently encompassing chemistry, biochemistry, and physics as integral components of its function and formation." There are over 1 billion individual organisms in just one teaspoon of healthy soil**,** representing thousands of species, including, Bacteria – Millions of species (many still unidentified), Fungi – Hundreds of thousands of species (e.g., mycorrhizae), Protozoa – Thousands of species, Nematodes – Over 20,000 known species, Arthropods – Mites, springtails, ants, beetles, etc., Earthworms – About 7,000 known species, Algae – Several species adapted to soil environments and Actinomycetes – Important bacteria-like organisms involved in decomposition.

Though precise numbers vary by soil type and climate, scientists suggest there could be more than 10 million different species living in soil worldwide—most still undiscovered. So, soil isn't just "dirt"—it's a dynamic, living system teeming with life.

Prolonged exploitation of soils for intensive crop production often leads to the degradation of their inherent properties, rendering them increasingly unproductive over time. If urgent and holistic rejuvenation strategies are not implemented, the world may face a critical food crisis in the near future. In many ways, the third world war has already begun—not between nations, but between humanity and nature. And history reminds us: nature always prevails. The only viable option now is to humbly yield to natural systems and focus on rectifying the man-made challenges. By doing so, we may not completely reverse the damage, but we can certainly delay its consequences and strive toward sustainable solutions.

Rejuvenating problematic soils is essential not merely for boosting food production, but more importantly, for conserving soil health and preventing further degradation. Ensuring the sustainability of our soil resources is a prerequisite for feeding the ever-growing population. In this context, aquaculture offers a promising solution—serving as both a remedial measure for soil rehabilitation and a productive farming practice. By integrating aquaculture into degraded or saline lands, we can restore soil vitality, improve farm economics, enhance overall productivity, and generate nutrient-rich fish for household consumption and market profitability. Farmers are welcome to reach out to us for any related services. We are committed to supporting them with dedicated care, personalized guidance, and timely assistance.

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Aquaculture in Problematic Soils:

Facts | Issues | Opportunities

Feeding the growing global population requires sustainable and efficient management of both soil and water resources. However, over the years, continuous cultivation of the same land and excessive irrigation practices have led to widespread degradation of soils, turning them saline, alkaline, or waterlogged. These problematic soils hinder crop productivity as they impair the plant's ability to absorb water, often leading to dehydration, shrinkage, and ultimately plant death.

Globally, more than 1.5 billion hectares of agricultural land are affected by issues related to salinity and sodicity. Among these, nearly 397 million hectares are classified as severely degraded, representing around 26.4% of the world's total arable land—a proportion that continues to grow and poses a serious threat to global food security. When including non-cultivable areas, it is estimated that approximately 10.7% (1.38 billion hectares) of the Earth's total land surface is impacted by salt-affected soils.

In the Indian context, out of the 156 million hectares of cultivated land, about 72 million hectares are irrigated. Alarmingly, 9.6 million hectares (13.33%) of this irrigated land have been identified as saline or alkaline, leading to drastically reduced crop productivity and raising serious concerns for sustainable agriculture.

Understanding the Nature of Soil

Soil is a dynamic, independent component of nature, and its physical and chemical characteristics are shaped by the forces acting upon it. Saline and alkaline soils are primarily found in arid and semi-arid regions, where extreme temperatures, limited rainfall, and improper irrigation practices prevail. These conditions, along with hydrological imbalances such as high-water tables, seawater intrusion, or exposure to brackish water, contribute to the formation and expansion of saline/alkaline lands.

Soil salinization and alkalization occur when sodium (Na^+) concentrations increase in the soil, displacing calcium (Ca^{2+}) from the soil colloids. Over time, this transformation renders the soil unproductive. However, the application of gypsum ($CaSO_4 \cdot 2H_2O$) can reverse this process by replacing sodium with calcium, thereby improving soil structure and reducing sodicity.

Aquaculture: A Productive Use of Problematic Soils

One promising solution for rehabilitating saline and alkaline soils is aquaculture. Controlled fish farming in these degraded lands not only provides a viable means of producing high-quality protein, but also contributes to soil restoration over time.

Field experiments have shown that fish culture in such environments is feasible and effective. The regular addition of organic matter through feed, fecal deposits, and water management gradually enhances soil health. Over time, these inputs, along with the strategic application of gypsum in alkaline soils, help normalize soil parameters. As a result, these lands may eventually be reclaimed and returned to their original agricultural use.

Saline and alkaline soils pose a major threat to global and national food security. However, when managed correctly, they offer a valuable opportunity for food production through aquaculture. This approach not only helps in nutritional enhancement, income generation, and employment creation, but also contributes to ecological balance and soil conservation.

Saline Soils

Soil with more than 4 electrical conductivity, less than 15 exchangeable sodium percentage, pH range of 7.5-8.5 and having sodium absorption range of 10-14 is referred as saline soil. These soils may or may not possess good physical condition, but in such soils, plants may suffer from its inability to absorb water from salty solution. Plants loose water to soil and shrink, resulting death of plant. This process is called plasmolysis. Salts present in saline soils are water-soluble. Leaching is the best method to reclamation the soil. Adding large amount of water at narrow regular frequent interval is necessary than adding small amount of water at long intervals. Trenches either side is necessary.

Alkaline Soils

Soil with less than 4 electrical conductivity, more than 15 exchangeable sodium percentage, pH of 8.5-10 and having sodium absorption ratio of 14 - 40 is referred as alkaline soil. Due to high Exchangeable Sodium Ratio (ESP) physical condition of soil is bad. Movement of air and water is greatly impended. Soil is sometime is too hard. This condition prevents good root system. ESP should be reduced to 5-6 and it can be achieved by adding gypsum. In-order to enable chemical reaction between soil and gypsum, sufficient water is supplied to soil/pond.

Understanding the True Nature of Saline Soils

Saline soils are often incorrectly interpreted as being affected solely by salt content. However, the scientific classification and evaluation of such soils is much more nuanced and is based on four critical parameters**:**

1. Exchangeable Sodium Percentage (ESP)
2. Sodium Adsorption Ratio (SAR)
3. Electrical Conductivity (EC)
4. Soil pH

Among these, sodium ions (Na^+) pose the greatest concern in the degradation of soil structure and plant health. When chloride ions (Cl^-) are also present, they combine with sodium to form sodium chloride (NaCl)—a highly soluble salt that leads to increased salinity. The presence of such salts is reflected in the Electrical Conductivity (EC) measurements of the soil solution, which is a direct indicator of salinity levels.

It is important to note that not all saline soils exhibit abnormal pH levels. In fact, many inland saline soils may maintain a neutral to slightly alkaline pH, making them visually indistinguishable from healthy soils. However, the real issue lies beneath the surface—groundwater in such regions can contain salinity levels ranging from 2 to 8 parts per thousand (ppt), which adversely affects irrigation and plant growth over time. These inland saline soils are widely distributed across various agro-climatic zones of India, including:

- **Haryana and Punjab**, where over-irrigation and high-water tables lead to salt accumulation,
- **Andhra Pradesh and Tamil Nadu**, with their coastal influence and poor drainage patterns,
- And the **Northern Dry Zones of Karnataka**, where erratic rainfall, traditional irrigation practices, and shallow aquifers contribute to saline groundwater intrusion.

Therefore, proper identification and classification of soil problems must go beyond just surface-level salinity. A comprehensive diagnostic approach considering ESP, SAR, EC, and pH is essential for implementing effective reclamation, water management, and crop planning strategies.

