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PGPR: RECENT CHARACTERIZATION AND BENEFICIAL EFFECT AGAINST FUNGAL DISEASES OF CHILLI

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Chilli (*Capsicum annum* L.) is a remunerative vegetable and spice-cum-cash crop of the Indian subcontinent. Chilli is also called red pepper which belongs to the family Solanaceae and genus *Capsicum* with chromosome number 2n = 24. It is believed to have originated in tropical America (Bosland, 1996). It is being extensively grown in regions with warm temperate, tropical and subtropical climates worldwide. Chilli produces two distinctive chemical compound groups namely capsaicinoids and carotenoids. Among these compounds, the abundant carotenoids not only contribute to its vibrant colour but also enhance its nutritional value (Perez-Galvez *et al.*, 2003). This versatile crop is recognized for its high content of essential vitamins such as C, A and B. Indian chilli has asserted its dominance in the global chilli market. Indian chilli is renowned on the global stage for its exceptional commercial attributes including its vibrant colour and distinctive pungency (Anonymous, 2021). India is the largest producer with 1.98 million tonnes and contributes 43% of world chilli production, followed by China, Ethiopia, Thailand, Pakistan and Bangladesh. In our country green chilli is cultivated in an area of 418.00 thousand ha. with an annual production of 4505.00 thousand MT and dried chilli is cultivated over an area of 852.00 thousand ha. with a production of 1578.00 thousand MT in 2021-22 (Anonymous, 2022). In India, major chilli-producing states are Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Orissa, Uttar Pradesh, Rajasthan and West Bengal (Sahitya *et al.*, 2014).

Soil microorganisms, comprising a diverse array of organisms, have gained significant attention for their role in promoting plant growth and defending against soil-borne plant pathogens. Particularly, the beneficial free-living soil bacteria are commonly known as Plant Growth Promoting Rhizobacteria (PGPR). These PGPRs confer various advantages, including the stimulation of growth-promoting hormones, phosphorus solubilization, production of siderophores and antibiotics, inhibition of plant ethylene production, and the induction of systemic resistance in plants against pathogens (Datta *et al.*, 2010). The direct interaction of these bacteria with root tissues, through root colonization, is deemed crucial for the promotion of plant growth. Employing biological control strategies with microbes, such as rhizobia, emerges as an alternative approach for disease management (PGPRs). Rhizobacteria function as antagonistic agents, reducing disease incidence and enhancing overall crop health. Consequently, addressing the escalating demand for chemical residue-free agricultural products necessitates the exploration of more effective and efficient bio-control agents (Kashyap *et al.*, 2020).

Isolation of PGPR Strains

Chilli plant seedlings, aged 5 to 6 weeks post-seeding were collected and then carefully removed from the soil. Soil samples from the immediate root zone known as the rhizosphere, were gathered. Using the serial dilution method, rhizobacterial strains were isolated from the collected soil samples and cultured on various growth media including TSA (Tryptone soya agar), NA (Nutrient Agar), CPG (Casamino peptone glucose) and Kings' B media. The plates were then incubated at 27±1°C for 48-72 hours. Bacteria exhibiting irregular and creamy white morphologies were selectively isolated and maintained on the YGCA (yeast glucose carbonate agar) medium (Kashyap *et al.*, 2020). These cultured strains are to be securely stored at 4ºC for future use in the isolation of rhizobacterial strains.

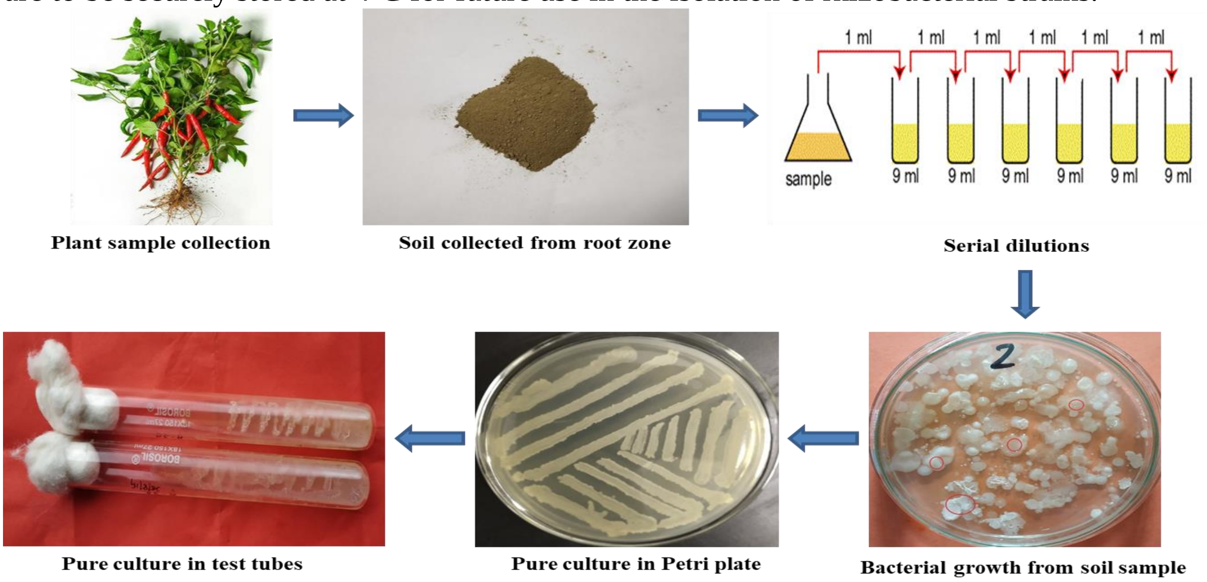


Fig. 1: Representative photographs of isolation of rhizobacteria

Morphological and Biochemical Characterization

The isolated bacterial strains underwent characterization based on morphological, cultural, staining and biochemical properties. Morphological characteristics, including colony colour, elevation, edge features and the presence or absence of capsules were assessed for each isolate. The gram nature of each strain was initially identified using crystal violet and safranin stain.

For biochemical characterization, standard microbiological techniques were employed to assess properties such as amylase, catalase, gelatin hydrolysis, citrate utilization, H_2S production, methyl red and urease. Additionally, a carbohydrate utilization test was conducted by inoculating isolated bacteria into a synthetic medium broth containing various carbohydrates like arabinose, cellobiose, dextrose, fructose, galactose, inositol, lactose, mannitol, maltose, raffinose and sucrose. The incubation period was at 27±1°C for 48-72 hours, during which the growth was measured at 600 nm (Datta *et al.*, 2010).

Characterization of Antagonism of Rhizobacteria Against Diseases of Chilli

The antagonistic potential of rhizobacterial isolates against chilli diseases was assessed using the dual culture method. The experiment involved replicating isolated chilli diseases on Potato Dextrose Agar (PDA). An actively growing pathogen mycelial plug was centrally placed on the agar medium with the PGPR strain streaked 2 cm away on both sides of the mycelial plug. The plates were subsequently incubated at 27±1°C for approximately 5 days or until the fungus leading edge in the control plate extended to the plate's edge (Dinesh, *et al.*, 2015). The radial growth of fungal mycelium was measured along with the percent inhibition of growth over untreated control and the percentage inhibition was compared with control using the formula:

$$I = \frac{C - T}{C} \times 100$$

Where,

I= Per cent growth inhibition, C = Colony diameter of pathogen in control, T = Colony diameter/radial growth of pathogen in treatment. Rhizobacterial isolates showed more than 50% inhibition against chilli pathogens.

