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Shrimp Aquaculture in Inland Saline Waters of Haryana: A Step towards Sustainable Aquafarming

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The sustainability of many rural communities is threatened by the rise in inland salinity brought on by human activity, which has significant economic, social, and environmental effects. As aquaculture becomes more and more in demand, new production technologies are being developed. Inland saline water shrimp farming, defined here as land-based aquaculture using saline groundwater, occurs in various Indian states, including Haryana, Punjab, and Rajasthan and has a substantial influence on the socioeconomic progress of the states. Commercial aquaculture has risen in places like Haryana due to the enormous potential for raising a wide range of shrimp and

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shellfish in inland saline groundwater (ISGW). The most often raised shrimp in Haryana, the Pacific whiteleg shrimp (*Litopenaeus vannamei*), is one of the most frequently utilized aquaculture species. Due to its increased capacity to utilise low protein diets, faster growth and survival rates, tolerance to a range of environmental changes, and high disease resistance, *Litopenaeus vannamei* is acknowledged as one of the desirable candidate species for inland saline aquaculture. Farmers in the area, however, frequently deal with issues including disease outbreaks, managing water quality, and the requirement for specialist feed that is tailored to the particular conditions of inland saltwater environments. Sustainable production depends on best practices such routinely checking the quality of the water, implementing biosecurity precautions, and adding probiotics to feed. Despite these obstacles, predictions show that shrimp farming in Haryana has the potential to grow considerably with further study, technology developments, and government support. This would boost the state's economy, create new job opportunities, and support environmental sustainability.

The current article focuses on the difficulties and restrictions that aquaculture in Haryana currently faces as well as it covers a number of methods for choosing the right soil and managing the water supply for inland saline aquaculture. Finally, the article also addresses how Haryana aquaculture may have access to new markets that will increase its overall productivity and sustainability as a result of rising inland salinity brought on by human activities.

Keywords: Soil; saline; inland; aquaculture; shrimp.

1. INTRODUCTION

Inland saline waters fuel land-based aquaculture with salty groundwater. Such saline water occurs in several countries, to name a few, USA, Israel, Australia and India [1]. The potential for aquaculture in inland saline water is novel, as is the potential for greater aquaculture output. Aquaculture is the fastest-growing food industry, accounting for 80 million tons of the world's total fish output [2,3]. However, salinization of land and ground water in the inland sector is a new issue that is getting worse as a result of both anthropogenic and natural activity [4,5]. Soil Salinity has an impact on an area of 8.62 million hectares in India [6]. Several experiments have been done in this area to locate culturable species that would boost aquaculture productivity [7,8,9,10]. Numerous rural town's existence is under risk because to the significant economic, social, and environmental effects of rising inland salinity brought on by human activity [11]. In more than 20 nations throughout the world, secondary salinity damages more than 380 million hectares of soil [12].

States like Gujarat, Rajasthan, Haryana, Punjab, Orissa, Uttar Pradesh, Delhi, West Bengal, Kerala, and Tamil Nadu have salt-affected soils [13,14]. In Haryana, saline groundwater is prevalent in the districts of Rewari, Charkhi Dadri, Palwal, Hisar, Bhiwani, Mahendargarh, Sirsa, Rohtak, and Jhajjar. Similarly, the southwestern districts of Punjab, such as Bhatinda, Faridkot, Firozepur, Mansa, and Muktsar, also experience groundwater salinity issues [15]. Although saline soils have no impact on the physical characteristics of the soil, they are hazardous because high levels of soluble salts in the soil solution decrease the amount of water that is available to plants in the soil. Inland salt-affected soils accumulate salt to such a degree that it significantly affects agricultural yields from typical crops [16]**.** According to estimates, salinization or sodification causes at least 3 hectares of agricultural soil to be lost globally every minute [17]. Aquaculture, encompassing freshwater carp culture in low salinity regions and shrimp farming in both low and high salinity waters, holds significant potential for inland salt-affected areas in Haryana. This innovative practice can transform these challenging environments into productive aquatic farming hubs. By leveraging saline waters, aquaculture can provide sustainable livelihoods and contribute to food security. Such initiatives not only utilize underexploited resources but also enhance economic resilience in the region. Thus, aquaculture presents a promising solution for maximizing the utility of saline impacted lands in Haryana.

In recent times with professional assistance from several Central and State Government Organisations, *L. vannamei* cultivation has recently become more prevalent in Haryana, Punjab, and Rajasthan [18]. Due to the high stocking density and greater tolerance to saline environments, *L. vannamei* farming has been proven to be lucrative [19]. Positive growth has been noted in these various regions of India, demonstrating that it is commercially viable to

cultivate the white leg shrimp *L. vannamei* if the farmers are properly taught, rigorous biosecurity precautions are observed, and best management practises (BMPs) are applied [20]. Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) in Punjab and the Regional Center of the ICAR- Central Institute of Fisheries Education (CIFE) in Haryana are leading innovative research and development (R&D) initiatives that are assisting farmers in raising awareness of shrimp aquaculture [21,22].

The current article offers insight into several facets of the inland aquacultural resources, production techniques and trends, and future possibilities in Haryana, keeping in view the significance of inland aquaculture in India. Recommendations are offered on how to expand India's inland aquaculture sector in light of the observations.