Table 1 Classification of Salt Affected Soils

Category	**EC Milli moles/cm at 25 °C**	**ESP**	**pH**	**SAR**
Saline	> 4	< 15	7.5-8.5	10-14
Saline alkaline	> 4	> 15	> 8.5	20-70
Alkaline	< 4	> 15	8.5-10	14-40

EC: Electrical conductivity of the saturated extract of the soil
ESP: Exchangeable sodium percentage
SAR: Sodium absorption ratio

Where:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}} \quad \text{Milli equivalent /L}$$

Limitations of Existing Management Practices

Numerous agricultural scientists have researched the management of saline and alkaline soils and have recommended a variety of strategies. These approaches have shown success, particularly when backed by government or institutional funding. In some cases, farmers have independently adopted certain practices with limited effectiveness and have continued using them due to a lack of viable alternatives. Traditional soil reclamation methods such as:

- Construction of deep trenches to drain excess water,
- Installation of subsurface drainage systems, and
- Application of chemical amendments (e.g., gypsum),

Though effective in theory, are **technically or economically unviable** in many low-lying and resource-poor settings. This results in vast tracts of arable land being left **fallow and unproductive**.

Acid Soils

Acid soils are those with a **pH below 5.5**, which makes them unfavorable for the growth of many crop plants. These soils are often characterized by:

- **High concentration of hydrogen (H^{+}) and aluminum (Al^{3+}) ions**, which are toxic to plant roots.
- **Deficiencies of essential nutrients** such as calcium, magnesium, phosphorus, and molybdenum.
- **Reduced microbial activity**, affecting organic matter decomposition and nutrient cycling.

Occurrence

In India, acid soils are primarily found in:

- Eastern and Northeastern states (Assam, West Bengal, Odisha)
- Parts of Jharkhand, Chhattisgarh, Parts of Karnataka and Kerala
- Hilly and high-rainfall regions with significant leaching

Globally, acid soils are common in tropical and subtropical areas with **high rainfall**, which leads to leaching of basic cations and buildup of soil acidity.

Causes of Soil Acidity

1. **High rainfall and leaching** of bases (Ca^{2+}, Mg^{2+}, K^{+}).
2. **Application of acid-forming fertilizers** (e.g., ammonium sulfate, urea).
3. **Decomposition of organic matter** releasing organic acids.
4. **Parent material** with low base saturation.

Effects of Soil Acidity

- Inhibits **root development** and nutrient uptake
- Leads to **aluminum and manganese toxicity**
- Poor plant growth and **low agricultural productivity**
- Reduces the effectiveness of **soil microbes** and nitrogen fixation

Global Phenomenon

Acid soils are typically region-specific, primarily influenced by the nature of the parent material and high rainfall that leaches away basic nutrients. In contrast, secondary salinization—commonly known as the 'white plague'—has emerged as a widespread global concern. This form of soil degradation arises largely due to prolonged agricultural use combined with poor irrigation practices. It is especially severe in arid and semi-arid regions, where evapotranspiration surpasses precipitation, causing salts to accumulate near the soil surface and impairing crop productivity.

A number of countries across continents are facing serious challenges due to increasing salinity in their agricultural lands. Prominent among them are Argentina, Australia, Bangladesh, China, Egypt, India, Iran, Mexico, Pakistan and United States of America Among these, Argentina stands out as the most severely affected, with nearly 33% of its cultivable land degraded by salinity, significantly reducing its agricultural productivity and long-term sustainability.

Fig. 1. *Soil Depth Characteristics and the Geographical Spread of Degraded Soils in Karnataka*

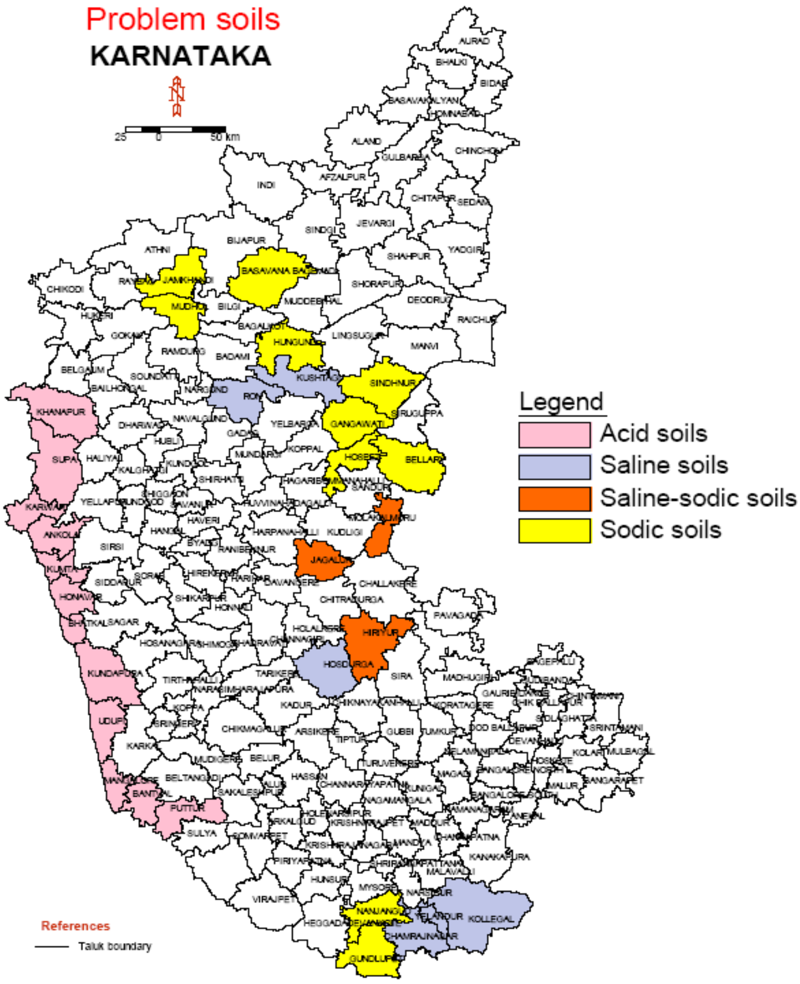


Fig. 2. *In hilly regions, the construction of fish ponds and implementation of integrated farming systems is a widely adopted strategy for managing excess surface runoff and optimizing water resource utilization*

Wetlands

Wetlands are transitional ecosystems between terrestrial and aquatic environments. They are characterized by **temporary or permanent inundation of water**, saturated soils, and distinct vegetation adapted to such conditions. According to the **Ramsar Convention**, wetlands include areas of marsh, fen, peatland, or water—natural or artificial, permanent or temporary—with water that is static or flowing, fresh, brackish, or salt, including areas of marine water not exceeding six meters in depth.

Importance of Wetlands

Wetlands are among the most productive ecosystems on the planet, providing numerous **ecological, economic, and social services**:

- **Biodiversity hot spots:** They support a wide range of flora and fauna, including many endangered and endemic species.
- **Water purification:** Wetlands filter pollutants, sediments, and nutrients from surface water.
- **Flood control:** They absorb and store excess rainwater, reducing the impact of floods.
- **Carbon sinks:** Wetlands help in mitigating climate change by capturing and storing carbon.
- **Groundwater recharge:** They help in replenishing aquifers.
- **Livelihood support:** Wetlands provide resources such as fish, reeds, medicinal plants, and fodder, supporting rural economies.

Types of Wetlands in India

According to the Ministry of Environment, Forest and Climate Change (MoEFCC), wetlands in India are categorized as:

- **Inland Natural Wetlands:** Lakes, rivers, marshes, swamps.
- **Inland Man-made Wetlands:** Reservoirs, tanks, ponds, dams.
- **Coastal Natural Wetlands:** Estuaries, lagoons, mangroves, coral reefs.
- **Coastal Man-made Wetlands:** Salt pans, aquaculture ponds, harbors.