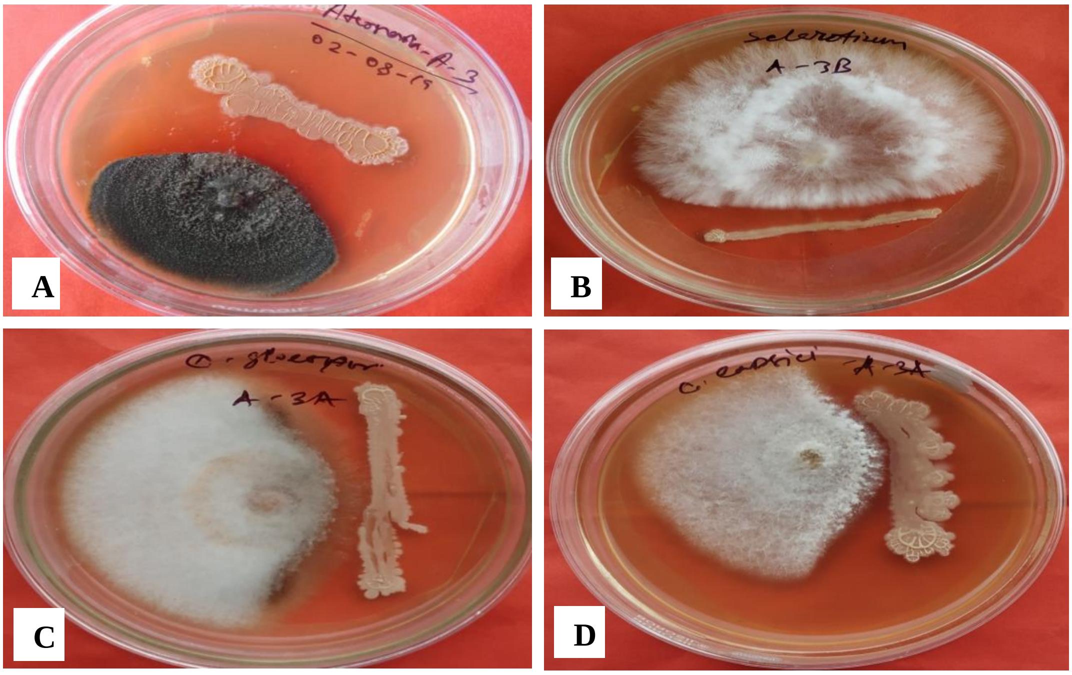
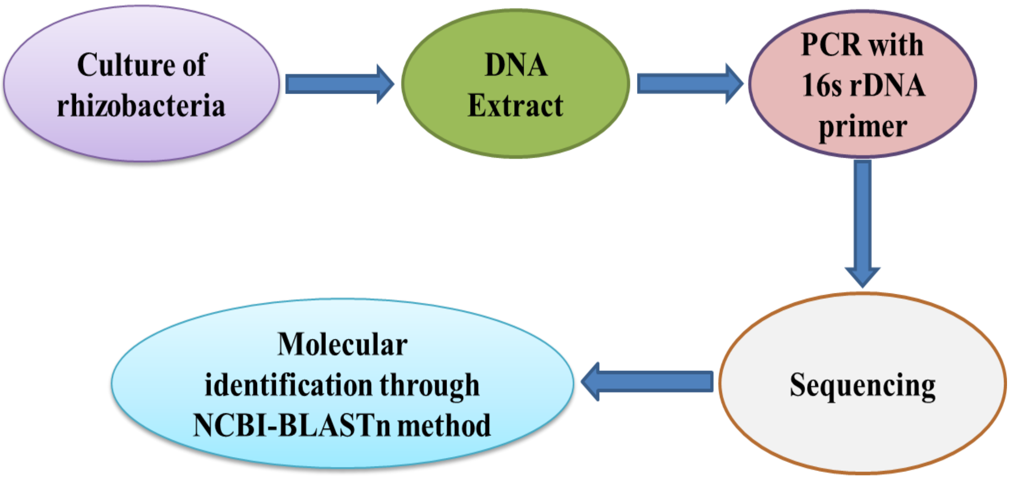


Fig. 2: Antagonistic potentiality of rhizobacteria against major fungal disease chilli. A] *Alternaria solani*, B] *S. rolfsii*, C] *Colletotrichum gloeosporioides* and D] *C. capsici*

Molecular Identification



Characterization of Rhizobacteria Isolates for Plant Growth-Promoting Traits

Indole acetic acid (IAA) production test:

To assess the production of indole-3-acetic acid (IAA) by bacterial isolates, 25 ml of rhizobacteria supernatant was collected. The pH of this solution was adjusted to 2.5 using 1N HCL in a 100 ml conical flask. Following this, an equal volume of diethyl ether was added and left to incubate in darkness for 4 hours. The extraction of indole acetic acid was carried out at 4°C using diethyl ether in a separate funnel. The organic phase was discarded, and the solvent was combined. The determination of IAA in the methanol extract was performed by mixing 0.5 ml of the extract with 1.5 ml of double distilled water and 4 ml of sampler reagent (1 ml of 0.5M FeCl3 in 50 ml of 35% perchloric acid). This mixture was then incubated in darkness for 1 hour. The presence of IAA was indicated by the development of a pink-red colour and the absorbance was measured at 530 nm using a spectrophotometer.

Siderophore production test:

The assessment of siderophore production involved the examination of rhizobacterial isolates on CAS-agar Petri dishes. Utilizing sterile toothpicks, 72-hour-old cultures were introduced to CAS-agar plates through stabbing, followed by a two-week incubation at 28°C in the absence of light. Colonies exhibiting orange zones were identified as possessing siderophore activity. Control plates containing CAS-agar but remaining uninoculated underwent identical incubation conditions, revealing no observable colour change in CAS-blue agar during the 1-15 day incubation period.

Phosphate solubilization test:

The phosphate solubilization test utilizing rhizobacteria was done using Pikovskaya's agar medium. Cultures of the most promising antagonistic isolates from rhizobacterial samples aged 48 hours, were inoculated into Pikovskaya's (PVK) broth medium and subsequently incubated at 27±1°C for 3-5 days. During the incubation period, 1 ml of each bacterial culture was transferred to separate culture tubes and 10 ml of ammonium molybdate was added to each culture ensuring thorough mixing. The solution's blue colour intensity was then measured at 600 nm using a spectrophotometer and the corresponding amount of soluble phosphorus was determined by a standard curve.

Production of Hydrogen Cyanide (HCN) test:

Rhizobacteria isolated specifically for hydrogen cyanide (HCN) production, were streaked onto a nutrient agar medium supplemented with glycine (4.4 g/L). A Whatman number 1 filter paper, was soaked in a specific solution (0.5% picric acid and 2% sodium carbonate w/v) and covered the agar. The Petri dishes were sealed with Parafilm and then incubated at 28 °C for 48 hours. The observation was focused on a colour change in the filter paper, noting the transition from yellow to light brown, brown, or reddish-brown.

Conclusion

Plant Growth Promoting Rhizobacteria (PGPR) comprises a community of bacteria residing in the soil rhizospheric zone of plants. These bacteria exhibit the ability to directly or indirectly suppress plant diseases caused by various pathogens simultaneously promoting plant growth. The rhizobacterial isolates demonstrate both plant-growth-promoting and bio-control activities. These rhizobacteria exhibit significant potential for utilization as bio-pesticides and bio-fertilizers to enhance crop health and growth. Functioning as antagonistic agents these rhizobacteria play a crucial role in reducing disease incidence and contributing to overall crop production. As the demand for chemical residue-free agricultural products continues to rise there is a pressing need to explore and implement more effective and efficient bio-control agents in farming practices which can be effectively achieved by the use of PGPRs.

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FISH CUM DUCK INTEGRATED FARMING SYSTEM IN INDIA

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Livestock integration in fish culture is a remnant of a bygone era. Mixed farming sometimes involves the use of ducks, poultry, pigs, cattle, buffalo, sheep, and goats. In wetland and watershed areas of the entire country, the use of mixed farming systems with cattle and fish has become increasingly popular due to the continual shortening of farm holdings to achieve maximum output. The use of a subsystem's a result, including cattle excrement, as an input into different subsystem, like fish culture, occurs. Animal excrement might be effectively used as fish feed, which would prevent environmental issues in addition to manure production and produce important animal protein a much-needed resource for India. States like West Bengal. Orissa, Bihar, Jharkhand, Andhra Pradesh, Assam and North Eastern states the demand for fish and fish products along with meat and animal products are very high.

Integration with fish and cattle is a very promising way to match supply and demand, and it has the potential for substantial improvements in unit area profitability, specifically for small-holding farmers. The majority of small-holder farmers are unable to meet the fish in intensive fish farming systems' demand for concentrate feed. Hence, by cultivating fish food organisms like plankton in ponds or other bodies of water in addition to feeding animal waste, integrated fish farming with livestock and the use of livestock excrement might satisfy demand. Plankton production can benefit greatly from the nutrients included in duck excrement. Fish and ducks in the treated pond have a higher chance of survival because the physiochemical characteristics of the water and soil are in a more productive range. Fish farming combined with duck farming has lower costs and higher returns than fish farming alone.

