

‘Sustainable Aquaculture’ and ‘Rural Women’

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Abstract:

According to the current population census, India ranks second with a net population of 144 crore 18 lakhs 77 thousand 249 in total. Among these, men account for 74 crores 44 lakhs 79 thousand 293 (51.6%), while females make up 69 crores 73 lakhs 97 thousand 957 (48.4%). Due to gender inequality and the substantial population difference, the participation rate has been consistently decreasing from male to female populations. This trend reflects a clear suppression of the inherent expertise of females. Migratory compulsions, influenced by various factors, have further contributed to this situation. However, extensive efforts by various fisheries extension and cooperative bodies, such as NFDB, KVKs, NGOs, etc., have yielded practical outcomes. These initiatives have successfully addressed the significant gender gap in aquaculture, utilizing natural resources optimally. The crucial role played by women in bridging this gap is of utmost importance. Failure to sustain this progress could lead to undesirable consequences and act as a barrier to achieving the top position in fish culture for our country, including our motherland Bengal, in the long run.

Introduction:

Aquaculture, which is generally a rural activity involving the farming of fish, crustaceans, edible mollusks, and aquatic plants of economic value under controlled or semi-controlled conditions, has a long history in India (Boyd et al., 2020; Sanyal et al., 2023; Mukherjee et al., 2022a; Mukherjee et al., 2022b). From almost a subsistence level of farming activity in the early '60s, India is now the second-largest producer of fish, registering a sixteen-fold increase during the last six decades. To a great extent, the contribution to this transformation process has been from freshwater aquaculture, which has grown from about 0.40 million tonnes in 1980 to 12 million tonnes at present (Sahoo et al., 2023). Today's aquaculture is diverse and varied; the diversity of aquaculture production is reflected in terms of holding units like ponds, raceways, pens, and cages; management levels like semi-intensive, intensive; monoculture or polyculture of species, static systems, or flow-through systems. Its spectacular growth so far has been possible mainly because of (i) sustained application of scientific principles generated through

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research efforts in various disciplines, including fish seed production, culture technology, genetics, nutrition and feeding, disease diagnostics, etc., (ii) inheritance of a strong gene pool involving multiple indigenous species, and (iii) the existence of diverse aquatic ecosystems, including ponds, tanks, lakes, reservoirs, canals, streams, rivers, and deepwater rice environments, etc. (Mallick & Panigrahi, 2018; Boyd et al., 2020).

The scenario, however, is altering with the changing environment; competition for resources such as land, water, and essential inputs like feed and fertilizer is likely to affect the context and content of the aquaculture sector in the country. The gradual implementation of stringent codes of conduct for responsible aquaculture and HACCP in the farming system for safe production plans all appear to be highly challenging for researchers, and development agencies, including farmers, faced with the task of 'producing more from less, for more'. This situation becomes more complex, especially in rural Bengal, with sizable groups of the male population migrating to nearby and distant cities for the betterment of their socio-economic conditions and livelihood options. This has led to the imbalance of adequate manpower to carry on aquaculture activities (Jahncke & Schwarz, 2008). In this connection, it may be stated that, unlike conventional agricultural activities where men and women jointly participated in equal contributions, aquaculture showed a major diversion, where it was fully overruled by male dominance completely. Consequently, this migration has created a significant vacuum in the field of aquaculture and allied activities, which needs to be filled up immediately; otherwise, this traditional economic and welfare activity of finfish and shellfish rearing would face a tremendous hurdle in their smooth and uninterrupted continuation shortly. Following this acute significance of manpower shrinkage, which has led to a major crisis, rural women have shown a dominant will force to enlighten a new hope and, side by side, bridge the gap efficiently, reflecting real 'magic' in this very particular field, both in a war-footing basis and efficient manner (Jaikumar et al., 2023; Ross, 1989; Das et al., 2020).

Sustainable aquaculture initiatives in the Sunderban area have gained traction, promoting both economic growth and environmental balance (Saha & Sarkar, 2022). Rural women play a pivotal role, engaging in sustainable practices that harmonize with the delicate ecosystem, ensuring the longevity of this vital region. Sustainable aquaculture ensures responsible practices, safeguarding marine ecosystems. Circular economy, sustainable aquaculture, and empowering rural women intersect in a harmonious narrative of environmental stewardship and social equity (Saha, 2023). Embracing circularity minimizes waste, promoting resource efficiency. Rural women, pivotal in these endeavors, play transformative roles, contributing to resilient communities and equitable growth. Together, they form a tapestry of sustainable development, fostering a balanced and thriving future.