India has over **7.7 million hectares** of wetlands, including **75 Ramsar Sites** (as of 2024).

Threats to Wetlands

Despite their importance, wetlands are facing rapid degradation due to:

- **Encroachment** for agriculture, urbanization, and industry.

- **Pollution** from domestic sewage, industrial effluents, and agricultural runoff.
- **Unsustainable aquaculture and overfishing**.
- **Climate change**, altering hydrological cycles and increasing salinity or drying of wetlands.
- **Invasive species** displacing native biodiversity.
- **Lack of awareness and weak enforcement** of conservation laws.

Integrated farming is not just integrating farming. It is beyond…

Management of Problematic Soils

Acid Soils

1. Liming

- **Application of lime ($CaCO_3$)** or dolomite ($CaMg(CO_3)_2$) is the most effective remedy.
- Lime **neutralizes soil acidity**, reduces aluminum toxicity, and improves nutrient availability.
- The **amount of lime** needed depends on soil pH, buffer capacity, and crop requirement.

2. Use of Acid-Tolerant Crops

- Grow acid-tolerant crops like **millets, potatoes, tea, pineapple, groundnut, and barley** in acidic regions.

3. Balanced Fertilizer Use

- Avoid excessive use of **acid-forming fertilizers**.
- Use **rock phosphate**, which is effective in acidic conditions.

4. Organic Matter Addition

- Application of **compost, green manure, and farmyard manure (FYM)** improves buffering capacity and enhances microbial activity.

5. Soil Conservation Practices

- Minimize erosion and leaching by using **contour farming, cover crops, and mulching**.

Acid soils, though challenging, can be made productive with proper scientific management. **Integrated soil fertility management**, including liming, crop selection, and organic amendments, can help reclaim acid soils, improve agricultural productivity, and ensure sustainable use of natural resources.

Fig. 3. *Formation of iron and other metal oxide stains. These reddish or rusty patches are often caused by the oxidation and precipitation of iron (Fe) and sometimes manganese (Mn) or aluminum (Al) on or near the soil surface.*

Wetland Management Strategies

A. Legal and Institutional Measures

- **Wetlands (Conservation and Management) Rules, 2017** by MoEFCC provide a framework for identification, notification, and conservation of wetlands.
- Implementation of **Ramsar Convention guidelines** for internationally important wetlands.
- Creation of **State Wetland Authorities** for decentralized planning and monitoring.

B. Scientific Assessment and Monitoring

- Mapping and inventory of wetlands using **GIS and remote sensing**.
- Periodic **biodiversity and water quality assessments**.
- Development of **Integrated Wetland Management Plans**.

C. Community Participation

- Involve **local communities** and traditional knowledge in wetland conservation.
- Promote **eco-tourism and sustainable livelihoods** such as responsible fishing, beekeeping, and craft-making.

D. Ecological Restoration

- Removal of **invasive species** and re-establishment of native vegetation.
- **Desiltation** and improvement of water inflow.
- Constructed wetlands for **sewage treatment and reuse**.
- Introduction of **buffer zones and green belts**.

E. Capacity Building and Awareness

- Training programs for **wetland managers, local bodies, and NGOs**.
- School and college-level **wetland education modules**.
- **Public awareness campaigns** through media and outreach events.

Role of Wetlands in Climate Resilience

Wetlands play a critical role in **climate adaptation and mitigation**:

- **Regulate micro-climate** and reduce urban heat islands.
- Serve as **natural infrastructure** against storms and floods.
- Enhance **agro-ecological resilience** in drought-prone regions.

The sustainable management of wetlands is vital for ecological security, food and water sustainability, and climate resilience. Protecting and restoring wetlands must be a national priority, and it requires **integrated efforts from governments, scientists, communities, and civil society**. Wetlands are not wastelands—they are **life-supporting ecosystems** that need recognition, respect, and restoration.

Fig. 4. *In wetland-based aquaculture systems, fish ponds can be created by constructing 90-degree embankments using sandbags for structural support and water retention.*

Not all wetlands are suitable for farming or commercial use. Many wetlands serve as critical ecosystems and must be preserved in their natural state due to the invaluable ecological services they provide—such as biodiversity support, groundwater recharge, flood control, and carbon sequestration.

However, certain wetlands that fall under private or community ownership may be productively and sustainably utilized, particularly for aquaculture**,** provided that environmental safeguards are respected. Along the western coast of India, especially during the monsoon season, extensive stretches of waterlogged lands emerge. These seasonal wetlands offer a unique opportunity: by constructing well-designed deep-water impoundments**,** excess rainwater can be channeled into designated ponds, making these areas viable for fish culture without compromising their ecological balance. This approach promotes both livelihood generation and water management**,** while ensuring the integrity of natural wetland ecosystems is maintained.

Fig. 5. *Mud crab fattening trenches established in coastal wetlands located somewhere in the southwestern region of Asia*

Saline and Alkaline Soils Management

Soil Amendment Principles:

In acidic soils, the pH is corrected by applying alkaline materials such as calcium carbonate ($CaCO_3$) in various forms (lime, dolomite, marl, etc.). These amendments neutralize soil acidity, thereby improving nutrient availability and enhancing microbial activity.

In contrast, saline and alkaline soils (characterized by high pH, excessive sodium accumulation, and poor soil structure) require different chemical treatments. Amendments like gypsum ($CaSO_4 \cdot 2H_2O$), iron pyrites (FeS_2), elemental sulfur (S), and sulfuric acid are commonly used. These materials work by replacing exchangeable sodium (Na^+) on soil colloids with calcium (Ca^{2+}) or other beneficial cations, which in turn reduce soil pH and improve soil structure.

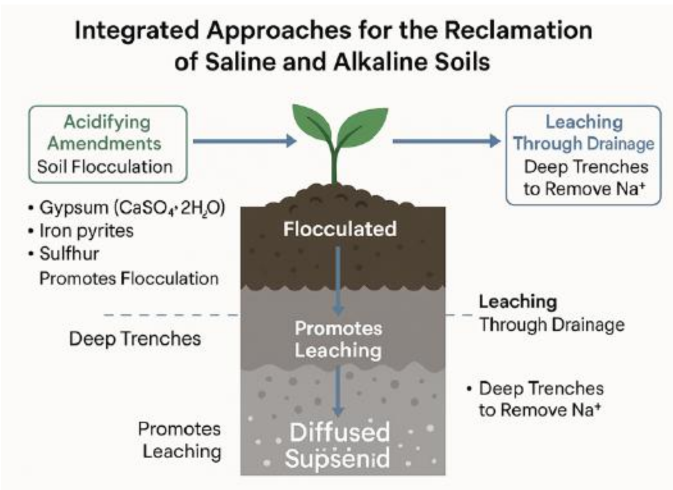
Soil Physics: From Deflocculation to Flocculation

At high pH levels, especially above 8.5, soils tend to undergo deflocculation — a process where soil particles disperse and remain suspended in water. This results in cloudy or muddy water with a high load of suspended solids, often observed in saline/alkaline fields. Deflocculated soils have poor water infiltration and aeration, further degrading plant growth.

The application of calcium-based amendments promotes flocculation, where soil particles aggregate and settle, enhancing soil porosity and reducing surface crusting. This improves water percolation and root penetration, restoring the soil's productive capacity.