2. NATIONAL STATUS OF INLAND SALINE WATER

Significant social, economic, and environmental ramifications result from the nation's interior regions becoming alarmingly more salinized. The non-coastal Indo-Gangetic plains of Northern India are home to around 1.20 million hectares of the 6.74 million hectares of salt-affected land in India [23,24]. There are salty soil regions along the shore in this region. The substantial portion of land impacted by salt presents difficulties for sustainable and productive agriculture. Improving crop yields and guaranteeing food security in these regions require addressing soil salinity. The detrimental effects of salt on agriculture in this area can be lessened by putting into practice efficient soil management techniques. These areas are distributed among seven states *viz*., Punjab (1.51 lakh ha), Haryana (2.32 lakh ha), Rajasthan (3.75 lakh ha), Bihar (1.53 lakh ha), Uttar Pradesh (1.37 lakh ha), Madhya Pradesh (1.39 lakh ha), and Jammu and Kashmir (0.17 lakh ha) (Table 1), [22,25].

There is a rising interest in creating commercial inland saline aquaculture since India has a lot of salty groundwater. In India, salinization of inland waterways, notably in the north-west area, is developing at an alarming rate due to both natural and anthropogenic activity [15,26]. Elevated soil salinity is frequently associated with a high water table. As subsoil water in such conditions is typically saline, its utilization for irrigation poses significant challenges to crop production. The presence of saline groundwater limits the effectiveness of irrigation practices and hampers agricultural productivity. Consequently, managing and mitigating soil and water salinity are critical for sustaining crop yields and ensuring agricultural viability. Therefore, the formation of saline soils is generally associated with the rise in water table due to the introduction of irrigation and inadequate drainage [27]. Investigations have shown that irrigation initiatives frequently result in the construction of regions afflicted by salinity, mainly because drainage concerns are not given enough consideration [28,29]. These kinds of initiatives may eventually have more detrimental effects than beneficial ones. For instance, agricultural output originally increased significantly in the Sharda Sahayak Canal Command Area, which was established in 1978 to irrigate 1.67 million hectares over 21 districts in Uttar Pradesh. But since there was insufficient drainage and continuous seepage from the canal, the water table rose and the salts rose to the surface. This scenario demonstrates how important it is to manage drainage properly in order to maintain the beneficial effects of irrigation projects. Although the irrigation project was initially designed to deliver substantial benefits, over a span of approximately three decades, around 0.37 million hectares of the area became salt-affected due to secondary salinization, leading to its degradation and barrenness [27]. This unintended consequence highlights a critical issue in managing large-scale irrigation projects.

Table 1. The proportion of saline soils in India's non-coastal areas

State	Saline soil (Total area in lakh hectare)
Haryana	2.32
Punjab	1.51
Rajasthan	3.75
Bihar	1.53
Uttar Pardesh	1.37
Madhya Pradesh	1.39
Jammu- Kashmir	0.17

Source: [22]

In contrast, the Indira Gandhi Nahar Priyojana (IGNP) and the Satluj Yamuna Link Canal (SYL) were developed with the objective of providing irrigation to the saline regions of Haryana, Punjab, and Rajasthan. These projects were intended to mitigate the adverse effects of salinity by enhancing irrigation infrastructure in areas suffering from saline conditions. By supplying controlled irrigation to these regions, the intention was to reduce the reliance on naturally saline groundwater and improve soil conditions.

However, the effectiveness of these canals in managing groundwater salinity has varied [30]. While the IGNP and SYL projects aimed to alleviate salinity issues, the success of these initiatives in controlling groundwater salinity depends on several factors, including the implementation of effective drainage systems, management practices, and the overall balance of water supply. Without adequate drainage and careful management, even well-intentioned irrigation projects can inadvertently contribute to the rise in groundwater salinity, underscoring the need for comprehensive planning and monitoring to ensure that irrigation infrastructure achieves its intended benefits without exacerbating salinity problems.

3. STATUS OF HARYANA INLAND SALINE SHRIMP AQUACULTURE

Around 1991–1994, brackish water shrimp or shrimp farming really started to take off, especially in the coastal regions of Andhra Pradesh and Tamil Nadu. It has also proven to be a very profitable venture for the company owners. It's interesting to note that for various reasons, the subsoil water in many inland places of Haryana has become salty or semi-salty, with the salinity frequently ranging between 5 ppt and 15 ppt [31]. These areas, which are not ideal for any other type of farming, can be utilised to grow brackish water shrimp like the well-known white leg Pacific shrimp or the *L. vannamei* shrimp.

The Central Institute of Fisheries Education (CIFE) in Sultanpur, Haryana, started a ground-breaking research project in 1986 with the goal of using groundwater and saline soils that are damaged by salt for aquaculture [32]. The Indian Council of Agricultural Research (ICAR) provided financial assistance for this project, which was started as part of an Operational Research Project (ORP). The goal of the research was to investigate and create novel ways to use these harsh salt conditions to support successful aquaculture systems. CIFE's research focused on adapting aquaculture practices to the specific conditions of saline soils and groundwater, which are often considered less suitable for traditional farming. By investigating the viability of cultivating aquatic species in these saline conditions, the project aimed to address the dual challenges of land degradation and water salinity. The goal was to transform saline-affected areas into productive aquaculture zones, thereby improving local livelihoods and contributing to food security [33]. In 1996, the location of this project was later changed to Lahli Fish Farm, Rohtak, and Haryana. Numerous schemes have been started for the culture of finfish and shellfish species in Rajasthan based on the experience of Sultanpur [34]. For the first time in the nation, the Central Institute of Fisheries Education (CIFE), Rohtak Centre, has begun raising *Penaeus monodon* and *Litopenaeus vannamei* in aquaculture utilising inland salty ground waters in farmers' fields. In 2009, the CIFE, Rohtak Centre began *Penaeus monodon* cultivation in the high-saline location of Baniyani Farm, where yield varied from 400 to 1600 kg/ha/120 day [33].