Inevitable roles of women:

Unlike crop farming activities in conventional agriculture, where women's participation has been and still is considered a normal phenomenon from seed sowing to harvesting, rural aquaculture activities have remained predominantly male-dominated, as mentioned earlier

(Pattnaik & Lahiri-Dutt, 2020). In the changing environment, due to the frequent migration of rural men in search of alternative livelihood options and prosperity in nearby and distant cities for jobs or trading purposes, leaving their homes for prolonged periods, some spirited rural women—mostly housewives—have stepped forward under such challenging conditions to contribute by gradually acquiring vocational skill development training in aquaculture-based farming systems facilitated by farmer-supportive agencies, enabling them to stand on their own with dignity. Fortunately, Krishi Vigyan Kendras (KVKs) and local research and development institutions of the Indian Council of Agricultural Research (ICAR) started working with these women, providing hands-on capacity-building training in ecological aquaculture (Ananth et al., 2019). This training included various aquatic bioresources such as Azolla, lotus, ipomoea, lily, and makhana (*Eurayle ferox*). Additionally, it incorporated seasonal leafy vegetable farming on pond dykes and, in some instances, integrated duck farming at certain locations to make these women self-reliant. They began working together, shouldering responsibilities jointly in the agro-ecological farming of indigenous small and medium fishes, utilizing locally available bio-inputs like green manure, farm-made neem-based phytoremediation products, and traditional knowledge from elderly farmer-scientists in the villages. Despite facing multiple challenges, this small beginning gradually allowed them to systematize production processes at reasonably low input costs, reviving local production and showcasing their missionary zeal and capabilities in bringing forth the latent potential of rural women to contribute generously towards steady family earnings (Das et al., 2023).

Now, organizations such as the National Fisheries Development Board (NFDB), the State Directorate of Fisheries, and various NGOs working in this sector have come forward with a spectrum of benefits for the development of fish seed production in situ. This includes input availability at the doorstep, fry to fingerling stage rearing, and farm-made chowmein-type pelleted fish feed preparations using local agro-based residues like oilseed cakes, rice polish, and corn dust. These women leaders, forming self-help groups with the cooperation of local panchayats, now have access to unconventional and unnoticed water resources, such as canals, swampy ponds, village ditches, and wetlands, most of which remained unutilized until now. Equipped with the required training, sincerity, seriousness, periodic exposure to successful farms and hatcheries, and developing expertise in mobile communication through the use of Android handsets, these dedicated women leaders have already developed competence in various aspects of aquaculture. This includes fish breeding, pond preparations, spawn/fry rearing, fingerling raising, farm-made feed formulation, processing, storage, and scientific application in farm ponds and tanks. They are well-versed in procedures for emergency care of fish, health, and disease diagnosis, thereby strengthening the fish production system more robustly (Bower et al., 2017). Their actual nurtured or equipped strengths are reflected through their inner passion and drive to continuously engage with local fisheries or aquaculture institutions, Krishi Vigyan Kendras, and various aquaculture-related capacity-building centers. This marks the beginning of harnessing the potential of half of the population, whose

contributions could not be fully realized for achieving the dream of 'Atmanirbhar Bharat' and bringing about magical changes in the quality of life in rural areas, including Gangasagar block of Sundarbans, some coastal villages of Tamluk in Purba Medinipur, and Kaliaganj block in Uttar Dinajpur district in the North Bengal region, which, hopefully, are successful to a greater extent. The role of this women's section in various aspects of aquaculture, such as fish rearing, hatchery management, ornamental fish nourishment, fish processing, etc., along with each phase from pond preparation to marketing, processing, and exporting them overseas, strengthened by intensive scientific and technical hands-on training from prestigious fisheries or aquaculture training centers, despite having limited educational qualifications (as proven by degrees from educational entities like colleges and universities), is discussed below in the following discussion.