Leaching and Drainage:

To remove the excess soluble sodium (Na^+) that accumulates in the soil solution after cation exchange, it is critical to facilitate leaching through well-designed drainage systems. Constructing deep peripheral trenches or subsurface drainage channels enables the leachate to be safely carried away from the root zone, preventing re-accumulation of salts and maintaining soil health.



Crop Rotation for Saline and Alkaline Soil Management

Crop rotation is an effective agronomic practice to improve soil health and reduce the impact of salinity and alkalinity on crop productivity. It involves alternating different crops on the same land to interrupt pest cycles, improve nutrient cycling, and manage soil salinity levels.

Why Crop Rotation Works in Saline/Alkaline Soils

- **Reduces salt accumulation:** Crops with deep root systems and high biomass can lower water tables and limit upward salt movement.
- **Improves soil structure:** Organic matter from diverse crops enhances soil porosity and water infiltration.
- **Facilitates reclamation:** Some crops aid in desalinization by mobilizing calcium (Ca^{2+}) and replacing sodium (Na^{+}) on soil particles.

Recommended Crop Rotation Strategies

Phase	Crops	Purpose
Salt-tolerant phase	Barley, Pearl millet, Quinoa, Mustard, Sugar beet	Withstand high salinity; biomass adds organic matter
Green manure phase	Sunhemp, Sesbania (Diancha), Cowpea	Fix nitrogen, enhance microbial activity, and organic content
Leaching phase	Paddy (under controlled irrigation), Fodder maize	Paddy helps leach salts under ponded conditions
Cash/low salt phase	Groundnut, Chickpea, Onion, Garlic, Ragi (Finger millet)	Grown after salt levels decline; economic benefit and root diversity

Suggested Rotations

- Wheat/Rice → Sunhemp → Chickpea
- Mustard → Dhaincha → Groundnut
- Paddy (low water) → Fodder maize → Onion
- Pearl millet → Sesbania → Ragi

Complementary Practices

- **Gypsum application:** Supplies Ca^{2+} to replace Na^{+}.
- **Organic amendments:** Farmyard manure, compost, and green mulch improve resilience.
- **Bio-drainage:** Use of deep-rooted trees like eucalyptus near field borders.
- **Intercropping:** With legumes to enhance nitrogen and reduce salt stress.

Aquaculture as a Treatment for Problematic Soils: A Sustainable Solution

Soil, being an **independent and dynamic natural system**, acquires characteristics based on the forces that act upon it. **Aquaculture**, especially in **saline or alkaline waterlogged lands**, presents a viable and sustainable alternative to conventional crop production on degraded soils. Recent experimental studies and field trials have demonstrated that **fish culture technologies** can be **standardized and successfully practiced** in problematic soils with appropriate site-specific interventions. Over time, aquaculture contributes to:

- **Rehabilitation of degraded soils** through the organic enrichment from uneaten feed and fish faecal matter,
- **Reduction in soil pH and salinity** through the continuous water-soil interaction and gypsum application,
- Enhanced **biological activity and nutrient cycling**, eventually restoring the land's capacity for other agricultural uses.
- Supports **conservation of problematic soils** through productive use, ensuring both **environmental and financial sustainability**.

Aquaculture in saline and alkaline soils not only facilitates the production of high-quality protein but also plays a vital role in ensuring nutritional security, enhancing farm income, and creating rural employment opportunities. However, if these lands are not utilized appropriately, it could give rise to environmental and socio-economic challenges that are even more complex than salinity itself. Therefore, a national-level consultation is essential to discuss, deliberate, and guide the sustainable and strategic use of such lands.

Recommendations

1. **Pilot-scale demonstration projects** should be established in saline/alkaline zones to validate aquaculture-based rehabilitation models.
2. **Studies on inundation of saline waters to the adjacent lands and other water sources like borewells and open wells**
3. Promote **inter-departmental collaboration** between agriculture, fisheries, and rural development departments for integrated land use planning.
4. Formulate and support a **national mission on productive use of problematic soils** through fish farming and allied activities.
5. Encourage farmers through **subsidies, training, and extension services** to adopt fish culture in degraded lands.

6. Support **collaborative research and innovation** in saline aquaculture species, water management, and bio-remediation.

Sustainable development in agriculture cannot rely solely on traditional soil reclamation. With a growing population and shrinking cultivable land, we must **reimagine degraded lands as opportunities** rather than obstacles. **Aquaculture in saline and alkaline soils** is not merely a substitute—it is a strategy that **restores productivity**, **enhances biodiversity**, and **ensures food and nutritional security** for future generations. By harnessing science, soil ecology, and socio-economic understanding, India can **lead the world** in turning adversity into opportunity — transforming **problematic soils into productive resources**.

However, any decisions cannot be taken only with the fisheries scientists. Hence, this consultation meeting is planned to involve the soil scientists, progressive farmers, agronomy experts, extension workers, economists etc. and come out with a tangible and actionable plan for the entire nation.

Fig 6. *In waterlogged areas, constructing a step-up pond by excavating soil only along the periphery by making a trench and subsequently leveling it upon completion can reduce construction costs by up to 60%.*

Utilization of Fodder Crops for Soil Improvement in Problematic Lands

In regions affected by problematic soils—such as saline, alkaline, or waterlogged conditions—farmers often resort to cultivating green manure or fodder crops like *sunn hemp* (*Crotalaria juncea*) to improve soil health. These crops are typically grown not for direct economic returns but to enhance the organic matter content and overall fertility of the soil. Once matured, the biomass is mulched or incorporated into the soil, which helps improve soil structure, increases microbial activity, and enhances the soil's water retention and nutrient-holding capacity.

This practice plays a significant role in initiating the biological recovery of degraded soils. The root systems of such crops also help in breaking compacted layers, promoting better aeration and percolation.

However, while the cultivation of such crops provides ecological and agronomic benefits, it may not always be economically viable—especially for resource-constrained farmers—since the crops do not yield immediate financial returns. The cost of seed, labor, and water input, combined with the lack of a direct marketable output, can deter small and marginal farmers from adopting this method on a large scale, despite its long-term benefits.

Therefore, for such interventions to be sustainable, they must be supported with policy incentives, awareness programs, or integration into broader soil reclamation and productivity enhancement schemes.

Fig 7. *In the Southern Dry Zone of Karnataka, trenches are constructed to drain saline seepage, while sun hemp is cultivated in saline-affected soils to improve soil health and organic content.*

Soil Salinity: The White Plague of Agriculture

Soil salinity, often referred to as the **“White Plague” of agriculture**, is one of the most widespread and destructive forms of soil degradation, particularly in irrigated and arid regions. The term "white plague" stems from the **white crusts of salts** that accumulate on the soil surface, visibly marking the land's declining fertility and symbolizing the creeping loss of agricultural productivity.

Salinity occurs when **water-soluble salts** such as sodium chloride, calcium sulfate, and magnesium accumulate in the root zone to levels that adversely affect plant growth. This usually results from **poor irrigation practices**, inadequate drainage, high evaporation rates, and the use of saline water for irrigation. Over time, salt buildup in the topsoil **interferes with plant water uptake**, causing dehydration even when water appears abundant.