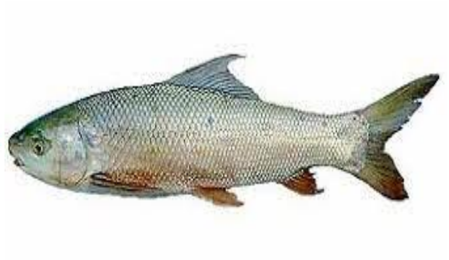
Fish Species for Integrated Duck-Fish Farming

Fish that can filter water and feed on bacteria, zooplankton, and phytoplankton are the best candidates for integrated livestock-fish farming. The goal of integrated livestock and fish farming is to use manuring to create as much plankton as possible in the water. Plankton is high in protein and provides fish with natural food. Fish species that are eaten by humans, effectively utilise phytoplankton and zooplankton, and have a tendency to feed on macrophytes are ideal for integrated livestock fish farming. Fish are categorised into three groups based on how they feed: surface feeders, column feeders and bottom feeders. It is advised to use both native and foreign species in an integrated fish farming system. The finest examples of surface feeders include indigenous species like Catla (*Catla catla*) which feeds on phytoplankton, and foreign species like Silver carp (*Hypophthalmichthys molitrix*) which consumes phytoplankton. On the other hand, an indigenous species called Rohu (*Labio rohita*) is an omnivore and a column feeder.

The native species Mrigal (*Cirrhinus mrigala*) and Kalabasu (*Labeo calbasu*) are omnivorous, but the alien species common carp (*Cyprinus carpio*) is a bottom feeder and is also a detritivorous. Exotic species that are herbivorous cover the surface, column and periphery of the feeding zone, such as the grass carp (*Ctenopharyngodon idella*).

Catla

Rohu



Mrigala

Grass Carp

Common Carp

Silver Carp

Ideal Housing for Duck- fish Integrated Farming System

Order to achieve maximum productivity and ease of day-to-day farm administration, livestock houses are built above bodies of water, particularly for ducks or poultry, close to ponds or their banks, or partially on land and in water. When duck cum fish farming is practised, the duck house may be built above the pond, allowing the excrement and feed waste to fall into the pond and feed the fish. A waterway is channelled from the animal shed to the pond when the home is built on the shoreline of a body of water, allowing the excreta or feed waste to be washed into the pond.

The ideal livestock-fish ratio in this situation needs to be kept in order to prevent excessive manuring in the water. Both birds have a slatted floor in mind. The animal waste was simply piped into the pond. One can build a slatted floor out of bamboo, wood, or another material.

Management of Pond in Integrated Livestock-Fish System

The pond ought to be able to hold water and not be located in a place that floods easily. There should be a year-round source of water or at least some water in the pond. Seasonal ponds are a viable option for an integrated farming system since they can hold water for eight to nine months. A minimum of 1.0 m of water is required, with 1.5 to 3.0 m being ideal. The ideal pH range for soil is 6.5 to 7.5. The application of lime can be used to adjust the pH of the soil if it is not at the desired level. The amount of lime to be applied is 2000 kg/ha for pH 4.0 to 5.0, 1200 kg for pH 5.1 to 6.0, 1000 kg for pH 6.1 to 6.5 (mildly acidic), 400 kg for pH 6.6 to 7.0 (more or less neutral), and 200 kg/ha for pH 7.1 to 7.5, which is mildly alkaline. Lime assists in preserving pH and eliminates and breaks down parasites. Three to four divided dosages of lime should be applied. The recommended minimum dosage for applying lime and cow dung per acre of water bodies is 1200 kg and 5000 kg, respectively.

Regular cleaning of the pond is necessary to remove aquatic vegetation that block the passage of sunshine and oxygen, and also serve as a haven for fish predators. There are several methods for removing weeds from a pond: mechanically, chemically, biologically, or by raising the water level. Mahua (*Bassicala tifolia*) can be put at a rate of 2500 kg/ha to water bodies to kill predatory fish. Unwanted fish can be removed by netting repeatedly. Fish that are adversarial can also be eliminated by using ammonia, tea seed cake, and bleaching powder.

Fish Cum Duck Integrated Farming

Khaki Campbell

Indian Runner

Stocking and Harvesting Time of Fishes

The ideal months for stocking fingerlings are June and July. The ideal water level in a pond is dependent upon both the climate in various parts of the nation and the stocking period. Fish development is inhibited below 18 to 20 inches of mercury. Fish grow slowly during the winter, but during the wet season, they grow more quickly. In addition, the water level in the bodies of water decreases significantly during the winter and dry season. It is best to stock fingerlings during the rainy season, which follows the winter months, and to harvest them before the pond becomes too short of water.

Fish are typically taken a year after they are stocked. On the other hand, fingerlings may be stocked in April and collected in November or December in areas where water bodies are still operational after eight to nine months. Three, four, or six species may be stocked in composite fish culture, depending on the market's supply of fingerlings. The fish ratios in integrated livestock and fish farming, taking into account surface, column, and bottom feeders, should be 4: 3: 3 (3 species) for Catla, Rohu, and Mrigal; in 4 species, the ratio is 3: 3: 3: 2, while in 6 species, the ratio is 1.5: 2.0: 1.5: 1.5: 1.5: 2.0, for Silver carp, Grass carp and Common carp, respectively.

For instance, since Catla and Silver carp are surface feeders, the total stocking density should not exceed 30 to 35%. On the other hand, Rohu, a column feeder that thrives in ponds with a water depth of 3 to 4 m, should be stocked at a rate of 15 to 20%, while the ratio may be as high as 40 to 45% for bottom feeders like Mrigal and Common carp. Grass carp should not exceed 5 to 10% of the total. Land grasses, vegetable waste, and banana leaves can be used as food. For an integrated duck-fish system, the Central Inland Fisheries Research Institute and the ICAR Research Complex for the NEH Region, Barapani suggested 6000 fingerlings per hectare.

Types of Livestock- Fish Integrated Farming System

Duck-cum fish farming is a very common and widespread practise in our nation, especially in the north-eastern states, Assam, West Bengal, Bihar, Orissa, Andhra Pradesh, Kerala, and Jharkhand. It is among the best systems for integrating fish and livestock. Duck droppings can land in the water directly or be collected and added to a pond for fertilisation. Fish eat spilled feed or gather duck droppings as direct meal. Ducks eat the larvae of mosquitoes, tadpoles, dragonflies, and snails, which are also a source of certain parasites.

Ducks' dabbling habit makes more oxygen available in pond water. Local ducks are not preferred in favour of high-yielding commercial ducks like Khaki Campbell or Indian Runner, which produce more eggs for maximum profit. For commercial farming, 200–240 eggs per duck year are anticipated, while for duck–fish farming, 250 ducks per hectare are advised on average.

Benefits of Fish Cum Duck Farming

Raising ducks allows ponds to fully utilise their water surface. Fish ponds offer ducks a great environment that shields them from parasite illness. Ducks aid in the growth of the fingerlings by feeding on predators. Raising ducks in fish ponds lowers the amount of protein required in their diets to 2-3%. Duck droppings enter the water quickly and add vital nutrients that boost the biomass of naturally occurring food species. Duck feed waste (about 20 to 30 grams per duck per day) can be used as manure or fish feed in ponds to increase fish productivity. Ducks do the manuring, and their droppings are dispersed evenly and not piled up. Ducks' digging for benthos causes the nutrients in the soil to disperse into the water, which in turn encourages the growth of plankton. As they swim, play, and chase about in the pond, ducks act as bio aerators.

Aeration is facilitated by this disruption of the pond's surface. Ducks' body weight and feed efficiency rise, and fish may be able to use the leftover feed. The clean environment of fish ponds boosts the survival rate of ducks raised in them by 3.5%. Fish production can be increased to 37.5 kg/ha by using duck droppings and the leftover feed from each duck. Ducks control aquatic vegetation. Activities related to duckeries don't require any additional land. Fish, duck eggs, and duck meat are produced in large quantities per unit of time and water area as a result. With less investment, a huge reward is guaranteed.

Stocking Density of Fish

After the pond's water has undergone a thorough detoxification, it is filled. A species ratio of 40% surface feeders, 20% column feeders, 30% bottom feeders, and 10%–20% weedy feeders is recommended for good fish yields. Stocking rates range from 6000 fingerlings/ha. It is possible to cultivate mixed cultures of just Indian main carps using a species ratio of 40% surface, 30% column, and 30% bottom feeders. Due to the harsh winters that hinder fish growth in the northern and north-western parts of India, ponds should be filled in March and harvested in October or November. Ponds should be supplied in June through September and fish should be caught after a year of raising them in the south, coastal regions, and north-eastern states of India, where winters are moderate.

Use of Duck Dropping as Manure

The ducks are allowed to roam freely around the surface of the pond from 9 AM until 5 PM, at which point they naturally manure the entire area by dispersing their droppings throughout it. Every morning, the duck house's voided droppings are gathered and added to the pond. per duck excretes 125–150 grams of droppings per day. 200–300 ducks per hectare at stocking density produce 10,000–15,000 kg of droppings annually, which are recycled in ponds covering one hectare. On a dry matter basis, the droppings comprise 81% moisture, 0.91% nitrogen, and 0.38% phosphate.