In induced fish spawning, seed production, and hatchery management:

Among all other fishes to be cultured, cyprinids, especially the major carp, rank first on the list of priorities due to their profound supremacy and strong emotional connection in the traditional dishes of the entire regions of the eastern and northeastern belts. The main disadvantage of such cultures, despite several pros like ensuring a high probability of recycling organic wastes, followed by high competency in culturing with other species, is the release of eggs in their natural environments in captivity, which remains at stake (Bais, 2018). Induced breeding helps solve this problem to obtain the seeds and resume this cycle of culture by capturing brood fishes from the culture sites and consequently injecting them with hormones that suppress the role of gonadotropin-inhibiting hormone (GnRH), thereby easing out the release of Gonadotropin-releasing hormone (GRH) (Sahadan et al., 2021). Selecting the proper dosage of hormones for fishes, injecting them in two phases in females and one in males at a 45-degree angle above the lateral line, striping the abdomen, and releasing the eggs, mixing them with the sperms gently with a sterilized quill, and then finally allowing the fertilized eggs to produce the spawns are now at the fingertips of women, replacing or shouldering their men to a great extent (Jhingran & Pullin, 1985).

As, owing to the various life stages of fishes, the cultures are broadly sectioned into three distinct groups viz., spawn to fry, fry to fingerling, fingerlings to table-sized fishes, etc., rearing the spawns up to the grow-out phases by taking proper nourishment of them, monitoring their health and other aspects sincerely are also carried out extensively by rural women with their utmost efficiency through acquiring capacity building and enhancement expertise (Williams & Syddall, 2022). For farmers, fishery entrepreneurs, aquaculturists, etc., the main constraint faced is the timely procurement of quality fish seeds – the vital input to begin aquaculture, which has created a great burden among them in continuing their culture phase smoothly. The advent of modern hatcheries and their management lies only in this aspect, that is breeding them and successfully rearing their young ones under controlled conditions for getting healthy hatchlings. As we all know, hatcheries are composed mainly of two types of units viz., breeding unit and hatching unit. The management of the hatching pool encompasses scientific strategic

measures for maintaining the healthy condition of the water containing the broken eggshells in its outer chamber by collecting them through the use of twined fibrous ropes made up of coconut fibers (generally similar to 'scrubbers'), to which the eggs can easily get adhered while moving along with the water current in the outer chamber of the hatching chamber. The significant roles of women in placing the nets of the hatching chamber and timely removal and cleaning of those scrubbers, including the management of water flow circulation, aeration systems, operational activities, and all such other related ancillary activities to keep its functional viability to the optimum are really to be adjudged in various parts of India extensively (Naish et al., 2007; Harper et al., 2013).

In pond management including the management of its water quality parameters:

Aquaculture involves more than just culturing and harvesting fish; it encompasses various tasks beyond these limits, extending to pre-stocking and post-harvesting management. In pre-stocking management, activities such as pond designing, removal of non-essential aquatic flora and fauna, and the construction of fences to deter crab entry are essential. Rural women actively participate in pond construction, selecting healthy cultivable fishes for stocking, and gaining intensive hands-on training in identifying urinogenital openings, dorsal fins, belly shapes, and sizes, making them fully compatible to compete with their fellow men or husbands in practical fields uniquely (Mramba & Kahindi, 2023; Ahmed et al., 2023).

In the next phase of the culture system, stocking involves introducing fishes into the water body in a definite proportion, covering each habitat (surface water, column water, or bottom water niches) appropriately. For single-species culture systems, determining stocking density is crucial, synchronized with size, carrying capacity, pond depths, and availability of natural feeds. Pond depth, ranging from 1.0 to 1.5m for nursery rearing, is a vital parameter for stocking specific age groups of fish. Rural women excel in assessing natural food organisms using secchi discs and plankton nets, defining the pond's suitability for fish culture, and showcasing their competence in pre-stocking activities (Ahmed et al., 2023; Jeanson et al., 2022; Harper et al., 2013).

Post-stocking management, dealing with activities after stocking and harvesting, is attributed to women for their acute and appreciable involvement in this sector. Fish, being a poikilothermic vertebrate, relies on ambient water quality parameters for nutrition. Aquaculturists must pay attention to water temperature, dissolved oxygen (D.O.), pH, salinity, and turbidity caused by Total Dissolved Solids (T.D.S.). A water temperature and D.O. below-prescribed limits (25-28°C and 5mg/L, respectively) can be lethal to warm water fishes due to triggering aerobic and anaerobic reactions, leading to the generation of excess carbon dioxide and ammonia. Women, proficient in using pH meters, salinometers, Winkler method, digital D.O. meters, Secchi discs, and refractometers, demonstrate their capability to check water quality and fish health, contributing significantly to the field of aquaculture (Elliott et al., 2022; Harper et al., 2013).