Causes of Soil Salinity

- Excessive irrigation without proper drainage
- Capillary rise of saline groundwater
- Use of low-quality (saline) irrigation water
- Natural weathering of rocks in dry climates
- Sea water intrusion in coastal areas

Impacts of Salinity on Agriculture

- Poor seed germination and stunted crop growth
- Reduced soil permeability and aeration
- Plant dehydration and nutrient imbalance
- Yield reduction and complete crop failure in severe cases
- Long-term land abandonment in extreme conditions

Symptoms and Field Indicators

- Visible white crust on the soil surface
- Patchy or poor crop stands
- Leaf scorching or tip burning
- Wilting and yellowing even under adequate moisture
- Hardened or compacted soil texture

Reclamation and Management Strategies

- Leaching of salts using good quality water (if drainage is possible)
- Installation of subsurface drainage systems
- Application of soil amendments like gypsum to displace sodium
- Planting salt-tolerant crops or grasses
- Mulching and green manuring to improve organic matter and soil structure

The silent spread of soil salinity poses a serious challenge to global food security and agricultural sustainability. Like a plague, it often goes unnoticed in the early stages but can devastate productive farmland over time. **Timely intervention**, **sound water management**, and **soil health monitoring** are crucial to prevent and reverse salinity. When managed wisely, even saline soils can be rehabilitated and put to productive use—such as in **aquaculture**, **silvipasture**, or **salt-tolerant crop systems**.

Economic Viability of Fingerling Production in Saline Ponds

In the below picture (Figure 8), it is the saline soil area in the Cauvery Command Area which is adjacent to the medium lake which is completely weed infested. Next to the pond area, the salt resistant variety 'Vikas' paddy was grown. After construction of the fish ponds, the paddy yield was increased by 1.2 t/ha and coconut yield was increased by 28-32 nuts per tree.

In the initial stages, carp seed rearing was undertaken in newly developed ponds, each with an area of 200 m². During the first culture cycle, the survival rate of carp spawn was relatively low, registering between 8 to 10%. However, with improved management practices and adaptation of stocking and feeding protocols, the survival rate increased to 14–16% in subsequent cycles.

In the first cycle, each 200 m² pond was stocked with approximately 1,00,000 carp spawn at a density of 500 spawn per m². Despite a low survival rate of 9%, the system yielded around 9,000 fingerlings. These were sold at a rate of ₹0.50 per seed, resulting in a gross income of ₹4,500 per pond.

After accounting for 30% of the income towards the cost of production (feed, labour, maintenance, etc.), the net profit stood at approximately ₹2,700 per 200 m², translating to a return of ₹13.5 per m².

This was a notable improvement when compared to returns from traditional crops on similar soil:

- Paddy: ₹2 per m^2
- Banana: ₹7–8 per m^2
- Coconut: ₹2–4 per m^2

Despite certain challenges such as high suspended solids and low primary productivity in the water, the economic returns from aquaculture were significantly higher. Moreover, the practice brought an added agro-ecological benefit—increased yields in the adjacent agricultural crops, likely due to the improved microclimate and soil moisture retention around the ponds.

Five Percent Pond

The Concept of 5% Pond in Agricultural Land is a simple concept where all the farmers across the globe must be followed. This will enhance the soil moisture and the humidity which enhances the productivity of the crop. Otherwise, plants will spend significant energy towards physiological maintenance. The **"5% pond"** principle is a sustainable land management strategy that involves allocating **5% of the total farm area** to construct a water harvesting pond. This seemingly small allocation plays a **transformative role** in conserving **natural resources**, improving **productivity**, and promoting **resilience** in farming systems, especially in **rainfed and degraded lands**.

1. Soil and Water Conservation

One of the core objectives of the 5% pond is to **trap rainwater runoff**. This helps in:

- **Reducing surface erosion** and **soil loss** during heavy rainfall.
- **Retaining topsoil** and nutrients within the farm.
- **Preventing siltation** in common water bodies and reservoirs.

By harvesting water at the source, the pond **reduces the velocity of runoff** and encourages **infiltration**, thus helping **recharge the groundwater** table.

2. Survival Irrigation and Water Security

During prolonged dry spells or droughts, crops face **moisture stress**, especially in critical stages of growth. A 5% pond serves as a **life-saving irrigation source** (also known as survival irrigation), allowing:

- Timely watering to standing crops.
- Protection of **horticultural plants**, nurseries, and **vegetable gardens**.
- **Drip or sprinkler-based micro-irrigation** systems to be powered efficiently.

This reduces **crop failure** and ensures **minimum economic loss**.

3. Salt Management and Soil Health

In saline and alkaline-prone areas, the accumulation of salts on the surface or in the root zone drastically affects productivity. 5% ponds help by:

- **Diluting salts** through controlled irrigation.
- Allowing **leaching** of excess salts below the root zone.
- Collecting **saline seepage or drainage** water from adjacent plots.

When combined with **bio-remediating aquaculture** or the use of gypsum in pond bunds, these ponds contribute to **soil reclamation** over time.

4. Groundwater Recharge

In areas with **shallow or overexploited aquifers**, 5% ponds act as **percolation tanks**:

- Allow **gradual seepage** of water into underground reservoirs.
- Replenish **open wells, borewells**, and other farm-level sources.
- Stabilize water tables, which are otherwise declining.

Adding **percolation pits or recharge shafts** inside the pond enhances this function significantly.

5. Integrated Farming Opportunities

The pond is not just a water reservoir—it becomes a **multi-functional asset**:

- **Fish farming** can be integrated for protein and additional income.
- **Duck rearing** or **azolla cultivation** enhances nutritional security.
- Bunds can be used for growing **fodder crops**, **banana**, or **vegetables**.
- Solar-powered pumps or **floating gardens** can be experimented with.

Thus, it aligns with **integrated farming systems (IFS)** and boosts **farm income**.

6. Climate Resilience and Sustainability

With climate change increasing the frequency of **unseasonal rains**, **droughts**, and **flash floods**, the 5% pond:

- Acts as a **shock absorber**.
- Supports **adaptive agriculture**.
- Builds long-term **resilience** in local ecosystems.

Design and Implementation Guidelines

- **Size**: 5% of total landholding. For example, in 1 acre (4047 m^2), pond size would be approx. 200 m^2.
- **Depth**: Generally, 1.5 to 2.5 meters, depending on water table and soil type.
- **Shape**: Rectangular or trapezoidal for easier desilting and lining.
- **Bunds**: Raised slopy bunds can be strengthened with **grasses**, **vetiver**, or **stone pitching**.
- **Lining**: Depending on the permeability of soil, **HDPE lining** or **clay puddling** can be used.

- **Safety**: Fencing and signage are important to prevent accidents, especially for livestock and children.

Fig. 9. *Farm pond in drylands in an area of 5% near Nandi Hills, Bangalore.*

The **5% pond model** is a **simple, scalable, and sustainable solution** for increasing **water-use efficiency**, enhancing **soil health**, improving **productivity**, and ensuring **livelihood security** for millions of farmers across diverse agro-climatic zones. Its multifunctional benefits make it one of the most effective **climate-smart interventions** for the future of Indian and global agriculture.

Fig. 10. *Waterlogging and poor growth of the paddy plants. If 100-200 m2 pond is constructed in the waterlogged area, the paddy yield will increase while fish gives an additional income*

Challenges of Management of Problematic Soils

Historical Shift in Cropping and Salinity Build-Up in the Cauvery Command Area

During the 1980s, farmers in the Cauvery Command Area of Karnataka routinely cultivated three crops of paddy annually, benefitting from the assured irrigation and fertile soils. However, this intensive practice has significantly declined over the years, and farmers are now able to cultivate only two crops due to soil degradation, declining water efficiency, and increasing soil salinity.

Around two decades ago, the estimated area under saline soils in this command region was approximately 16,400 hectares. At the state level, Karnataka was reported to have 2.41 lakh hectares of saline-affected soils. However, due to the lack of a dedicated, updated survey on soil salinity, it is logically assumed that the area under salinity stress in the state may have now exceeded 1 million hectares, considering current agricultural practices and environmental conditions.