Table 2. The water quality characters of ground water from Haryana

Parameter	Range
pH	7.8 - 9.0
Dissolved Oxygen	5.3 - 8.2
Water Salinity	13 - 15
Total alkalinity	200 - 230
Hardness	3200 - 3700
Sodium	**-**
Potassium	80 - 100
Magnesium	610 - 695

Source: [33]

Under the Rashtriya Krishi Vikas Yojana, RKVY, white shrimp farming was started in Haryana on an area of 70 acres in 2014-15. Aquaculture methods were expanded to a number of districts, including Sonipat, Faridabad, Gurugram, Mewat, Palwal, Rohtak, Bhiwani, Hisar, Sirsa, Rewari, Jhajjar, Fatehabad, and Charkhi Dadri, as a result of their good results [35]. The goal of this extension was to apply the tried-and-true methods to a larger field. The application of successful study findings to workable aquaculture solutions in these regions was a major step forward. On 1,250 acres, a record 2,900 tonnes of shrimps were produced in 2021–2022. Since pond culture in saline soils in the provinces of Haryana and Punjab showed some potential, other states in northern India have started engaging in shrimp farming. The Haryana government expanded the shrimp culture area from 1,250 acres to 2,500 acres to enhance production [36]. As a result, approximately 9,000 tonnes of shrimp were produced in the states of Punjab and Haryana in India, with Haryana contributing 4,000 tonnes of this total [37]. Shrimp aquaculture farms in Haryana have mostly embraced intense culture techniques, which is indicative of the area's dedication to high-yield production. These methods allow for higher productivity in a given space since shrimp are stocked at high densities, often 20 to 50 per square meter. To maximize water exchange, the ponds are normally situated close to the top limit of the tidal range and have a typical size of one acre. Such dense systems demand careful attention to detail and a deep comprehension of a number of important components. For the shrimp to develop and be healthy overall, farmers must follow certain feeding schedules that guarantee the shrimp receive a balanced diet. To stop the accumulation of dangerous compounds and to keep the environment stable and favorable, it is crucial to regularly check and alter water quality parameters including pH, salinity, and ammonia levels.

The ponds used by the farmers for fish and prawn farming were approximately one acre in size. It was found that the majority of them were constructed properly, making it possible for straightforward draining and drying after each harvest. In terms of managing organic and inorganic fertilisers, keeping water parameters, providing suitable seed stocking, formulating feeds, and ensuring correct aeration, the farms were usually judged to be well-maintained. Sufficient oxygen levels in the water are essential for the shrimp's metabolic functions and general health, which makes effective aeration even more important. To properly handle these variables and guarantee ideal shrimp development and output, these systems' intensive nature necessitates a high degree of technical proficiency and ongoing attention to detail.

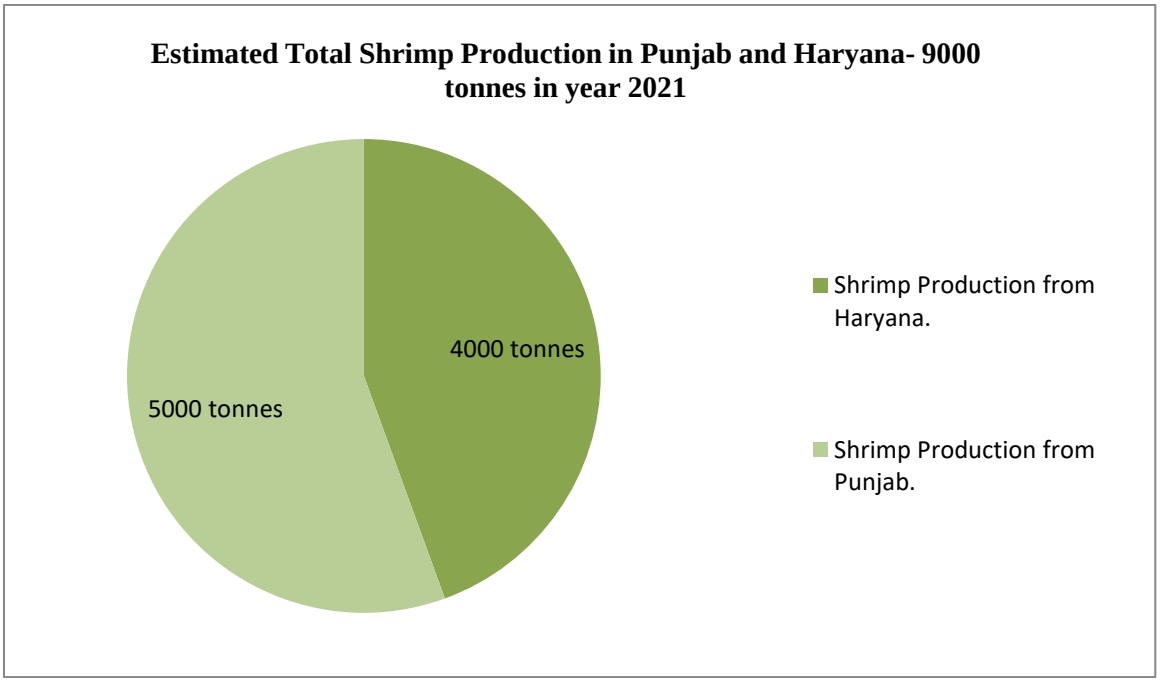
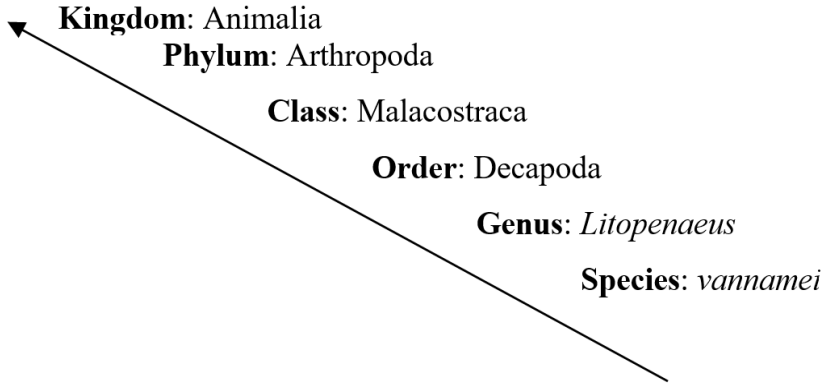