Duck Husbandry Practices

The following three types of farming practice are adopted.

I. Raising large group of ducks in open water

This kind of duck raising is known as grazing. When using the grazing approach, a flock of ducks typically consists of around 1000 ducks. During the day, the ducks are left to graze in huge bodies of water such as lakes and reservoirs, but at night they are confined in enclosures. In huge bodies of water, this is a useful way for increasing fish productivity.

II. Raising ducks in centralised enclosures near the fish pond

A centralised duck shed with a cementated area for wet and dry runs outside is built next to fish ponds. Ducks are typically stocked at a density of four to six per square metre. Every day, the wet and dry runs are cleaned. Waste water is permitted to enter the pond following cleaning of the duck shed.

III. Raising ducks in fish pond

This is the normal operating procedure. To create a wet run, the pond embankments are partially caged with net. In order to prevent ducks from escaping below the walled net, the net is positioned 40–50 cm above and below the water's surface, allowing fish to enter the wet run.

IV. Selection of ducks and stocking

Since all domesticated races of ducks are unproductive, care must be taken while selecting the type to be raised. The Sylhet Mete and Nageswari.The ducks are two of the most significant Indian breeds. Although they are not as good layers as the exotic Khaki Campbell, the upgraded breed, Indian runner, has been proven to be the best ideal for this purpose due to their hardiness. Another thing to think about is how many ducks a one-hectare fish pond needs to be properly manured. It has been discovered that 200–300 ducks will yield enough manure to fertilise one hectare of water used for fish culture. After giving them the appropriate preventive medications, two to four-month-old ducklings are housed on the pond to protect against epidemics.

V. Feeding

While ducks in open water can obtain naturally occurring food from the pond, this is insufficient for their healthy development. The ducks can be given additional feed at a rate of 100 gm/bird/day, which is a blend of any regular balanced poultry feed and rice bran in a 1:2

weight ratio. Two times a day, one in the morning and one in the evening, the feed is administered. Feed is administered in the duck house or on the pond embankment, and any spilled feed is emptied into the pond Feed and water should be placed in receptacles deep enough for the ducks to dip their bills into. Without water, the ducks cannot eat. Since ducks are easily contaminated by aflatoxin, long-term storage of mouldy feed is not recommended. Aflatoxin contamination is caused by Aspergilus flavus, which can be removed from feed by treating maize and ground nut oil cakes.

VI. Egg laying

The ducks begin to lay eggs when they turn 24 weeks old, and they keep on laying for two years. Ducks only lay their eggs at night. For egg laying, it is usually preferable to have some hay or straw in the duck house's corners. Every morning, when the ducks are released from the duck house, the eggs are gathered.

Health Care

Compared to poultry, ducks are comparatively less susceptible to illnesses. Ducks native to the area have a higher disease resistance than other types. Just like with poultry, ducks require proper sanitation and medical attention. The diseases that can spread among ducks include keel disease, duck cholera, hepatitis, and the duck virus. It is necessary to vaccinate ducks against diseases like duck plague. Birds that are sick can be identified by their sounds, any decrease in their daily feed intake, watery discharges from their eyes and noses, sneezing, and coughing. The sick birds need to be isolated right away, kept out of the water, and given medication.

Harvesting

A portion of the table-size fish are harvested, taking into account the demand for fish in the nearby market. The pond should be replenished with the same species and quantity of fingerlings following partial harvesting. The last harvest is completed after a year of raising. Fish yields of between 3500 and 4000 kg/ha/yr and 2000 and 3000 kg/ha/yr are typically attained with stockings of six and three species, respectively. Every morning, eggs are collected. Ducks can be sold for flesh in the market after two years. There are roughly 18,000–18,500 eggs and 500–600 kg of duck meat produced.

Conclusion

Fish Cum Duck Culture was boosting for plankton production in culture ponds, duck manure is a very good way to increase fish pond productivity. Fish and ducks have good survival rates in treated ponds because the water's physio-chemical parameters are in a more productive range. Everything mentioned above has helped to maximise the fish output in the control pond. Fish farming in conjunction with duck farming has a higher cost-benefit ratio than fish farming alone.

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MEASURING THE ROLE OF FORESTS AND TREES IN HOUSEHOLD WELFARE AND LIVELIHOODS

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The well-being and livelihoods of communities are significantly influenced by forests, which are known as the lungs of the planet. According to FAO (2016), Forests is defined as land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

Particularly, wood products are frequently referred to as forest products even though they may have originated in woodlots, agro forestry systems (such as home gardens and silvipastures), fallows, or other tree-based vegetation systems that are not strictly speaking considered to be forests. While defining the economic level of forest income, there is often confusion as to apply narrow forest concept or the ample forest product concept, however both forms of income delimitation may actually be of use to natural resource managers and policymakers. While the precise source of income from forests and trees may vary, in terms of welfare be of secondary concern for the management of forest areas, given that they provide revenue. It will be crucial to understand capacity. For instance, if a region that needs to be protected offers a large source of extractive income for the community; denying anyone access could have inconsistent effects on welfare. Furthermore, forest systems can offer significant ecosystem services (such as the preservation of biodiversity, carbon stocks, or recreational benefits) that aren't always replicated by tree-based systems found outside of forests.

When we refer to forest products, we primarily mean naturally occurring, unplanted, or wild products that are harvested from old-growth, secondary, and regenerating natural forests as well as farmed or planted products from managed plantation forests. The term forest products refers to a variety of natural tree-based products (NTFPs), plants (like tubers), animals (like bush pigs), and timber. But forest and tree products also include non-forest tree products from home gardens, farm trees, and other agro forestry systems.

Non-forest tree-based and non-forest natural systems are the two categories into which non-forest systems fall. Savannahs, fallows, and cultivated trees found in agroforestry systems are examples of non-forest tree-based systems. Determining the boundary between what is considered agriculture and forest can be difficult since it frequently lies between or below different definitions of land cover hence determining its significance can also be difficult. Products and revenue from the non-forest and wild systems are referred to as wild products and wild product income for the purpose of simplicity.

Categories of Forest Income

- The first source of natural forest income comes from extractive, environmental sources. These sources are naturally found in old-growth, secondary, and regenerating natural forests and are derived from forest species that are rapidly growing (or little managed).
- Second, the products found in well-managed plantation forests provide the source of planted forest income. The primary source of income in a smallholder rural developing country is undoubtedly the forest environment.
- Non-forest tree income from woodlots, farm trees, home gardens, and other agroforestry systems.

A significant differentiation to be made is the exclusion of resources that are cultivated and harvested from aquatic environments, which are currently covered under the LSMS-ISA agricultural and fisheries modules, from agricultural lands (cropland, pasture, crops harvested in agroforestry and silvipasture, fowl areas).

Crucially, the forestry and agricultural modules may both include cultivated trees from plantations as well as trees on farm plots and other agroforestry systems. In the long run, the NSO and other module users will have to choose which tool to use to properly capture this product, though generally speaking, we would contend that the forestry modules will offer a natural setting to evaluate these income flows in sufficient detail.

It is recommended that users utilize the Central Product Classification for products and the ISIC code for all economic activities when implementing the survey, as these are internationally recognized classifications' accepted codes and definitions. Although all products can, in theory, be assigned to pre-existing classification codes, the survey analyst runs the risk of overloading residual categories by grouping particular forest products into general categories like gathering non-wood forest products.

Methods of Data Collection

The forestry modules contain questions aimed at households at the community level as well as at individuals. As a result, questions have been assigned to the appropriate modules based on whether it is anticipated that the variable being studied will change within the community. It will be less expensive to gather data at the community level rather than using resources to conduct a household survey if the variable is not anticipated to change at the household level. It will occasionally be helpful or required to gather data at both levels. When analyzing individual households, community-level data can offer contextual information and potentially inform the creation of household surveys.

On the other hand, data gathered at the household level will be useful for community-focused studies as it can offer insights into particular interhousehold variations, such as how various kinds of households in the community perceive and follow local laws governing resource usage. In a community study, having household-level data also lessens the possibility of making poor judgments based only on aggregated data.

In the community questionnaires (standard modules on most important products and seasonal calendar, and extended modules on forest institutions and community environmental services), focus groups (FGDs) are a frequently used technique.Village meetings and focus group discussions (FGDs) are valuable tools for gathering qualitative data that is significant because they capture values and importance that go beyond immediate economic gain, such as those associated with forest and wild products. Small FGDs give participants more room to discuss and reach an agreement. An appropriate number of participants was considered to be 13 for the FGDs in the Indonesian field-testing of the forestry modules, as reported by Bong et al. (2016). This allowed for an inclusive and productive discussion. These sections could be finished in conjunction with a key informant to take into consideration the time and resource constraints that NSOs may encounter when implementing FGDs at the community level.