One of the major causes of this increasing salinity is inefficient water use. While it typically requires 1,800 to 2,500 litres of water to produce 1 kilogram of paddy, farmers in the command areas are reportedly using as much as 8,000 to 9,000 litres, primarily due to flood irrigation, poor drainage, and mismanagement of canal water.

In the earlier decades, especially during the 1980s, the soil was sustained with rich organic inputs such as green manures like Daincha (Sesbania), Sunn hemp, Yucca, and Pongamia greens, along with well-composted farmyard manure. These traditional practices, maintained soil health and organic carbon content, which stood around 1.6%. However, in the past 30–40 years, with the increased dependency on ammoniacal chemical fertilizers, the organic carbon content in the soil has dropped drastically to 0.6%–0.7%. This decline has negatively impacted the soil's buffering capacity, leading to an accumulation of sodium (Na^+) salts and deterioration in soil structure. Excessive irrigation, unbalanced fertilizer usage, monocropping patterns, and lack of soil health management have all contributed to the expansion of problematic soils, including saline, alkaline, and waterlogged categories. If left unchecked, this trend poses a significant threat to the agricultural sustainability and food security of the region.

This scenario underscores the urgent need for:

- A comprehensive soil salinity mapping and monitoring program
- Adoption of integrated soil fertility management
- Promotion of alternate cropping systems and water-saving irrigation technologies

- Incentivizing farmers to return to organic amendments and green manuring practices

By addressing these issues proactively though education and policy interventions, countries can reclaim degraded lands and ensure long-term productivity of its irrigated command areas.

Fig. 11. *Plastic lined deep Impoundment connected with network of perforated pipes*

Strategic Use of Low-Lying Saline/Alkaline Lands through Deep Pond Construction

In regions where soil is heavily degraded due to salinity or alkalinity, especially in low-lying areas, one promising solution is the construction of deep ponds. These ponds can serve multiple purposes, including rainwater harvesting, groundwater recharge, and controlled aquaculture. The concept involves excavating the ponds to a depth of 1.5 to 2.0 meters and installing a network of perforated drainage pipes at the base. These pipes help collect and redirect the excess saline water into the pond system.

Although this method may not be economically viable for all farmers due to the high initial cost, it holds significant potential for reclaiming highly derelict or unproductive lands. When lined with impermeable plastic sheets (geomembranes), these ponds prevent lateral seepage and salt migration into nearby agricultural lands. This containment is critical in stopping secondary salinization, especially in adjoining cultivable areas.

Over time, these pond systems not only support aquaculture but also improve the microclimate and soil conditions around them. When implemented with proper technical guidance, they offer a long-term sustainable solution for managing severely salt-affected landscapes and promoting alternate, eco-friendly land use.

Fig. 12. *Deep ponds to drain the excess water from the adjacent lands*

Fig. 13. *Wherever cultivation is not possible, Papaya, brinjal or any other crops can be grown in the grow bags or such lands can be utilized for 'Compost Production'*

Fig. 14. Protected cultivation in the polyhouses and Aqua-Tourism

Shrimp Farming in Inland Saline Soils

In recent years, the economic viability and high productivity of inland shrimp farming have attracted widespread attention, especially in Punjab, Haryana, Uttar Pradesh, and parts of Northern Karnataka. Farmers in these regions, many of whom previously struggled with saline and sodic soils unfit for conventional agriculture, have now turned to the culture of Pacific White Shrimp (*Litopenaeus vannamei*) as a sustainable and profitable alternative.

Performance of *Litopenaeus vannamei*

Farmers in the Rohtak and Baniyani regions of Haryana have reported impressive results, achieving 8–10 tonnes per hectare over a culture period of 120–130 days under field conditions. With the implementation of optimized ionic balancing and refined water quality management protocols, research efforts by CIFE-Rohtak have successfully demonstrated production yields as high as 13.5 tonnes per hectare within just 120 days in water with salinity levels ranging from 12 to 15 ppt.

A separate trial under similar conditions recorded the same 13.5 tonnes/ha yield in 131 days, with a production cost of ₹177 per kg. The gross income from such a crop amounted to approximately ₹1.43 million per hectare, showcasing the high return on investment (ROI) associated with this form of aquaculture.

Performance of *Penaeus monodon* and other Species

In addition to L. vannamei, trials with Giant Tiger Shrimp (*Penaeus monodon*) and other species have been carried out in lower salinity environments (2–5 ppt). In such conditions, shrimp yields of 2.7 tonnes per hectare in 130 days have been achieved. However, in areas with higher salinity, P. monodon has also demonstrated yield potential comparable to L. vannamei, with harvests reaching up to 13 tonnes per hectare in 120 days.

Early field demonstrations of P. monodon showed modest yields of 661 kg/ha in 110 days with a survival rate of 65%. With improvements in pond management and water quality adjustments, later trials recorded increased yields of 1,340 kg/ha**, with an** 84% survival rate.

The transition from low-productivity saline lands to high-value aquaculture is proving to be a transformative livelihood option for farmers across these states. Shrimp farming, particularly of *L. vannamei*, has shown not only technical feasibility but also economic robustness under inland saline conditions. With proper scientific support, water quality management, and training, even the most degraded lands can become engines of employment, nutrition, and rural prosperity.

In Karnataka, districts such as Yadgir, Kalaburagi, Bellary, and Raichur have witnessed the emergence of shrimp farming over more than 1,000 hectares, predominantly on saline-affected lands. These regions have effectively repurposed low-productive soils for aquaculture, demonstrating the adaptability and profitability of shrimp culture in inland saline conditions.

However, despite the presence of extensive saline and alkaline tracts in Bagalkot and Vijayapura (Bijapur) districts, the adoption of aquaculture remains limited. This slower uptake may be attributed to high initial capital investment, lack of awareness or technical guidance, or an absence of entrepreneurial initiatives in those areas.

In contrast, districts such as Raichur and Bellary have attracted private investors who have acquired large stretches of degraded land for semi-intensive aquaculture, primarily culturing carps, Pangasius (striped catfish) and murrel etc. These ventures highlight how strategic investment and business-oriented approaches can unlock the productive potential of saline and barren soils, offering income generation, rural employment, and sustainable land use.

Aquaculture: A Profitable and Soil-Restorative Farming System

Aquaculture has proven to be unquestionably more profitable than most conventional farming systems, especially in marginal and fallow lands that are otherwise deemed unfit for traditional agriculture. Across various regions, farmers have successfully converted unproductive or abandoned lands into thriving aquaculture units, particularly for carp culture, thereby unlocking both economic and ecological value.

In carp-based aquaculture, farmers typically apply substantial amounts of organic manure, notably raw cow dung at rates of 10–12 tonnes per hectare, to enhance the natural productivity of the ponds. Additionally, fish are routinely fed supplementary feed equivalent to 3–4% of their body weight, promoting faster growth and higher yields.

This constant input of organic matter—including leftover feed, fecal waste, and decomposed biomass—results in the gradual enrichment of soil organic carbon in the pond bottom. Over time, this process significantly improves both the chemical (e.g., nutrient content, cation exchange capacity) and physical (e.g., structure, porosity, water-holding capacity) properties of the soil.

Thus, aquaculture not only ensures high returns on investment and supports rural livelihoods, but also plays a critical role in restoring soil health, particularly in saline, alkaline, or otherwise degraded soils. With proper management, it serves as a sustainable land-use model that aligns with long-term goals of soil conservation, climate resilience, and food security.