In nutrition and feeding:

As it is widely acknowledged, the significance of food extends beyond mere sustenance for fishes; their effective growth and survival also hinge on the intricacies of biological tuning, encompassing factors such as particle size, color, odor, and more. All these allied considerations bear equal weight for the very same reasons. The incorporation of these elements into feed formulation demands specialized technical training. This pertains specifically to the domain of preparing natural fish food items, denoted as 'planktonic particles,' namely phytoplankton and/or zooplankton (Ragasa et al., 2022). This crucial aspect of feed formulation is exclusively entrusted to the expertise of women. They undergo extensive training, encompassing both theoretical knowledge and hands-on skills. This training covers a spectrum of tasks, ranging from effectively selecting feed ingredients to adeptly combining them with feed additives. The process extends to shaping the mixture into noodles, achieved through the utilization of hand/motor palletizers. Consequently, women are now recognized as 'experts' in these intricate and vital areas.

Including feeding, there are many more aspects of aquaculture, such as providing proper nutrients to enhance soil activity, maintaining the equilibrium of phytoplankton and zooplankton, checking the efficiency of aqua instruments to judge their optimal functioning, and conducting periodic water quality check-ups to prevent major deterioration, among other tasks. In all of these activities, women actively contribute, leading to a positive impact on the overall results. Insights can be gained from their involvement in preparing biofertilizers and organic manures. Women play a crucial role in strategically placing these materials in ponds for their gradual and sustained release. This is done either directly by the women themselves or indirectly by assisting their male counterparts. They organize related tasks and have rightfully earned recognition as 'qualified experts' due to their commendable contributions.

In today's aquacultural scenario, the exorbitant cost of fish feed poses a significant challenge for farmers, creating a comical burden as they strive for an uninterrupted continuation of their livelihood in aquaculture. This cost primarily stems from the reliance on industrially manufactured feeds, prompting the recommendation to opt for farm-made preparations utilizing local resources. This shift becomes imperative due to the farmers' dependence on very limited funding sources (Oliva-Teles et al., 2022). The home-based preparation of these feeds entails a series of simple steps that incur minimal economic and labor costs. Crucially, the involvement of rural female individuals is indispensable throughout this process (Fig. 1).

Azolla, a small floating rooted aquatic fern belonging to the taxonomic family 'Salvinaceae,' stands out as a common and valuable ingredient and supplement in fish feeds due to its exceptional nutritional profile. To cultivate Azolla, small ponds or traditional, underutilized ponds can be employed after clearing undesired weeds. Ditches, pits excavated in backyards, and similar spaces serve as suitable cultivation sites. These areas are then filled with a small, quantified mass of the stock (wild Azolla), which doubles in mass within a few days, creating an optimal nutrient medium for its expansion. Subsequent management of these organic feed

ingredients necessitates daily monitoring of the cultured mass. If required, frequent additions to the nutrient medium become essential (Hamli et al., 2020; Abo-Taleb, 2019; Smith, 1988). Remarkably, these tasks are efficiently executed by rural housewives who have enhanced their vocational skills through active participation in training programs conducted widely in their native areas. This empowerment not only supports sustainable aquaculture but also strengthens the economic foundation of these communities.