The community instrument uses key informant interviews (KIIs) to gather data on things like pricing and quantitative units. Village officials and other stakeholders who have been part of the community for a long time and/or who are aware of changes and patterns in the socioeconomic, political, and cultural conditions in the area are frequently involved in KIIs. They are frequently excellent sources of information, particularly in the absence of written records.

Secondary data are valuable resources for contextual information about village land uses (forest, farms), demographics (population, age distributions), and infrastructure (roads, schools). Implementers of surveys may also utilize observation or measurement to put the gathered data into context. In actuality, it's critical to triangulate data by gathering data using a variety of sources and techniques in order to guarantee data accuracy.

Even in LSMS surveys, perception data collection also known as subjective data is a commonly used technique to gather people's expressed opinions or perceptions on a given subject.

Data Collection Issues

- Difficult concepts - Enumerators may discover during a survey that some terms and concepts are poorly understood by respondents, possibly as a result of inadequate communication. Enumerators and pre-test survey instruments must therefore be trained in order to rectify and modify questions appropriately.
- Seasonality and recall period- Since forest-based activities frequently exhibit strong seasonality; care must be taken when scheduling the survey and remembering key points during the data collection process. Ideally, surveys should be conducted more frequently and with recall periods that are shorter than annual (e.g., quarterly) to better capture seasonal variations in forest uses. In national surveys, this will not always be feasible, though. Shorter recall periods are ideal for recording information about routine, non-seasonal transactions and activities like gathering wood fuel; longer recall periods may be necessary for irregular activities like seasonally harvested NTFPs or a significant flooding incident.
- Distinguishing product origins- The categories for origin consist of managed plantation forests (code = 3), old-growth natural forests (code = 1), secondary/regenerating natural forests (code = 2), and non-forest tree-based wild

systems (code = 4), non-forest tree-based cultivated systems (code = 5), and non-forest natural systems (code = 6), such as savannah and fallows. When analyzing data from a survey with a wide range of origins, issues with data validation and comparability may arise. However, tying the products' origins to the places where they are gathered will draw attention to the regions that might be under more strain due to resource use and the sustainability of the resource base.

- Measurement unit and price - When it comes to estimating income and performing intersite comparisons and aggregations, the widespread use of non-standardized weight or volume measures in local markets across nations for the trade of forest and wild products may pose challenges. Data entry in local units is made possible by the forestry modules, and the Codebook contains a complete list of codes. Keeping track of local units will guarantee more accurate data. To enable data analysis and comparison across communities, regions, and even nations, local measurements must be standardized to common units.

Conclusion

As essential collaborators in promoting household well-being and livelihoods, forests merit a thorough analysis of assessment techniques. This method guarantees a sophisticated comprehension that honors the intricacies of regional ecosystems and human relationships. By deepening our knowledge of the functions of forests, we are better able to make decisions that strike a balance between the demands of modern life and the necessity of protecting these essential natural resources for future generations.

Variations in concepts related to forests, resource ownership, and resource use are likely to occur among study sites due to differences in socioeconomic, biophysical, and cultural factors. Consequently, we require a shared list of definitions that are recognized globally that can be methodically used to the greatest extent possible to enable intersite contrasts.

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RISING TOGETHER: A PARTICIPATORY PATH TO RURAL POVERTY ALLEVIATION

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Amidst the hustle and bustle of modern life, the quiet persistence of poverty serves as a stark reminder that progress is meaningful only when it is shared by all. Poverty is a global concern which needs to be addressed as it reaches far beyond the geographical boundaries touching the lives of individuals across continents. Poverty has an impact on every part of the world, from small towns to large cities, and this interconnectedness highlights the need for collaborative efforts and a united front in the pursuit of a more equitable and inclusive future for everyone.

Participatory Approach for Poverty Reduction

Participatory frameworks, approaches and methods allows the rural people to become active stakeholders and ensure that rural poverty interventions better respond to their needs and interests. To involve the stakeholders, stakeholder analysis is carried out where the main stakeholders are identified. A targeting strategy identifies the specific stakeholders for participation in the policy-making. Target groups may include any vulnerable people or groups like women, youth, resource-poor households, ethnic minorities etc. who may be the beneficiaries of any policy or programme.

A participatory framework acts as an instrument that promotes the inclusion of marginalized populations in the decisions and actions that impact their lives. It will provide the poor to become active participant and exercise control over their own livelihoods, boosting their awareness and self confidence. Through participatory framework, it ensures an effective and sustainable poverty reduction policies and will ultimately empower the poor. Some key issues affecting the participatory frameworks are such as politics & power balance, governance, accountability and scale. Politics and power balance implies the power disparities from the home to the national level which prohibits the inclusion of vulnerable people. Governance plays a major role in creating an conducive institutional space where the rural poor can participate, preventing the elite capture. Accountability means the ability of the rural poor to hold policymakers and programme administrators accountable and the scale refers to the extent of participation, ranging from local to regional and national levels.

Also, participatory research is crucial for designing effective participatory interventions to reduce poverty. Participatory research will provide new insights into rural poverty and allows individual to gain ownership of data about their lives. It promotes a collaborative and inclusive approach to understand and address complex issues. Some common participatory research approaches are Rapid rural appraisal (RRA), Participatory rural appraisal (PRA) and Participatory research action (PAR).

Some other participatory methods include digital storytelling, participatory mapping, participatory photography and videography, focus group discussions etc.

RRA	PRA	PAR
First collaborative and Time-efficient approach	Emphasizes community involvement in gathering data.	Experimentation and action
Data is collected from the target group but analysed by outsiders.	Local people have ownership of process and end products.	Action and reflection with participants engaging in the research process to address real world problems.

There are several benefits of using participatory research methods such as it encourages local people to take ownership of the interventions, develops local capacity, acknowledges stakeholders' concerns, develops appropriate technologies and so on.

Rural people participate in participatory method and other aspects of reducing rural poverty both individually and through organizations. Rural people can collaborate with different rural organizations or agencies, such as Cooperatives and producer organizations (POs), Market-based associations, social movements etc. Cooperatives acts as an autonomous association of people who unites voluntarily to meet their common economic, social and cultural needs. Producer organizations are formal or informal associations created by and for their member. Market based associations comprises of category of rural organizations such as trader associations and commodity associations. Social movement is a collective action taken by a group of problem to raise any issue or for opposing any ideas or to tackle social problems.

Collaborating with rural organizations will empower the marginalized people, provide access and control over the natural resources, ensures access to markets, assets, information and knowledge and also increases political capital. For collaboration, different strategies can be adopted such as Public-private partnerships, partnerships with research institutions, multistakeholder partnerships etc.

For engaging rural people in the decision making for participatory rural poverty reduction policies or programmes, it becomes necessary to improve the skills and knowledge of rural people through capacity development.

According to OECD, Capacity development is the 'process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time'. Since capacity building equips people with the information and skill they need to obtain a sustainable livelihoods, it is essential for reducing poverty. Building stronger communities promotes self-sufficiency and increases the capacity of rural poor. Each stakeholder has different needs and so requires specific types of services. All these varying needs of different stakeholders are interdependent.

Therefore, capacity development strategies should be tailor-made which ensures that different needs of the stakeholders are being met.

Capacity development services are provided by public sector (Govt., NGOs, donors etc.), private sector (companies, distributors etc.), Producer organizations. Trainings, mentoring and coaching, advisory services, multistakeholder platforms and consultative fora are some of the common methods which can be used individually or by combining with each other for capacity development.

Empowering rural communities to overcome poverty necessitates addressing a set of challenges in delivering effective capacity development. The challenges are lack of awareness about target audience's conditions, lack of sensitivity to local stakeholder's timing, top-down decision-making approach and so on.

Conclusion

Adopting a participatory approach in decision-making for policies and programmes aimed at poverty reduction is imperative. By involving diverse stakeholders, including those directly affected by these initiatives, policy makers can tap into a wealth of local knowledge and firsthand experiences. This inclusivity not only fosters a sense of ownership and empowerment within communities but also ensures that interventions are contextually relevant and sustainable. A Participatory framework promotes transparency and accountability, fostering a collaborative environment that is crucial for the success of poverty reduction efforts. Therefore, promoting a participatory approach ensures better effectiveness and responsiveness of policies and programmes, contributing to more meaningful and lasting impacts on the journey towards alleviating poverty.