Fig. 1. Shrimp production in Punjab and Haryana

3.1 *Litopenaeus vannamei* as most potential species in Haryana's inland saline conditions.

Taxonomic classification of *L. vannamei* (white shrimp) [38]:-



Litopenaeus vannamei was introduced to India on a pilot scale in 2009 and quickly emerged as a leading candidate for aquaculture in inland saline environments. This shrimp species has gained prominence due to its exceptional adaptability to high stocking densities, with the Coastal Aquaculture Authority recommending a density of 60 individuals per square meter [39,40]. It thrives on low-protein diets, making it cost-effective to feed. *L. vannamei* demonstrates a remarkable tolerance to a broad range of environmental fluctuations, including variations in temperature (15-30°C) and salinity (0.5-45 ppt). Its ability to mature in captivity facilitates domestication and genetic improvement, which is beneficial for enhancing stock quality [41,42,43]. Compared to *Penaeus monodon*, *Litopenaeus* vannamei offers higher meat yield and benefits from relatively straightforward spawning in captivity due to its open thelycum. Additionally, it exhibits high resistance to diseases, further solidifying its status as a highly suitable species for inland saline aquaculture in states like Haryana and Punjab [34].

3.2 *Litopenaeus vannamei* Farming in Haryana

The whiteleg shrimp, *Litopenaeus vannamei*, demonstrates resilience to elevated salinity levels, making it well-suited for aquaculture in saline environments. In the picturesque landscapes of Kultana Village, Rohtak district, and Mithri Village, Sirsa district, Haryana, the farming of *Litopenaeus vannamei* unfolds against the backdrop of inland saline waters. These images capture the innovative spirit and resilient aquaculture practices thriving in Haryana's unique saline environments. Amidst the serene waters, the shrimp farming operations stand as a testament to the region's adaptability and resourcefulness (Figs. 2 and 3). Farming this species has proven to be economically viable due to its ability to thrive in high-density stocking conditions. In recent times in the last few years fast few years the *L. vannamei* farming is in leaning in Haryana, with technical support from various Central and State Government Organisations like The Central Institute of Fisheries Education (CIFE), Rohtak, Haryana [22,44]. Haryana has distinguished itself as the first landlocked state in India to effectively utilize inland underground saline water for the cultivation of white shrimp, *Litopenaeus vannamei*. This pioneering approach highlights the state's innovative use of saline resources for aquaculture. Fisheries, as a sector, play a crucial role in the socio-economic development of the country, providing a significant source of livelihood for many economically disadvantaged communities [45].

Among various fisheries enterprises, aquaculture has emerged as the fastest-growing sector globally, driven by its increasing importance in food production. In recent decades, India has witnessed a remarkable transformation in aquaculture, evolving from a subsistence activity to a highly profitable commercial industry. This growth underscores the sector's expanding role in enhancing food security and economic opportunities across the nation.

In the surveyed areas of Haryana, most respondents have chosen to conduct only a single harvest of shrimp each year, with an average production of approximately 3,500 kilograms per acre per season. Farmers usually

receive a farm gate price of Rs. 350 to Rs. 400 per kilogram when selling their shrimp to exporters or processors. The figure below illustrates the process of stocking postlarvae in Sulodha village, Jhajjar, demonstrating the steps involved in achieving a successful and vibrant shrimp harvest (Fig. 4).

By introducing the novel practice of aquaculture, which is being used for the first time in India into inland salty groundwater, the Central Institute of Fisheries Education (CIFE), Rohtak Center, has made noteworthy progress. In the saline-rich surroundings of Baniyani farm, *Penaeus monodon* was first cultivated in 2009 by CIFE, Rohtak Center. Over the course of the first 120 days, output levels ranged from 400 to 1600 kilos per acre [6].

This pioneering effort has opened new avenues for shrimp farming in areas where traditional agriculture is no longer viable due to soil salinity. The successful adoption of these aquaculture practices has allowed many local farmers to significantly increase their income, with some reporting earnings that are double what they previously achieved. The economic benefits of shrimp farming are especially pronounced for those with lands that have been rendered barren and unfit for conventional crop cultivation.