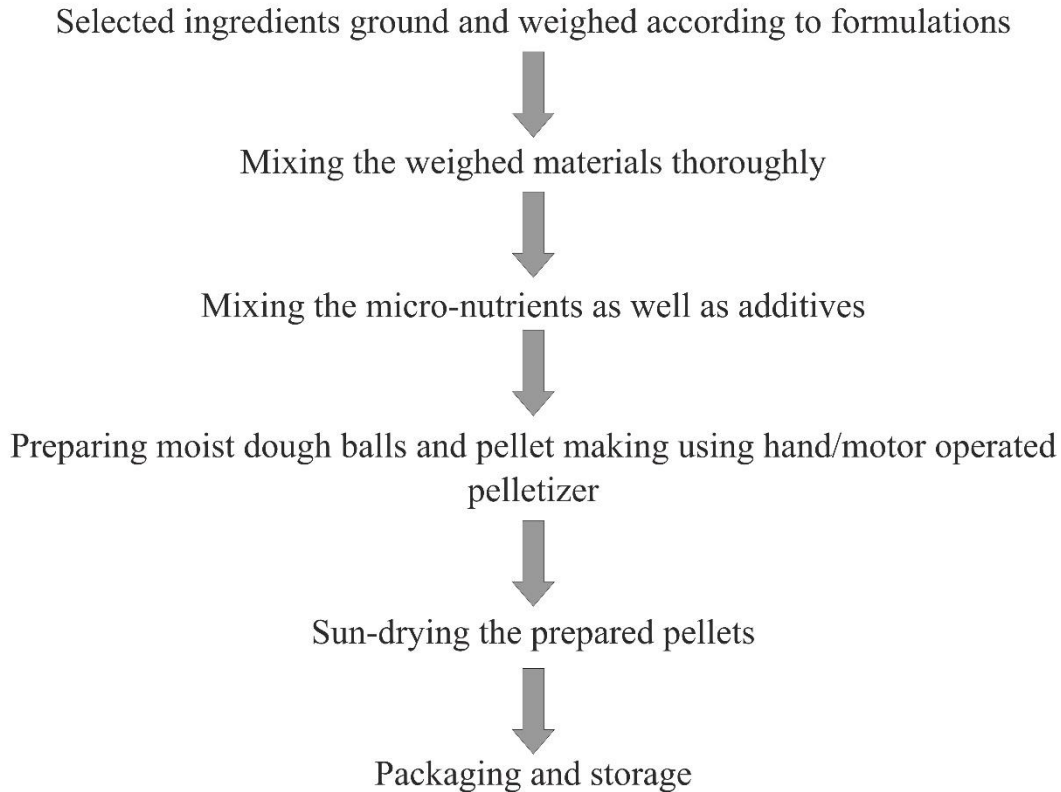


Figure 1. Flowchart showing the simple steps of fish feed preparation (farm-based).

In post-harvest and fish processing:

Post-harvest technologies seamlessly lead to processing techniques since, in most cases, products are marketed if not consumed immediately. In aquaculture, the cultivation of fish primarily serves exportation purposes. Processing doesn't always involve mechanical interventions; even a simple traditional sun-drying method is considered crucial. Its principle is to extend the shelf life of fish intended for consumption, as mentioned earlier. Similarly, mechanical means include packaging and wrapping fish in a vacuum, following the mechanisms of MAP (Modified Atmospheric Packaging) and CAP (Controlled Atmospheric Packaging). These methods prevent spoilage in the early stages after harvest. They involve introducing a mixture of gases with known compositions (Yesudhasan et al., 2014; Nie et al., 2022). In CAP, the gases are controlled, while in MAP, they remain fixed or unaltered.

However, these techniques slightly contradict vacuum packaging, which entirely restricts air introduction to resist metabolic activities and oxidative phosphorylation within the muscular structures of the specimens (Otwell et al., 2006). Even in the post-harvest section, women play an active role in preserving harvested fish by allowing them to dry under the scorching rays of the sun. This simple technique, requiring minimal attention, is a regular habit among a large section of rural women in coastal sections of India, such as Digha Mandarmani beach areas, Purba-Midnapore, Sagar Islands in Dakshin 24 Parganas, etc. Harvested fishes are often noticed lying on horizontally placed bamboo poles in lines. In the fish processing sector, a significant section is solely concerned with turning fish flesh into fillets and preparing various products and by-products. More than 40% of the workforce identified with these tasks comprises women (Sahu et al., 2018; Chandra & Sagar, 2003; Pradhan et al., 2023).

In ornamental fish and pearl farming:

'Fish is only to eat' – this concept is now totally in vogue. The commencement of technological advancement in every aspect of our daily life, such as health and nutrition, corporate careers, food production systems, and overseas trade, as well as in the fields of modern science, especially in biotechnological divisions, has, though, ended our lives in acute hustle (Mishra, 2019). Contradictorily, it has gifted us with a bio-diversified population of millions of fishes around us, featured with lustrous color patterns in their body. This, in turn, encourages us to keep them as 'pets' in our homes by domesticating them in small glass tanks in our residences (Pountney, 2023). Naturally, these populations are present within a million or shallow depths of water in the oceans or the coral reefs of either fresh, marine, or brackish water habitats, some of which even exhibit optical illuminations in their bodies in the form of bioluminescence (Thompson & Rees, 1995). These ornamental fishes, named so by comparing them with female ornaments, have become major stress relievers, dollar-earners, and great interests for trade for many (Priyashadi et al., 2022). Moreover, the cross-bred varieties of their several species are gaining more attraction than the native (parental) ones in the economic market. Hence, constructing aquariums for these fishes, rearing, and breeding them in domestication, and trading them suitably have now become just a 'very simple activity' for rural women (Pountney, 2023).