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MILLETS: SEED PRODUCTION GUIDE

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A cereal grain called millets is one of the oldest known foods to humans, perhaps even the first cereal grain used for domestic purposes. The crops provide food for people in areas where hunger is a common occurrence. Millets of many types, such as sorghum, pearl millet, finger millet, foxtail millet, little millet, barnyard millet, proso millet, and kodo millet, are farmed in India. Most of the farmers do cultivation of these crops indifferently because these crops neither get any special commercial value nor do the general public have special interest in eating them. But consider it the irony of the method or the mental tragedy of the civilized society that some of these crops are paramount in terms of nutritional value, even if their taste is not tempting. In order to encourage the growth of millets, some efforts have been made in many parts of India, particularly in regions most severely impacted by climate change. India designated 2018 as the "National Year of Millets." The Food and Agriculture Organisation (FAO) Council of the United Nations later agreed with India's proposal to recognise 2023 as the "International Year of Millets" in order to raise awareness of millets around the world and reintroduce these nutritious cereals to the food supply (Kumar *et al.* 2021). Seed production of any crop variety is an important aspect of its successful cultivation. Simple and accessible details of millet crops, such as seed production method and precautions to be taken during seed production is not there. Written knowledge of methods and precautions for seed production will prove useful to the farmers. That's why this seed production guide is being addressed for interested farmers and following is the description of seed production of these crops.

1. **Amaranth :** Chaulai, Sihul, Siryara, Rajgira, Bathu, Bithu, Tulsi, Dankhar, Kalji

Amaranth is grown to meet both the requirements of greens and grains. Amaranth can be grown satisfactorily from sea level to an altitude of 3000 meters. It grows well in the land where water seeps well. Minerals like iron and calcium are found in plenty in its greens. Amaranth is cultivated for grains in the valleys of high hills. Although in some places it is also single-cultivated, but mixed cultivation of amaranth with maize, kidney beans, bharas, potato, urd, soyabean, ragi and colocasia is found in different parts of our state. Its plants are able to withstand water scarcity or drought and other unfavorable conditions strongly. In fact, Amaranth grows best in hot and dry conditions. On the contrary, good moisture is always needed for greens and amaranth.

Varieties: Among the advanced varieties of Amaranth, Annapurna, Suvarna are high yielding varieties. PRA 8801, PRA- 9401 and IC 35407 are also good yielding varieties. There are early ripening varieties and at some places it ripens even in 100 days, mostly it ripens in 100-120 days.

Rouging : In the crop being grown for seed production, it is necessary to take special care that only plants of that variety of the crop for which we want to prepare seeds should grow in them. If any plant looks different or strange, it is necessary to uproot such plants before flowering. Early weeding is also mandatory and one hoeing is required after 30-35 days of sowing.

Harvesting and threshing: Normally the crop is ready in 120-150 days. When ready, the grains ripen on the bunches/ bundles, but the bundles and plants look green. The problem of seed dispersal comes in the way of waiting for the plants to ripen, so the green ones should be cut on time. After drying, seeds can be obtained by beating with sticks or by running animals, collecting the grains, sifting and grinding. Keep in mind that the seed should be very clean.

2. **Pearl millet:** Bajra, Bajree, Sajje, Kambu, Sajja

There are several types of millet, but pearl millet is one of the most widely grown. African and Indian subcontinents have grown it since ancient times. It is possible to grow pearl millet at altitudes between 50m and 2000m above mean sea level. India has used it as a main food source for thousands of years. Due to the way it appears when it is processed into flour, bajra millet is also known as pearl millet. Protein, fibre, calcium, iron, magnesium, and vitamin B are all present in it, giving it a high nutritional value. The pearl millet crop is an annual summer crop well suited to rotation and double cropping. A wide range of soil types, from deep sands to clay loams, can be used to cultivate pearl millet. However, deep, productive soil with good drainage produces the highest yields and grain quality.

Varieties: These are the new varieties: ICTP 8203, GB 8735, ICMV 221 Wbr, ICRI- Tabi, Jira Ni, as well as hybrids ICMH IS 14002, ICMH IS 14003, ICMH IS 14009, ICMH IS 14011, ICMH IS 15012, ICMH IS 16265 and ICMH IS 16266 of pearl millet with high iron content developed from ICRISAT.

Rouging: A healthy crop requires effective weed management, and early emerging weeds need to be particularly well-controlled. Planning your crop rotations so that pearl millet follows a crop where grass-controlling herbicides were applied may be advantageous.

Harvesting and threshing: Grain can be harvested as soon as 40 days following flowering. Initiate harvesting when the seed moisture level falls below 15%. To increase the effectiveness of harvesting, dry both the leaves and the stems with a desiccant before using them. To achieve an effective harvest, specific modifications in the combine are required since pearl millet grain cannot readily detached from the seed head.

3. **Sorghum:** Jowar, Jwari, Juari, Jola, Cholam, Janha, Jonnalu, Milo, Chari

After maize, rice, wheat, and barley, sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most significant cereal in the world. A sorghum plant grows from seed, and its parts are widely used in different ways. Sorghum, an indigenous plant to Africa, will continue to be an essential staple diet for a lot of rural areas even if commercial requirements and applications shift over time. Sorghum can be grown in a variety of environments, but it prefers warm climates. It is also commonly cultivated at elevations up to 2300m in the tropics and in temperate regions. Sorghum can be a nutritious supplement because it is high in protein, devoid of gluten, and packed with antioxidants. Since the hull of sorghum is edible, the entire grain can be consumed. This implies that along with many other essential elements, it also provides greater fibre. Various types of soils can be used to grow sorghum. The ideal soils for sorghum production are loamy soils which are deep, fertile, and well-drained. However, it can works well in dry weather and shallow soils.

Varieties: The recently produced national varieties/hybrids are CSV-216R, CSV-18, CSV-22, CSH-15R, CSH-19R, and CSV-26 are just a few of the many better varieties for the rabi season than the local variety M35-1. Whereas, CSH 27, CSH 30 and CSH 35 are the best hybrids of kharif sorghum that are released at national level.

Rouging: For about 35 days after planting, keep the crop free of weeds. A two or three time inter-cultivation should be performed after sowing to control weed growth.

Harvesting and threshing: When sorghum achieves normal maturity, it should be harvested right away to lower the likelihood of mould growth. The remaining plants are harvested after the panicles. The grains are extracted from the harvested panicles by either human or machine threshing after the panicles are dried in the field for roughly a week. The grains are dried in the sun for 1-2 days after threshing to get the moisture level down to 10-12%.

4. **Proso millet:** Chena, Barri, Vari, Baragu, Variga, Pani Varagu, Cheena, Cheno

Proso millet (*Panicum miliaceum* L.) is a popular and significant member of the Gramineae family. Common millet is another name for proso millet. It is believed that it was domesticated in central and eastern Asia. As a result of its quick maturation, it is well suited to the hot summers that prevail in the tropics and at high elevations, where the growth season is very short and the soil is marginal and deficient in nutrients. These crops are grown as high as 2700 meters above mean sea level in the Himalayas. Growing it in areas with sparse rainfall is possible due to its drought resistance. Proso-millet is a rich source of niacin, B-complex vitamins, folic acid, P, Ca, Zn, Fe, essential amino acids, starch, and phenolic compounds (Gowda *et al*. 2022). A wide range of soil textures are suitable for growing proso millet, from sandy loams to clay soils of black cotton. The best conditions for growing proso millet are well-drained beds of loam or sandy loam that are free from stones and gravel, have a high level of organic matter, and are well-drained.

Varieties: Co-5, TNAU 151, TNAU 164, TNAU 145, TNAU 202, CO 4, K2, CO 3, CO 2, GPUP 21, GPUP 8 are some of the best varieties of proso millet with high yield potential.

Rouging: In order to yield quality seeds, the field should be kept weed-free for at least 35 days after planting. For removing broadleaf weeds, hand weeding is an option.

