Reviving Farm Ponds: Navigating Water Scarcity and Agricultural Sustainability

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ABSTRACT

The article summarizes the critical aspects of farm ponds, highlighting their role in addressing food security and water conservation challenges, the ecosystem services they provide, the pitfalls they face, and proposed solutions to enhance their effectiveness. Farm ponds, essential for agricultural sustainability, offer a range of ecosystem services, including water conservation, flood control, and biodiversity support. However, challenges such as overreliance on groundwater, misalignment with policy goals, and inadequate regulation hinder their potential. To address these issues, regulatory measures like prohibiting groundwater extraction, limiting pond numbers, and promoting eco-friendly pond lining alternatives are crucial. Implementing these strategies can enhance the sustainability of farm ponds, ensuring they effectively contribute to mitigating water scarcity issues and supporting agricultural ecosystems.

INTRODUCTION

The challenges of ensuring food security and conserving water resources have become intertwined imperatives for societies worldwide in the 21st century. Agricultural ecosystems, as primary food providers and significant water consumers globally, stand at the nexus of these challenges. With freshwater consumption for agricultural irrigation ranging from 60% to 90%, the sustainability of agriculture is inseparable from efficient water management, especially in regions with arid and semi-arid climates. Therefore, developing environmentally safe agricultural practices that optimize food production while conserving natural resources, particularly water, is paramount.

In this context, revisiting traditional agricultural management practices offers promise for both agricultural sustainability and environmental conservation. One such practice is the utilization of farm ponds. Farm ponds (FPs), which have been employed for centuries in both domestic and agricultural settings, are small bodies of water ranging from 1 to 50,000 m², either man-made or naturally formed (López *et al.*, 2020). Globally, farm ponds constitute a significant portion of standing water bodies, with over 90% of them covering less than one hectare. Despite the absence of global data on the area and volume of farm ponds, regional studies, such as those in India, shed light on their prevalence and importance in agricultural landscapes. Farm ponds serve as vital reservoirs, capturing rainfall and conserving water from various sources, thus enabling supplemental irrigation, particularly in water-scarce regions. They play a crucial role in stabilizing crop yields and intensifying production systems, especially during prolonged droughts. Moreover, their location and design, considering factors like soil type, slope, and rainfall distribution, are essential for optimizing water collection and utilization. Farm ponds not only benefit agriculture but also contribute to groundwater replenishment and provide various ecosystem services, including biodiversity conservation, water and air quality improvement, and flood control. However, challenges such as dependence on uncertain rainfall, water losses through evaporation and filtration, and sedimentation-induced loss of storage capacity.

MES and Farm Ponds

The Millennium Ecosystem Assessment (MA), launched by the United Nations from 2001 to 2005, underscores the global interest in establishing frameworks for improved management of ecosystem services. Its findings reveal that humans have significantly altered ecosystems over the past 50 years, necessitating urgent action to prevent irreversible changes. Assigning economic values to ecosystem services requires an understanding of how changes in these services affect human welfare. Ecosystems provide a range of goods and services, classified as provisional, regulatory, or cultural services. Additionally, ecosystems offer supporting services, such as water bodies providing resilience to surrounding ecosystems, biodiversity, and biogeochemical cycling, all of which indirectly enhance human welfare.

Farm ponds offer a diverse array of ecosystem services, spanning from regulating hydrology and water quality to providing provisioning, cultural, and biodiversity services. These ponds play a critical role in mitigating flooding by regulating runoff volume and peak runoff rates, while also enhancing groundwater recharge potential. Furthermore, they act as natural filters, reducing sediment, excess nutrients, pathogens, and other contaminants in runoff through physical, chemical, and biological processes, thus improving water quality. Additionally, farm ponds contribute to greenhouse gas regulation by sequestering atmospheric $CO2$ through vegetation, albeit with the potential for methane generation, and improving air quality through filtration and absorption of particulates and air contaminants. Beyond their environmental functions, farm ponds offer provisioning services by supporting edible plants and providing raw materials for various purposes. Culturally, they serve as spaces for recreation, education, and aesthetic appreciation, promoting physical activity, wildlife viewing, and enhancing well-being. Moreover, farm ponds foster biodiversity by providing habitats for a wide range of plants, microorganisms, invertebrates, and vertebrates, thereby contributing to biological and genetic diversity.