In the realm of ornamentals, pearls hold a distinct position among females due to their ornate appeal and their ability to enhance beauty significantly (Bustamante-Álvarez et al., 2021). Interestingly, despite belonging to the category of bivalves, which plays a crucial role in aquaculture beyond just fish, pearls have a unique allure. The roots of pearl familiarity extend back to ancient monarchies, where these prized embellishments adorned crowns, beds, and even some of the era's books. These pearls manifest in two primary types: those sourced from natural origins and those cultivated artificially to achieve diverse structures. Through controlled conditions, pearls can be synthetically generated by delicately inserting a bead into the mantle layer of bivalves. This is achieved by gently prying open their tightly conjoined valves using mechanical means. Following bead insertion, the valves remain undisturbed for several months,

culminating in the formation of the ultimate pearl over an extended period. Engaging in this activity offers the advantage of the potential for lucrative financial returns, all achieved with a relatively modest capital investment. A second significant advantage lies in the fact that this cultivation practice can be carried out within household premises, easily accessible to housewives or other female individuals with the appropriate training (Yan et al., 2019; Forrest et al., 2009).

In ancillary activities:

The ancillary activities primarily include a. pond construction, aiding in clearing off the pond construction sites or associating with the valuable decision-making process to select the site of the construction of the fish ponds, b. net fabrication, c. vermicomposting, which involves sourcing out for the production of nutritious feed for the fishes (sometimes acting as a relevant source of nutrition to phytoplanktons) or its inclusion in the fish feeds, d. handling and marketing of fish. This is regarded as a chain of activities related to the selling of said products, involving suitable market research, and other relevant tasks (Sanchirico & Essington, 2021). In fishery or aquaculture, net fabrication mentioned first is a very important aspect. This is because the proper choice of net construction materials, their colors, and tensile strengths holds a crucial factor for governing the success of harvesting fish from the ponds. The color is more prioritized, drawing significant attention, as this color, in the case of gill nets, should be uniquely transparent for fooling the fish. This facilitates their slippage through the meshes and entangles them in their gill regions. Tensile strengths, on the other hand, are more effectively dealt with in the case of drag nets or seine nets, requiring a considerable labor force for filtering a certain section of water and collecting the fish from their bags. Among the most common types of nets being used in the rural grounds, the throw-out nets (cast nets or 'khepla jal' in local terms) are most common. The weaving and knotting of these types of nets are mainly done by women sections only (Azam et al., 2013; Haque et al., 2021). Handling and marketing of the fish, on the other hand, another important ancillary activity related to aquaculture, is regarded as the chain of activities related to selling said products, involving a suitable logistic series of supply-chain activities, indulging in a thorough critical survey of the market demands. In the domestic local markets, these fishes are generally marketed by the women communities, including their assistance in their transportation to the respective sites in the urban areas also (Jaikumar et al., 2023).

Conclusion:

In conclusion, the intersection of 'Sustainable Aquaculture' and the pivotal role of 'Rural Women' holds immense promise for addressing pressing issues related to nutritional security, economic viability, and ecological sustainability. The anticipated contribution of aquaculture to rural household nutritional security underscores the need for a focused effort on the development of production systems that are not only efficient but sustainable in the long term.

The future trajectory of aquaculture expansion should be guided by a commitment to enhancing the overall efficiency of natural resource utilization. This necessitates the establishment of farming systems grounded in primary renewable resources, striking a balance between economic viability and ecological soundness. The ongoing efforts to harness the potential of the rural women population are commendable, marking a crucial step towards realizing the vision of 'Atmanirbhar Bharat' and fostering transformative changes in the lives and livelihoods of rural communities. Moreover, the imperative to utilize all available water bodies for the production of aquatic food sources with high biological value cannot be overstated. This not only addresses nutritional needs but also underscores the importance of sustainable resource management. The introduction of social aquaculture, mirroring the successful model of social forestry, with a participatory approach involving local women, presents an intriguing prospect. This approach, particularly with the utilization of small indigenous fish species, serves a dual purpose—the conservation of endangered species and the production of affordable, high-quality edible animal products, contributing to the enhancement of human health in rural areas. In essence, the convergence of sustainable aquaculture and the active involvement of rural women offers a holistic and promising avenue for achieving the broader objectives of food security, economic empowerment, and environmental sustainability in the context of rural development. This synthesis not only underscores the interdependence of these themes but also highlights the potential for transformative change through collaborative and sustainable practices.

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