Harvesting and threshing: Once the earheads are fully developed, the harvesting should be done. Normally, 65 to 75 days after seeding, the crop is ready for harvest. When two thirds of the seeds are ready, the crop should be picked. The harvested earheads are threshed either manually or by bullocks crushing them under their feet. Winnowing is used to further clean the threshed grains. It is possible to delay threshing until the grain has a moisture content below 13%

5. **Finger millet:** Ragi, Mandika, Marwah, Mandua, Nagli, Nachni, Ragulu, Chodi, Keppai

Eleusine coracana is an annual herb, is farmed extensively as a cereal crop in the arid and semiarid regions of Africa and Asia. In India, it is also known as ragi. The mountains of Ethiopia and Uganda are home to finger millet. The ability of finger millet to endure cultivation at altitudes exceeding 2000 m above sea level, its strong drought tolerance, and the lengthy grain storage period are fascinating crop traits. The states that grow the most finger millet in India are Karnataka and Uttarkhand, Maharashtra, Orissa, Jharkhand, Andhra Pradesh, and Tamil Nadu. Finger millet grains are very nutritious and known for having the highest concentration of calcium (344 mg/100g grain), iron, zinc, dietary fibre, and essential amino acids. The crop can be produced in a variety of soils and at elevations ranging from the mean sea level to the foothills of the Himalaya. The crop is capable of withstanding a certain level of alkalinity. Alluvial, loamy, and sandy soil with adequate drainage are the best types of soil for finger millet.

Varieties: There are various improved varieties of finger millet grown all around the world. Some of the varieties grown in India are CO 9, CO 13, TRY 1, Paiyur 1, Paiyur 2, GPU 26, GPU 45, VR 708 etc.

Rouging: It is important to eradicate weeds when a plant is young and developing. At 25 days after sowing, hand hoeing should be done for inter-cultivation and weeding.

Harvesting and threshing: Depending on the area and the variety, the crop develops in approximately 95 to 110 days for early varieties and 115 to 125 days for medium to late varieties. With standard sickles, the ear heads are picked, and the straw is chopped closely to the ground. After being piled up, earheads are dried for three to four days in the sun. After thorough drying, threshing is done. In some locations the entire plant with the ear head is chopped when it is raining, piled, and then threshed.

6. **Foxtail millet:** Kangni, Kakum, Kang, Rala, Navane, Korra, Keppai, Thenai, Kaon, Kora

The annual grass foxtail millet, scientifically known as *Setaria italica* (also known as *Panicum italicum* L.), is cultivated for human consumption. The earliest evidence of foxtail millet cultivation was discovered in Cishan, China, along the historic Yellow River route. Foxtail millet can be cultivated at an altitude of 2000 m above mean sea level. Foxtail millet can be grown in temperate and tropical climates with low to moderate rainfall. It is also intolerant of intense drought or standing water. Foxtail millet is a powerful source of energy since they are stuffed with excellent calories. Foxtail millet may thrive on a variety of soil types, including sandy and heavy clay soils, although it requires a moderately fertile, well-drained soil for high yields.

Varieties: Several varieties with high yield potential have been released for foxtail millet. Some of these varieties are SiA 3088, SiA 3156, SiA 3085, Lepakshi, SiA 326 etc.

Rouging: For higher yields, it is advised to do two inter cultivations and one hand weeding in line-sown crops. In a broadcast crop, two manual weedings should be done at 20–25 DAS.

Harvesting and threshing: Depending on the cultivar, the crop matures about 80 to 100 days. When the earheads are dry, the crop is harvested by either sickling the entire plant or picking the individual ears. Threshing the crop and grading the seeds are the part of post-harvesting.

7. **Kodo millet:** Kodon, Kodra, Harka, Arikelu, Arika, Varagu, Kodo, Kodua

The annual grain *Paspalum scrobiculatum*, also known as Kodo millet or Koda millet is grown primarily in Nepal as well as in India, the Philippines, Indonesia, Vietnam, Thailand, and West Africa, where it originated. Kodo millets are often grown in tropical and subtropical climates up to an altitude of 2100 m. It is cultivated in areas with 500–900mm of annual rainfall. Kodo millet has a high lecithin content and is very simple to digest. From stony and gravelly upland poor soils to loam soils, kodo millet is grown. Organically rich, deep, loamy soils are suitable for growing crops and yielding larger yields. The crop needs well-drained soils with a sufficient amount of moisture to grow consistently.

Varieties: JK-13, JK-48, GK-2, Vamban, IPS 147-1, JK-62, JK-76, GPUK-3, and Kherapa are a few of the important kodo millet's varieties.

Rouging: Weeds must be managed when plants are still in the early stages of development. Usually, two weedings separated by 15 days are enough. In a line-sown crop, weeding can be done with a hand or wheel hoe. Around 20 and 35 days following sowing, two hand weedings should be done.

Harvesting and threshing: In northern India, the crop matures for harvest during the Kharif season in the months of September or October. Once the ear heads are physically mature, the harvest is finished. The crop is typically ready for harvest in 100 days. Before threshing, plants are chopped just above the ground, bunched, and stacked for a week. Additionally, the threshed grains are cleansed by winnowing.

8. **Little millet:** Kutki, Shavan, Sava, Same, Save, Samalu, Samai, Sama, Gajro, Kuri

The Little millet (*Panicum sumatrense*) is a member of the Gramineae (Poaceae) family. Little millet is a herbaceous annual that can reach a height of 30 cm to 1 m and can grow either straight or with folded blades. India domesticates and distributes little millet to Nepal, Pakistan, Sri Lanka, eastern Indonesia, and western Myanmar. In order to achieve good crop yields and proper development, the average temperature should be between 26 and 29°C. It can be grown upto an elevation of 2100 m above mean sea level. Little millet is a traditional crop in India, it is a nutritious grain that is very popular among health-conscious people. Magnesium is abundant in little millet, which benefits cardiovascular health. Little millet can thrive on a variety of soil types, including clay, loam, and sandy soils. The desired soil is one that has a lot of organic content and is good at holding moisture.

Varieties: In diverse regions of the world, thousands of advanced and hybrid types are grown. Only a few high-yielding cultivars may be able to be listed here: JK-4, JK-8, JK-36, OLM 203, JK, TNAU 63, CO 3, CO 4, K1, OLM 203, GV2 and GV1.

Rouging: For effective weed management, two inter-cultivations, one hand weeding in a line-sown crop and two hand weeding in a broadcast crop are required.

Harvesting and threshing: Crops for the Kharif season mature in September and October, while those for the Rabi season mature in January and February. When the seeds have reached maturity and the plant has gone yellow or brown, little millet becomes ready for harvest. Normally, it happens three to four months after planting. The seeds are ready for harvest if they are tough and challenging to smash. In little millet farming, threshing is the process of removing the grain from the plant's stem and chaff. It can be carried out manually by bashing the plants with a stick or mechanically by using a thresher.

9. **Barnyard millet:** Sanwa, Jhangora, Bhagar, Oodalu, Udhalu, Kodisama, Kuthiraivali

The ancient millet crop known as barnyard millet (*Echinochloa* species) is farmed around the world in warm, temperate climates. It is very popular in Asia, particularly in India, China, Japan, and Korea. In the northern hills of India, particularly in the foothills of the Himalayas, barnyard millet is extremely common. Due to its drought tolerance, barnyard millet is planted as a rainfed crop. It can thrive in situations where there is some water logging. It is grown on the Himalayan slopes between sea level and 2000 metres above mean sea level. The barnyard millet, also known as Sanwa rice, has significant concentrations of minerals, protein, iron, calcium, and vitamin B complex. The crop can be cultivated on a variety of soil types, but sandy loam soils that drain well and are somewhat productive are preferable. Barnyard millet cannot tolerate standing water. Lateritic loams are the ideal habitat for it.

Varieties: Many different types of barnyard millet have been introduced recently. For various states, a number of cultivars with high yield potential have been released such as CO 1, CO 2, VL 172, VL 207, RAU 11, RAU 9 etc.

Rouging: It is recommended to perform two intercultivations and one hand weeding in line sown crops. In a broadcast crop, two-handed weeding is recommended.

Harvesting and threshing: When the panicle dries out, the crop is ready to be harvested. With the use of sickles, it is chopped at the ground level and stored in the field for roughly a week. Three to four pickings are generally needed for the collection of ear heads from the field. Trampling is done by using bullocks or any other suitable threshing machine.

Conclusion

In conclusion, millets cultivation offers a promising avenue for sustainable agriculture and food security. The comprehensive millets seed production guide presented in this article serves as a valuable resource for farmers looking to enhance their yields and overall crop quality. By understanding the intricacies of millets cultivation, from selecting the right varieties to implementing effective management practices, farmers can optimize their production and contribute to the resilience of agricultural systems.