Regulating services	
Hydrologic	Flooding reduced through regulating runoff volume and/or peak runoff rates.
Water quality	Sediment, excess nutrients, pathogens, and other contaminant loadings in runoff reduced through combination of physical, chemical, and biological processes.
Greenhouse gas regulation	Atmospheric CO_2 removed by FPs vegetation and is subsequently re-released through microbial respiration or stored through burial and sediment accretion. Methane and other greenhouse gases may be generated.
Air quality	Air quality may be improved through filtration and/or absorption of particulates, NO_2, and other air contaminants by FPs vegetation and soils.
Climate	More favorable microclimate may be maintained through direct shading and/or evapo-transpirative heat dissipation.
Provisioning services	
Food	Many edible plants can be supported by FPs and could be harvested as a food resource.
Raw material	Vegetation in FPs can be harvested and used as raw material for composting, ornamental purposes, or other beneficial uses.
Cultural services	
Recreation	FPs can be used for walking/jogging, wildlife viewing, and other recreational pursuits.
Education	Physical, chemical, and biological processes and structure of FPs can be studied and used to enhance educational programs.
Aesthetic	Vegetation and open water areas are known to provide soothing benefits, to promote health and well-being, and to provide a sense of beauty to observers.
Biodiversity services	May contribute to biological and genetic diversity through habitat provision for plants, microorganisms, invertebrates, and vertebrates.

Table: Ecosystem services that are (or could be) provided, in Farm Ponds (adapted from Moore and Hunt, 2017)./

What are the pitfalls of farm ponds?

The arid regions of India face a dire water crisis exacerbated by consecutive droughts and water scarcity, pushing communities, particularly farmers, to the brink of despair. This unprecedented scenario has forced rural masses to migrate to nearby urban centres in search of livelihoods and basic potable water, marking them as ecological refugees. The roots of this crisis lie in historical practices during the green revolution era, where widespread electrification led to excessive groundwater extraction through deep borewells. Despite advancements like farm pond technology aimed at rainwater harvesting, their implementation falls short of the intended objectives due to a mismatch between policy goals and ground-level realities. While government schemes incentivize farm pond construction, the actual usage often deviates from rainwater harvesting, with most ponds serving as storage tanks for extracted groundwater. Moreover, the widespread use of plastic lining in farm ponds impedes groundwater recharge, exacerbating the depletion of groundwater levels. The absence of regulation and oversight further compounds the issue, with farmers enlarging pond sizes beyond approved limits, exacerbating water evaporation and exacerbating water shortages for drinking and domestic needs. Consequently, farm ponds, once hailed as saviours, now contribute to a man-made natural resource disaster, depleting groundwater reserves, altering water flows, and exacerbating the water crisis in rural Maharashtra.

Addressing the Imperatives: What Must and can be Done

In arid and semi-arid regions, especially those used for orchards and crop cultivation in the rabi and summer seasons, the farm pond strategy holds significant promise. However, current practices in farm pond construction and water usage exacerbate water scarcity issues. To effectively tackle this challenge, several regulatory and policy measures must be seriously considered:

1. Prohibition of Groundwater Extraction: In regions already under severe water stress, particularly those declared as semi-critical and overexploited zones, extracting groundwater for storage in farm ponds should be strictly banned. Instead, farm pond owners should be mandated to store rainwater or runoff.

2. Limitation on Farm Pond Numbers: To ensure overall water resource sustainability and respect carrying capacity, there should be a cap on the number of farm ponds allowed per village or watershed area. Consideration should be given to local hydrogeology, groundwater depletion levels, and downstream water dependencies.

3. Regulation of Farm Pond Size: Enforcing limits on the enlargement of farm ponds by farmers beyond sanctioned norms is crucial to prevent excessive groundwater extraction. State subsidies for pond construction should only be granted to farmers adhering to sanctioned designs.

4. Equity in Subsidy Provision: Current subsidy schemes predominantly benefit large farmers and orchard cultivators. However, priority should be given to small farmers reliant on rainfall for irrigation.

5. Alternative to Plastic Lining: Research into cost-effective and eco-friendly alternatives to high-micron plastic paper used for pond lining is imperative. Initiatives like the use of soil-cement mixtures with additives like jaggery show promise in reducing costs and environmental impact.

6. Common Farm Ponds for Drinking Water Security: Farm Pond strategies, effective for protective irrigation, can also secure domestic and drinking water need if implemented collectively. Pilot projects demonstrating this concept's feasibility in providing year-round water access need scaling up and further research.

7. Mitigation of Evaporation Rates: Urgent measures to reduce water evaporation from farm ponds include modifying pond structures, utilizing non-harmful solutions in stored water, and implementing

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floating covers. Long-term strategies must focus on regulating pond numbers, sizes, and preventing groundwater extraction.

CONCLUSION

The intersection of agricultural sustainability and water conservation presents a pressing challenge in the face of global food security concerns. Farm ponds, a traditional practice with modern applications, offer a multifaceted solution by serving as reservoirs for rainwater harvesting and providing a range of ecosystem services. However, the realization of their potential is hindered by various pitfalls, including misalignment between policy goals and ground-level implementation, overreliance on groundwater, and inadequate regulation. Addressing these issues requires a concerted effort involving regulatory measures, policy adjustments, and technological innovations to ensure the sustainable utilization of farm ponds to mitigating their negative impacts on ground water resources.

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