Recommended Strategies to Mitigate Secondary Salinization

To balance economic benefits with environmental sustainability, the following precautionary and remedial measures are recommended:

1. **Plastic Lining of Ponds**

- Using HDPE or LDPE plastic liners in shrimp ponds can prevent seepage of saline water into adjacent soils and groundwater.
- However, this method is feasible only when sufficient freshwater is available from borewells or open wells, as lined ponds cannot facilitate natural recharge from surface runoff or adjacent lands.

2. **Construction of Deep Trenches**

- Creating common deep drainage trenches along the farm boundaries or around pond embankments can effectively collect and redirect excess saline water into designated reservoirs or ponds.
- This helps protect surrounding agricultural lands from salt seepage.

3. **Use of Green Manure Crops**

- Cultivating green manure crops such as sunhemp (*Crotalaria juncea*), fodder cowpea, or dhaincha (*Sesbania bispinosa*) in the vicinity or during fallow periods helps restore organic carbon, bind excess salts, and improve soil structure and microbial activity.

4. **Crop Rotation and Diversification**

- Implementing smart crop rotations like: Paddy – Ragi – Vegetables
- Sugarcane – Soybean (combined 90-day duration)
- Oilseeds, green gram, horse gram, and fodder crops
- These rotations break monoculture cycles, improve nutrient cycling, and reduce vulnerability to salinization.

5. **Biofencing and Buffer Plantations**

- Planting biofences along pond perimeters and field boundaries with species like:
  - Hebbevu (*Melia dubia* or Malabar Neem)
  - Subabul (*Leucaena leucocephala*)
  - Drumstick (Moringa oleifera)
  - Hybrid Napier grasses

- These species act as natural barriers to salt movement, enhance biodiversity, and offer additional income or fodder.

6. **Soil Fortification**

- Incorporating organic-rich material such as:
  - Lake-bed silt, fish pond sludge, or composted biomass
  - Grass pellets and farmyard manure
- This enhances soil buffering capacity, improves water retention, and promotes healthier root zones for future crops.

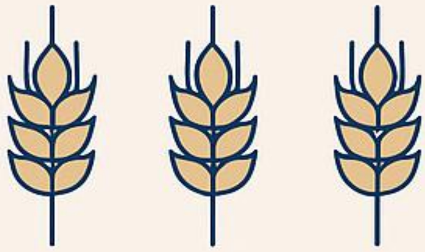
Regulatory Considerations

While coastal shrimp farming is regulated under the Coastal Aquaculture Authority (CAA), Chennai, shrimp farming in inland saline zones currently falls outside the purview of CAA regulations. This regulatory gap has enabled farmers in various inland regions to practice shrimp aquaculture without stringent oversight, leading to both innovation and potential misuse.

There is an urgent need to frame context-specific guidelines for inland saline aquaculture to ensure that it remains economically beneficial without compromising the ecological and agricultural sustainability of surrounding areas.

Fig. 15. *Shrimp farming in the coastal region in plastic lined ponds*

Historical Shift in Cropping and Salinity Build-Up in the Cauvery Command Area



REDUCED CROPPING

Farmers once cultivated 3 annual paddy crops; now rdowly to 2 crops

SALINITY EXPANSION ESTIMATES

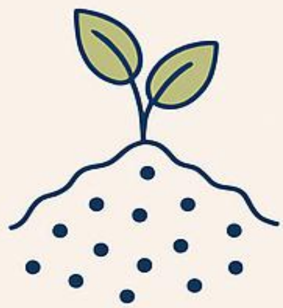
16,400 ha of saline soils within Command Area two decades ago; Karnataka's affected area may now exceed 1 million ha

INEFFICIENT WATER USE

8,000-9,000 litres of water used to produce 1 kg of paddy vs, standard 1,800-2,500 litres

DECLINE IN ORGANIC PRACTICES & CARBON CONTENT

Organic content dropped from 1.6% to 0.6–0.7% due to ammoniacal fertilizers over last 30-40 years



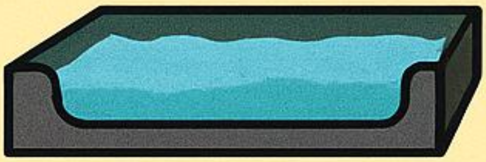
CONCLUSION

- Comprehensive salinity mapping & monitoring program
- Adopt soil fertliity management, diverse cropping, efficient
- Incentivize return to organic amendments, green manuuriñg

PREVENTING SECONDA SALINIZATION IN SHRIMP FARMING

While profitable, shrimp farming's continuous use of salts (such as common salt or sea salt) often leads to the salinization of adjacent lands and water sources: Here are some measures to mitigate this impact:

PLASTIC LINING



Installing plastic liners can prevent salt seepage into the soil.

DEEP TRENCHES

Constructing deep trenches around ponds helps contain salty water runoff.

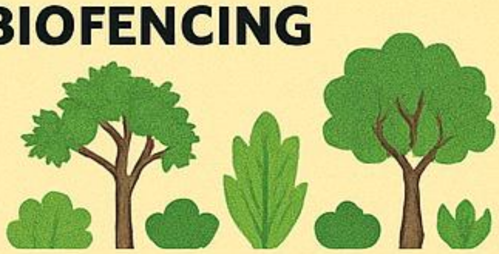
GREEN MANURE

Planting green manure crops such as sunhemp and sesbania can enhance soil health.

CROP ROTATION

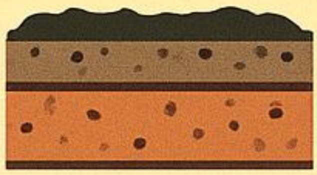
Rotating crops like paddy, millet (ragi), and vegetables can reduce soil salinity.

BIOFENCING



Biofences with Malabar neem, subabul, and hybrid grass limit salt spread.

FORTIFICATION



Adding better quality soil, humus, and grass pellets can improve soil

Poster # 05/SeaMC2

sea=MC²

Arabian Sea Fisheries Management Coordination Committee

This is an international organization which has been formally constituted under the Karnataka Societies Registration Act of 1960, bearing the registration number DRDK/SOR/118/2024-25. Headquartered in the coastal city of Mangalore, the society is a pioneering initiative with a clear mission: to unite all stakeholders connected to the Arabian Sea in a collaborative effort to sustainably manage and conserve its fisheries resources.

At the heart of the society's vision lies the commitment to protect not just marine biodiversity but also the livelihoods of the countless fishing communities that depend on the Arabian Sea for their sustenance and survival. Recognizing that the challenges facing this vast marine ecosystem are transboundary in nature, the society seeks to foster international cooperation and dialogue.

Currently, member nations include Iran, Oman, Maldives, Somalia, and Yemen—countries that share coastlines with the Arabian Sea and face common ecological and socio-economic concerns. Active efforts are underway to bring additional stakeholders and nations into the fold, thereby broadening the coalition and enhancing its ability to implement effective, region-wide strategies for conservation, responsible fisheries management, and the safeguarding of maritime livelihoods.