Fig. 2. Shrimp culture pond in inland saline water at Kultana Village, Rohtak, Haryana

A **B**

Fig. 3. *L. vannamei* inland saline farming at Mithri Village, Sirsa, Haryana

Fig. 4. Stocking postlarvae for a vibrant shrimp harvest in Sulodha village, Jhajjar

As a result, shrimp farming is emerging as a promising solution for revitalizing saline-affected lands and improving the livelihoods of farmers. The increased income and economic stability provided by shrimp farming are contributing to broader regional prosperity, demonstrating the potential of aquaculture as a sustainable and profitable agricultural practice in saline environments. This success story underscores the transformative impact of innovative aquaculture techniques in addressing the challenges posed by soil salinity and enhancing agricultural productivity.

4. SITE SELECTION AND POND PREPARATION AND MANAGEMENT FOR SMALL SCALE SHRIMP FARMING IN HARYANA

Selecting the ideal location for the pond is one of among the most crucial aspects of planning. Based on the historical records of aquafarming initiatives across the nation and internationally, it can be concluded that the most critical aspect determining the viability of operations is likely the appropriate choice of locations [46,47]. The most popular installations in land-based aquaculture are pond farms and hatcheries. The geomembrane-covered ponds at Jhanjarola, Gurugram, Haryana, are illustrated below in the figure. These ponds are designed to enhance water management and efficiency in shrimp farming (Fig. 5). Since earthen ponds are a common feature of these farms, essential factors to take into account include the soil's properties, the water's quality. In pond farms, soil quality is crucial because it affects productivity and the quality of the water above it, as well as because it can be used to build dikes. Additionally, the soil's qualities have a big impact on a pond's capacity to maintain the necessary water level [48]. Thus, it is imperative to conduct relevant soil studies when selecting sites. Fine-textured soils (clay, silty clay loam, and sandy clay) are better suited for pond farms due to their cohesive qualities. They are more resistant to erosion and other forms of harm due to their larger surface area, which allows them to absorb more nutrients, hold onto them, and release them for organic production in ponds [49,50].

The two most crucial physical characteristics that need to be looked at are porosity and texture. The relative characteristics of clay, silt, and sand particles affect the texture of the soil. One can generally assess the texture by touching and feeling. The soil must be clayey if the kneaded sample can be made into a bar that is about 6 mm thick and bent such that it forms a ring around the thumb without any breaks. The sample is sandy if it cannot be formed into a bar and stays separate with distinct grains after drying. If the sample does not fit into one of these categories, it may be categorised as silty or loamy. Even if they are not easily seen in loamy soils, sand granules can still be felt clearly. Silty soils have a texture similar to dough or wheat when touched with the fingertips [51].

4.1 Specific Safety Measures

Culture of white leg shrimp in brackish or coastal waters is not the same as raising them in salty ponds located inland. Consequently, while farming in inland saline ponds, specific safety measures must be followed. These are:

- Successful aquaculture requires careful selection of farm sites, stringent biosecurity controls, timely manuring, accurate feed management, scheduled sludge disposal, regular growth and health evaluations, and daily water supply assessment. Neglecting any of these critical practices can lead to significant cultural failures [52].
- Sustaining potassium (K) Level: The K content of inland saltwaters is low. The K level of the water must be determined in order to maintain an ideal K level. Next, potassium murate is introduced to the pond until the necessary K level is reached; this level must be maintained until the conclusion of the cultivation [53,54].
- Maintaining Ca and Mg levels: Ensuring appropriate levels of calcium (Ca) and magnesium (Mg) is crucial, as shrimp are sensitive to the balance of these elements in the culture medium. For better growth and survival percentage the Ca:Mg ratio to be maintained as 1:3 [55].
- Turbidity: If the species selected can be reared in the area, maintaining the water's temperature, salinity, and turbidity will be crucial. The productivity and species life might be impacted by high water turbidity brought on by suspended particulates. It will lessen light penetration into the water, which will lessen primary production in the water and so diminish primary production. It is best to avoid using turbid water in hatcheries since it can significantly impair larval hatching and rearing [56,57]. The clay turbidity in water to 30cm or less may prevent development of plankton biomass. 30cm to 60cm & as below 30cm is generally good for fish production. Higher turbidity can cause temperature and DO stratification in prawn ponds. It can cause clogging of gills or direct injury to tissues of prawns. Clay turbidity that restricts visibility to 30 cm (12 in.) or less can inhibit the development of good phytoplankton blooms [58].
- Acidity and alkalinity are two additional water quality factors that are significant when choosing a site. The most suitable p of water for aquaculture farms is thought to lie in the range of 6.7-8.6 [59].

Fig. 5. Geomembrane-covered ponds ponds at Jhanjarola, Gurugram, Haryana

4.2 Strategies for Successful Shrimp Farming

For getting successful production of the shrimp, following don'ts must be followed scrupulously [59,60,61]:

- **Eliminate Pond Sludge Promptly**: Ensure that sludge does not accumulate at the pond bottom, as it can degrade water quality and harm shrimp health.
- **Avoid Excessive Lime Applications**: Use lime sparingly; excessive doses can disrupt the pond's pH balance and negatively impact shrimp.
- **Minimize Gaps in Bird Nets**: Ensure bird nets are installed with minimal gaps to prevent bird intrusion, which can lead to significant shrimp losses.
- **Filter Water Before Use**: Always use filtered water for your culture ponds to prevent introducing contaminants and maintain optimal water quality.
- **Avoid Poor Quality Seed**: Select only high-quality seed for stocking; inferior seed can lead to poor growth and increased mortality.
- **Acclimate Seed Properly**: Do not release shrimp seed into the pond without proper acclimation; this step is crucial for reducing stress and ensuring survival.
- **Prioritize Routine Health Checks**: Regular health check-ups are essential; neglecting them can lead to undetected issues that may jeopardize the entire crop.
- **Maintain Seed Quality**: Consistently use quality seed to ensure healthy growth and maximize the productivity of your aquaculture operations.

5. CHALLENGES FACED BY FARMERS AND RECOMMENDATIONS FOR ENHANCING SHRIMP FARMING

Although the Haryana government offers a lot of technical and financial support to farmers, there are still several significant obstacles they must overcome. The main obstacle cited by shrimp growers was the emergence of bacterial and viral diseases [62]. In the current survey, a spectrum of shrimp diseases has been identified, each posing unique challenges to aquaculture [63]. The Black Gill Illness darkens the gills, vibriosis, while the IHHNV (Infectious Hypodermal and Hematopoietic Necrosis Virus) silently wreaks havoc on shrimp tissues. The White Muscle condition paints a distressing picture of muscle deterioration, and the White Gut disrupts the digestive system with its telltale pale appearance. Running Mortality Syndrome spreads rapidly, claiming lives with alarming speed, and the White Spot Syndrome Virus (WSSV) creates telltale white spots on the exoskeleton, signaling a serious threat to shrimp health. Each disease underscores the need for vigilant monitoring and robust management strategies to safeguard aquaculture productivity.

Beyond these disease concerns, farmers face a host of operational difficulties. They are notably troubled by the scarcity of high-quality prawn seed from hatcheries, soaring feed costs, and poor collaboration among fellow farmers. Additional obstacles include deteriorating water quality, erratic power supplies, and fluctuating power tariffs, all of which complicate the economic viability of prawn farming.

To address these issues, many farmers have proposed several recommendations for improving shrimp farming practices in Haryana. They suggest that quality seed should be sourced from registered hatcheries, certified by the Central Aquaculture Authority (CAA), to ensure reliability. They also advocate for the dissemination of price information through advanced information and communication technology. Furthermore, there is a call for educating shrimp farmers on Better Management Practices (BMPs), particularly concerning water quality, to enhance overall farming efficiency and sustainability. They also believed that each farmer should maintain a separate reservoir pond for water collection and filtering.

Farmers have put forward a series of recommendations aimed at improving shrimp farming practices and addressing existing challenges. They propose that price information be disseminated through mass media to keep farmers well-informed about market trends. Additionally, there is a strong call for educating farmers on Better Management Practices (BMPs) to enhance their skills and knowledge. Ensuring the availability of high-quality seed is crucial, as is maintaining the standards of chemicals and probiotics used in aquaculture. To support financial stability, farmers recommend the provision of credit and insurance options. They also advocate for electricity tariff concessions to reduce operational costs. The establishment of disease diagnostic centers or laboratories would facilitate timely and accurate disease

management. Government support is deemed essential for sustainable development, while controlling feed rates can help manage costs effectively. These recommendations reflect a comprehensive approach to addressing the multifaceted issues faced by shrimp farmers and improving the overall viability of the industry.

6. TECHNICAL AND FINANCIAL ASSIATANCE PROVIDED BY THE GOVERNMENT FOR AQUACULTURE DEVELOPMENT IN HARYANA

Aquaculture farmers who want to engage in a variety of fishing-related activities can receive financial support from the Fisheries Department of Haryana. The following is a breakdown of the financial aid programs.

6.1 Technical Assistance

The department offers a range of technical support services designed to facilitate the successful establishment and management of aquaculture units. This includes assistance in securing village ponds on lease for both shrimp and fish farming, ensuring that farmers have access to suitable locations for their operations. Additionally, the department aids in obtaining loans for the construction of aquaculture units, providing a crucial financial foundation for setting up new ventures.

Shrimp farmers receive valuable training and refresher courses organized by the department, enhancing their skills and knowledge in aquaculture practices. Soil and water analysis of pond sites is conducted to ensure optimal conditions for farming, while the preparation of plans and estimates for pond construction is also supported. The department supplies high-quality seed and feed, which are essential for the successful cultivation of shrimp and fish.

Regular monitoring is conducted to check the healthy growth of the aquatic species, and assistance is provided during the harvesting process to ensure efficient operations. Moreover, the department helps with the transportation and marketing of the harvested products, facilitating their entry into the market and maximizing economic returns for shrimp farmers.

6.2 Financial Assistance

Shrimp farmers might get substantial financial support under the plan program for the Intensive fisheries development programme. Aquaculture development is supported in a number of ways by this money, including infrastructure, operating expenses, and other necessary costs. The objective of the financial assistance is to augment the efficiency and financial gain of aquaculture businesses, so aiding in the general expansion of the shrimp industry in Haryana. Significant financial support for fishermen under the Intensive Fisheries Development Program Plan Scheme shown in (Table 3), [64].

6.3 Plan Scheme for Welfare of Scheduled Castes Families in Fisheries Sector

The Plan Scheme for the Welfare of Scheduled Castes (SC) Families in the Fisheries Sector is designed with the primary objective of enhancing the socio-economic status of individuals from SC families through comprehensive support in the fisheries industry. This initiative aims to provide full-time employment opportunities within the sector, thereby fostering economic development and improving living standards.