This society stands as a timely and necessary step toward a unified regional approach in confronting climate change impacts, overfishing, and habitat degradation, with the long-term goal of ensuring a sustainable future for both marine life and coastal communities. This acronym emphasizes the "Sea" at the beginning and the management aspects represented by "MC2", combining the initials of Management and Coordination Committee creatively. The concept and the title was conceived and created by Dr Shivakumar Magada, and the logo was designed by Mr. Dasari Bommaiah from ICAR-CIFE, Mumbai and registered on 18.12.2024

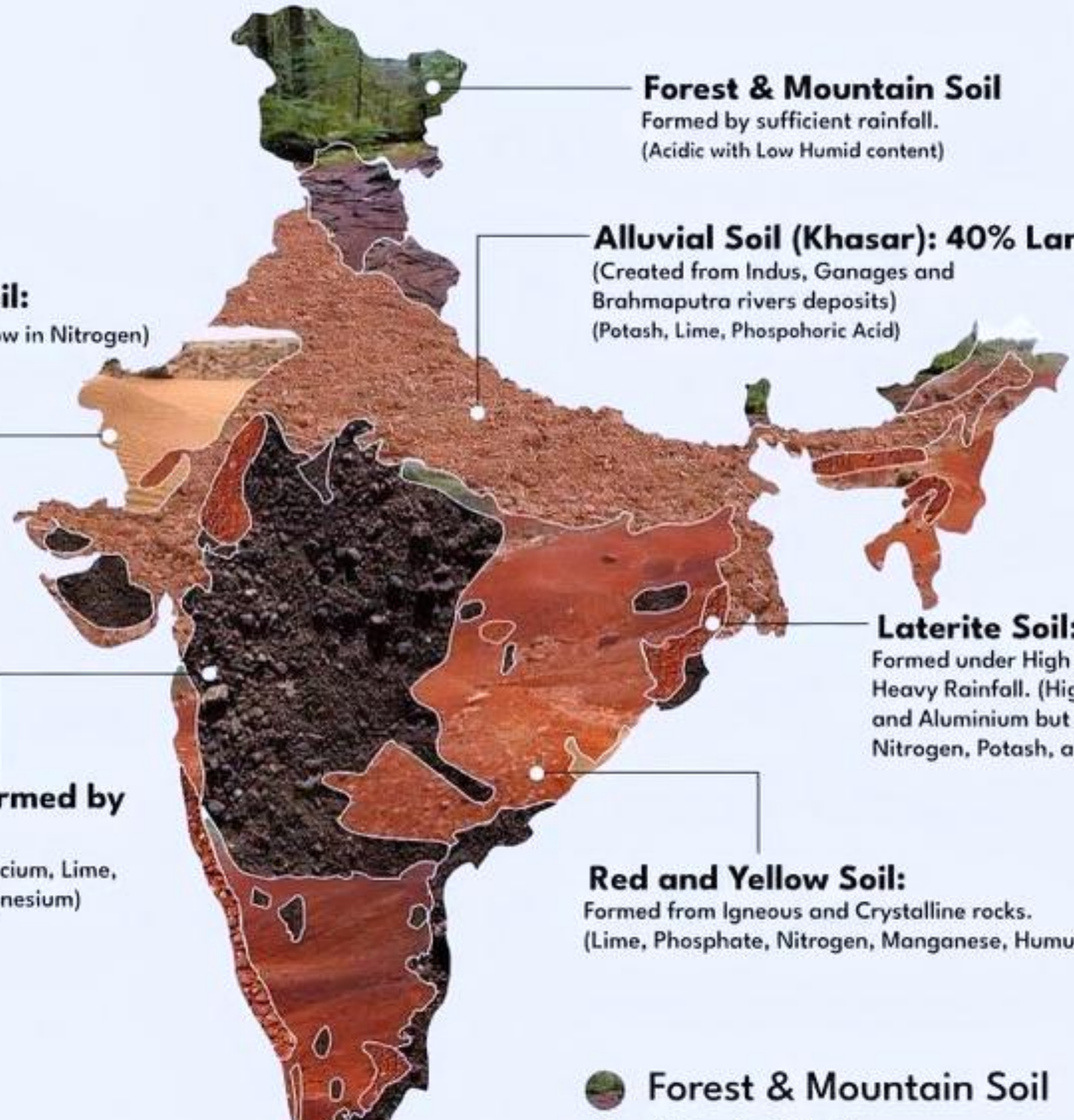
Objectives:

- **Sustainable Fisheries Management**: Develop and implement policies to ensure sustainable fishing practices that protect fish populations and ecosystems.

- **Regulatory Compliance and Policy Advocacy**: Coordinate with regional and international bodies to enforce fishing regulations and combat illegal, unreported, and unregulated (IUU) fishing. Advocate for policies at the national and international levels that support sustainable fisheries and marine biodiversity.
- **Fisheries Research Vessel:** Through crowd funding, a "Fisheries Research Vessel" will be obtained to facilitate research on stock assessment, pollution, and various issues concerning common property resources.
- **Fisheries Improvement Program (FIP)**: FIPs engage multiple stakeholders, including fishers, seafood companies, conservation organizations, and governments, to work together towards achieving sustainable fishing practices.
- **Boat Certification:** Boats, nets, tackles and other systems in the fishing vessel, mariculture and brackishwater farms.
- **Data Collection and Research**: Promote scientific research and data collection to monitor fish stocks, ecosystem health, and the impact of fishing activities.
- **Establishment of referral laboratory**: In many states, there are no adequate laboratories equipped to test food samples, water, and other materials from processing plants and exporters. Therefore, a 'Referral Lab' with NABL accreditation will be established to address this need.
- **Habitat Protection**: Identify and protect critical habitats, mangroves and breeding grounds to support fishery conservation efforts.
- **To initiate ocean and river clean-up program with the CSR funds**
- **Stakeholder Collaboration and Capacity Building**: Foster collaboration among governments, fishing communities, and other stakeholders to align efforts and share best practices in fisheries management. Enhance the capacity of local agencies and communities to manage fisheries effectively through training and resource allocation.
- **Economic Development**: Support the economic development of fishing communities through sustainable practices and value-added activities.
- **Education and Awareness**: **Organizing International and Regional Workshops/Conferences**/Webinars/Writeshops to raise awareness about sustainable fishing practices and the importance of marine conservation among stakeholders and the public.
- **Emergency Response**: Develop strategies for responding to environmental disasters or even

Become a member at http://seamc2.com

Soils of India



Forest & Mountain Soil
Formed by sufficient rainfall.
(Acidic with Low Humid content)

Alluvial Soil (Khasar): 40% Land Area
(Created from Indus, Ganages and Brahmaputra rivers deposits)
(Potash, Lime, Phospohoric Acid)

Arid or Desert Soil:
(High in Phosphate and Low in Nitrogen)

Laterite Soil:
Formed under High Temp & Heavy Rainfall. (High in Iron and Aluminium but low in Nitrogen, Potash, and Lime)

Black Soil: Formed by Lava flow
(Iron, Potassium, Calcium, Lime, Aluminium, and Magnesium)

Red and Yellow Soil:
Formed from Igneous and Crystalline rocks.
(Lime, Phosphate, Nitrogen, Manganese, Humus, and Potash)

- Forest & Mountain Soil
- Alluvial Soil
- Arid or Desert Soil
- Black Soil
- Laterite Soil
- Red and Yellow Soil

Dr Shivakumar Magada has done his masters and doctoral degree in Aquaculture. He has 32 years of experience in the profession where 30 years in academics and 2 years as Aquaculture Consultant dealing with marine shrimp and freshwater prawn seed production and farming. In his career, Dr Magada handled 28 research projects funded by DBT, NADP, European Union, NFDB and RKVY.

He has written 16 books, 24 handbooks and 22 research papers, hundreds of popular articles. Dr Magada is a popular science writer and motivational speaker and he has delivered 393 talks covering more than one lakh farmers and youths, organized 53 training programs covering 7800 beneficiaries and organized several professional events.

Special Achievements:

- Developed Package of Practice for reclamation of problematic soils
- Developed Beach Tourism Plan for the Government of Karnataka
- Developed Productivity Index Scale for stocking natural waterbodies