Table 3. Financial assistance provided by the government

Sr. No	Name of Activity	Financial Assistance
1.	Subsidy on Insurance Premium for shrimp crop Insurance	As per 50% subsidy on Insurance Premium for shrimp crop insurance.
2.	Subsidy on installation of Aerator	A maximum of two aerators per farmer may be subsidized in the amount of Rs. 20,000 per aerator or 50% of the aerator's real cost, whichever is less.
3.	Subsidy on Solar System for power generation.	Subsidy of amounting to Rs. 20,000/ Horse Power (hp) with a maximum limit of 10 hp/farmer.(Subsidy not applicable in areas which fall under Red, Pink & Blue category as categorized by HWRA).
4.	Subsidy on four wheeler	Subsidy @ 25% of the actual cost of four wheeler (Rs 6 lakh) or Rs.1.5 lakh whichever is less.

One of the core goals of the scheme is to uplift the socio-economic conditions of SC families by offering financial assistance across various components. This support is intended to empower these families, facilitating their active participation in the fisheries sector and helping them achieve greater economic stability. Training is a critical component of the scheme, focusing on equipping SC families with the necessary skills and knowledge for successful fish culture and marketing. The department organizes training programs that cover various aspects of aquaculture, ensuring that beneficiaries are well-prepared to manage and operate fish farming ventures effectively. Financial assistance is provided to shrimp farmers in the form of subsidies for shrimp culture. Specifically, the scheme offers a subsidy on inputs such as pelleted feed, covering up to 60% of the costs. This subsidy is available to farmers managing up to 2 hectares of aquaculture, making it a significant support measure that reduces the financial burden associated with input costs and promotes the sustainability of fish farming operations.

By focusing on these key areas, the Plan Scheme for the Welfare of Scheduled Castes Families in the Fisheries Sector aims to create meaningful employment, improve economic conditions, and provide the necessary resources and training for successful participation in the fisheries industry. This comprehensive approach underscores the commitment to enhancing the well-being of SC families and fostering their active involvement in aquaculture.

6.4 Pradhan Mantri Matasya Sampada Yojana

The Pradhan Mantri Matsya Sampada Yojana (PMMSY), launched by the Department of Fisheries under the Ministry of Fisheries, Animal Husbandry, and Dairying, is a visionary scheme designed to elevate India’s fisheries sector with a focus on inclusivity, commercial viability, and environmental sustainability. In a bold and supportive move, Chief Minister Manohar Lal Khattar has pledged to bolster shrimp production in saline and waterlogged areas. Should delays in central government subsidies occur, he has committed to providing advance subsidies to PMMSY beneficiaries, ensuring that progress continues unabated. This proactive stance underscores his dedication to nurturing the growth of aquaculture, turning challenges into opportunities for advancement and prosperity in the shrimp industry.

Benefits: The scheme provides substantial financial support across several critical areas to enhance the fisheries sector. For fishing infrastructure, it assists in developing essential facilities such as harbors, landing centers, markets, feed plants, seed farms, and processing units. These investments are crucial for improving the efficiency and scalability of fisheries operations. For fish farmers, the scheme offers financial aid for building and upgrading essential infrastructure, including ponds, cages, hatcheries, and nurseries, as well as for installing aeration systems and other vital equipment. This support helps farmers optimize their operations and boost productivity. In the realm of fisheries management, the scheme funds the adoption of scientific methods, development of management plans, and establishment of information systems, all aimed at promoting sustainable and effective resource management. To encourage fish farming as a viable business, a credit-linked subsidy is provided, easing the financial burden and fostering entrepreneurial growth in the sector.

Additionally, the scheme supports the marketing and export of fish products by funding the development of cold chains, processing units, and packaging facilities, thereby enhancing product quality and market reach. This comprehensive assistance ensures that all facets of the fisheries industry, from infrastructure to marketing, are adequately supported for growth and sustainability [65].

6.5 Major Government Initiatives for Fostering Aquaculture in Haryana

Haryana has carved out a pioneering role in India's aquaculture landscape by becoming the first landlocked state to harness inland underground saline water for the culture of white shrimp, *Litopenaeus vannamei*. The state has already achieved a notable milestone by being declared disease-free in fish culture by the Indian Council of Agricultural Research (ICAR). This progress is underpinned by a series of strategic initiatives designed to foster the growth of aquafarming across Haryana [64,66].

In a significant boost to the fisheries sector, the Haryana government has substantially increased subsidies under the Central Sector Scheme on Blue Revolution, elevating support from 20% to

60%. This enhancement is directed towards the excavation, renovation, and inputs for ponds, and the development of waterlogged and saline-affected areas, thereby facilitating a more robust aquaculture infrastructure.

Further advancing the sector, Haryana is set to become home to a state-of-the-art Hi-tech Ornamental Fish Hatchery in Jhajjar. This ambitious project, with a projected cost of 13.68 crore, will be the only one of its kind in North India, setting new standards for ornamental fish production and contributing to the region's growing aquaculture capabilities.

The Fisheries Department is also spearheading the establishment of 71 Recirculatory Aquaculture System (RAS) units across the state. These units are expected to significantly boost aquaculture productivity and double farmers' incomes, with subsidies provided in accordance with government norms.

In a major push for expansion, the government plans to bring 1,000 hectares of saline-affected wasteland under white shrimp culture during the 2023-24 period. This initiative aims to convert unproductive land into profitable aquaculture areas, further integrating saline land into productive use.

In response to potential delays in central subsidies, the state government has pledged to provide advance subsidies to farmers engaged in aquafarming under the Pradhan Mantri Matsya Sampada Yojana (PMMSY). This proactive measure ensures continuous support for farmers, mitigating the impact of any administrative delays.

Additionally, the state is addressing practical needs with the establishment of a new testing lab in Sirsa, which will ease the burden on local farmers previously required to travel to Rohtak for lab services. This development will enhance accessibility to critical testing facilities, supporting the health and quality of aquaculture operations.

Economic progress is further supported by the announcement of a wholesale fish market in either Jhajjar or Gurugram, designed to boost farmers' profitability. The introduction of credit cards similar to Kisan Credit Cards and ongoing discussions with banks and insurance companies for fisheries insurance also signal a comprehensive approach to financial support in the sector.

Recognizing the challenge of power consumption in aquaculture, the government has set a favorable electricity rate of 4.75 per unit for farmers consuming up to 20 kW. To promote sustainable energy solutions, farmers are encouraged to install solar plants with a government subsidy of 20,000 per horsepower, capped at 2 lakh. This initiative not only supports energy efficiency but also aligns with broader environmental goals.

By implementing these diverse strategies, Haryana is not only developing its aquaculture industry but also establishing a model for creative and sustainable methods of developing fisheries. Appearing in (Table 4) is the progress report for the Haryana fisheries sector [64].

Table 4. Progress report of fisheries Department Haryana upto March, 2024 (Fisheries)

Sr. No.	Items	Unit	Achievement	
			Targets.	Achievement
1	Area under aqua culture	Hect.	24250.00	20518.29
2	Fish/Shrimp seed stocking	Lakh	5575.00	8164.00
3	Fish Production	Tonne	216310.00	215173
4	Training to Aquaculture farmers	No.	8500.00	5226

7. MAJOR CONCERNS, FUTURE ROAD MAP

There are several issues with the future growth of this new shrimp farming sector. One of the main problems is that Shrimp culture is a "high-cost, high-risk" intensive production process that necessitates highly specialized labour, exacting oversight, and high levels of biosecurity.

Additionally, registered hatcheries in distant coastal states must fly specified pathogen free (SPF) seedstock to non-coastal areas where shrimp farming is being developed. Additionally, there are no enterprises producing or processing shrimp feed in the non-coastal states. Finally, unlike conventional saltwater, inland saline waters vary in salinity and chemical composition depending on location, even within a single district.

For the development of aquaculture techniques unique to a given location, the sector requires an ecological mapping of salt-affected regions (including salinity, composition). In addition, the introduction of low-cost, low-risk species is required for the sustainable growth of inland saline water aquaculture, with particular emphasis on small and less wealthy farmers. Additionally, a National aquaculture network should be established, as should Public Private Partnerships (PPP) to promote marketing, processing, and exports to non-coastal states while ensuring the availability of inputs like seed, feed, and others. Investigation on inland saline aquaculture conducted in India demonstrates that the country's resources are suitable for the development of commercial aquaculture.

8. SOCIO-ECONOMIC IMPORTANCE OF INLAND SALINE AQUACULTURE

Shrimp farming in inland saline waters is making a transformative impact on the socio-economic landscape of India, particularly in states like Haryana and Punjab. This innovative approach is not just enhancing local economies but also playing a pivotal role in improving the livelihoods of communities in these regions. By utilizing inland saline water resources for shrimp culture, the industry is establishing a prosperous sector that provides significant economic opportunities and nutritional benefits. This innovative approach is transforming the aquaculture landscape and contributing to local economies. The process of shrimp harvesting is depicted in the figure below, showcasing operations at Naurangpur village in Jhajjar, Haryana. This visual highlights the effectiveness of saline water use in shrimp farming and its positive impact on the region (Fig. 6).

The seed generation of brackish water fish in these inland saline areas is emerging as a highly profitable venture. This approach not only promises economic viability but also contributes to the reclamation of previously unproductive lands. Research into inland saline aquaculture in India underscores the potential of these resources to support robust commercial operations. With appropriate management, these saline lands can be transformed into productive aquaculture sites, offering a viable alternative to traditional marine and brackish water areas.

Inland saline aquaculture stands as a beacon of opportunity, offering a sustainable solution to the challenges faced by conventional fisheries. By cultivating protein-rich organisms, this method ensures nutritional security for local populations while fostering economic growth. The expansion of aquaculture into saline lands not only addresses land reclamation but also enhances the socio-economic fabric of the region, providing a multifaceted solution that benefits both the environment and the community.

A B

Fig. 6. Shrimp harvesting at Naurangpur village, Jhajjar, Haryana

9. CONCLUSION AND FUTURE PROSPECTS

Shrimp farming in inland saline waters is proving to be a game-changer for farmers, offering superior profitability compared to traditional agriculture and horticulture. Unlike conventional crops, which require months to mature, shrimp farming yields impressive returns within a brisk 100-120 days. This rapid turnaround not only boosts incomes but also provides a much-needed financial uplift for farmers. Moreover, the practice of utilizing groundwater and seepage water for shrimp culture presents a dual benefit. It effectively prevents water logging, enhances soil texture, and combats secondary salinization. This sustainable approach helps revitalize land that might otherwise remain unproductive, creating a win-win scenario for both the environment and the agricultural landscape.

Envisioning the potential of cluster farming, large saline areas can be segmented into two productive clusters, each cultivating shrimp twice a year. This method promises not only increased profits but also significant employment opportunities. By transforming expansive saline lands into vibrant aquaculture hubs, this innovative approach holds the key to unlocking both economic and social prosperity in affected regions. Moreover, it may reduce the production cost while on the other hand might increase the foreign export thereby improving the country's economy. So, cluster farming of shrimp is an alternative approach for aquafarming in inland saline waters of Haryana.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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