Field Standarads For Various Millet Crops:

Crop	Contaminants	Minimum distance (meters)		Seed rate(kg/ ha)	Spacing (cm)	Sowing Time	Fertilizers (N:P:K) kg / ha	Yield
		Foundataion	Certified					
Amaranth	Fields of other varieties	400	200	1.5-2.5	50 × 15-20	April to first week of July	40:20:20	10-12 q/ ha
	Fields of the same variety not conforming to varietal purity requirements for certification	400	200					
Pearl millet	Fields of other varieties	400	200	3	45 × 10-15	Kharif crop (first two weeks of July) Rabi crop	40:20:00	16.4 q/ acre
	Fields of the same variety not conforming to varietal purity	400	200					

	requirements for certification					(first two weeks of October)		
Sorghum	Fields of other varieties of grain and dual-purpose sorghum	200	100	8-10	45 × 12-15	Kharif crop (third week of June to the first week of July) Rabi crop (second week of September to the first week of October)	Kharif (30:20:20) Rabi (40:20:00)	Kharif sorghum: 38-40 q/ha Rabi sorghum: 6.5-7.5 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	200	100					
	Johnson grass (*Sorghum halpense* L.) Pers.)	400	400					
	Forage sorghum with high tillering and grassy panicle	400	400					
Proso millet	Fields of other varieties	3	3	10	22.5 × 10	Kharif crop (First two weeks of July) Rabi crop (February to March)	40-60:30:20	Irrgated conditions: 20–23 q/ha Rainfed conditions: 10–15 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					
Finger millet	Fields of other varieties	3	3	8-10	22.5-30 × 7.5-10	Kharif crop (June to July) Rabi crop (September to October)	40:20:20	25–30 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					
Foxtail millet	Fields of other varieties	3	3	8-10	25-30 × 8-10	Rainfed crop (June toAugust) Summer crop (January)	40:20:20	20-25 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					
Kodo millet	Fields of other varieties	3	3	10-15	22.5 × 10	Between June and July	40:20:20	15–18 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					
Little millet	Fields of other varieties	3	3	10-12	22.5 × 22.5	Kharif crop (June to July) Rabi crop (September to October)	40:20:20	15-20 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					
Barnyard millet	Fields of other varieties	3	3	10-1 5	25 × 10	Kharif crop (June to July) Rabi crop (September to October)	40:20:20	12–15 q/ha
	Fields of the same variety not conforming to varietal purity requirements for certification	3	3					

(Trivedi and Gunasekaran, 2013; Chapke *et al*. 2020)

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REVOLUTIONIZING AQUACULTURE THROUGH ARTIFICIAL INTELLIGENCE

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This article delves into the transformative impact of Artificial Intelligence (AI) on aquaculture, emphasizing global food security and sustainability. Smart aquaculture, driven by AI, addresses challenges through applications such as automated feeding, remote monitoring, and disease prevention. Emerging technologies like drones and blockchain further amplify industry efficiency. Despite existing limitations, future prospects centre on data sharing, adaptability, affordability, and ethical considerations. As AI becomes integral to aquaculture, it propels the industry toward a more sustainable and resilient future.

The imperative to achieve global food security, as meticulously outlined by Jorgensen and Costanza (2016), is underscored by the United Nations Sustainable Development Goal (SDG) 2. Food security, meticulously defined by the Food and Agriculture Organization (FAO, 2008), emphasizes the dire need for both physical and economic access to sufficient, safe, and nutritious food. Despite the collective efforts invested in addressing this challenge, a staggering 690 million people worldwide continue to endure the harsh reality of hunger (FAO, 2020).

With the global population projected to burgeon to 9.7 billion by 2050 (Gerland *et al.*, 2014), the demand for food intensifies, exerting significant pressure on traditional food production systems (Lewis and Nocera, 2006; Chen *et al.*, 2016). Amid this burgeoning demand, aquaculture emerges as a critical protagonist, playing a pivotal role in providing high-quality proteins (Nash, 2010; Gui *et al.*, 2018).

Experiencing unprecedented growth, aquaculture surpassed wild fisheries production in the pivotal year of 2013 (FAO, 2020). The advent of the Fourth Industrial Revolution (4IR) introduces transformative technologies, with Artificial Intelligence (AI) positioned strategically to address inherent structural weaknesses in global food systems (Liao *et al.*, 2018).

Aquaculture, intricately involving the cultivation of aquatic animals and plants for commercial purposes, confronts traditional challenges that not only limit production but also necessitate significant labour inputs. Among these challenges are intricacies related to water quality management, disease detection, and precise monitoring of factors such as leftover food and fish count.

Smart aquaculture signifies a profound paradigm shift, strategically leveraging intelligent and automated systems to surmount age-old challenges. This transformative trend harmonizes seamlessly with sustainable development goals, integrating modern technology to enhance efficiency while concurrently minimizing environmental impact. The transition to smart aquaculture is not merely a necessity; it represents a transformative leap towards a more sustainable and resilient food production system.

In the past 50 years, applications of science and the introduction of new technologies have propelled the rapid development of aquaculture. Improved reproductive technologies, live feeds, selective breeding, and advancements in disease management have significantly contributed to the growth of the aquaculture industry (Burnell & Allan, 2009; Weber & Lee, 2014).

Artificial intelligence refers to the simulation of human intelligence through machines programmed to think like humans and mimic their actions (Russell and Norvig, 2016). The goals of AI include learning, reasoning, and perception (Copeland and Proudfoot, 2004). It encompasses machines exhibiting characters associated with a human mind, such as learning, problem-solving, rationalizing, and taking actions to achieve specific goals.

The advancement of AI techniques offers promising solutions for optimizing fish farming practices and ensuring sustainable aquaculture. By leveraging AI, fish farmers gain valuable insights into fish growth patterns, feeding behaviour, and environmental factors affecting fish health.

Applications of AI in Aquaculture:

1. Automated Feeding Systems:

Transformative Impact:

The AI-driven automated feeding systems, intelligently adapt feeding schedules based on historical data. Machine learning algorithms process information on fish behaviour, growth rates, and environmental parameters, minimizing feed wastage and ensuring optimal nutrition. This promotes healthier and more sustainable growth, contributing significantly to precision farming tailored to specific aquaculture sites. (Li *et al.*, 2019; Wang *et al.*, 2021).

2. Remote Monitoring and Maintenance:

Paradigm Shift:

Integration of AI into remote monitoring systems, represents a transformative leap in aquaculture management. Sensors and cameras continuously collect data on water quality, temperature, and equipment status, processed in real-time by AI algorithms. This allows farmers to remotely detect anomalies, facilitating prompt interventions and enhancing overall operational efficiency. (*Sun et al.*, 2018; Garcia *et al.*, 2020)

3. Growth Statistics Analysis:

Data-Driven Precision:

AI's pivotal role in growth statistics analysis, involves dynamic monitoring and interpretation of diverse metrics related to aquatic organisms. Machine learning models predict growth trajectories based on factors like water quality, feeding patterns, and genetic influences. This data-driven precision fosters personalized aquaculture practices, enhancing overall productivity and economic viability in a sustainable manner. (Xu *et al.*, 2019; Liang *et al.*, 2020)

4. Temperature Optimization:

Stable Thermal Environment:

AI systems optimizing water temperature, analyse historical data and seasonal variations. Tailored to the specific requirements of aquatic species, these systems ensure a stable and favourable thermal environment, critical for metabolic processes, growth rates, and overall health. This AI-driven temperature optimization minimizes stress and maximizes productivity, contributing to the creation of ideal conditions for aquaculture. (Nguyen *et al.*, 2017; Zhang *et al.*, 2021)

5. Water Quality Management:

Proactive Approach:

AI-powered sensors for water quality management, continuously monitor parameters like oxygen levels, pH, and salinity. Upon detecting deviations from optimal conditions, AI systems trigger automated responses, such as adjusting aeration or activating water treatment processes. This proactive approach prevents stress and diseases among aquatic organisms, ensuring a consistently healthy environment and promoting sustainable production practices. (Wu *et al.*, 2018; Chen *et al.*, 2019)

6. Consistent Aeration:

Optimized Oxygen Levels:

AI ensuring consistent aeration, dynamically adjusts aeration systems based on real-time data. Optimal oxygen levels are vital for the survival and growth of aquatic organisms. AI algorithms consider factors such as stocking density, water temperature, and oxygen consumption rates to determine precise aeration requirements. This automation not only improves the well-being of cultured species but also optimizes energy consumption, making aquaculture operations more resource-efficient. (Guo *et al.*, 2016; Kim *et al.*, 2020).

7. Smart Sensors Implementation:

Transformative Environmental Monitoring:

The integration of smart sensors into aquaculture systems, signifies a transformative leap in environmental monitoring. Equipped with advanced AI algorithms, these sensors precisely measure critical parameters such as oxygen levels, salinity, and temperature. The real-time data streams generated provide aqua culturists with a detailed understanding of the aquatic environment, enabling informed decision-making in real time. The AI-driven analysis goes beyond basic monitoring, offering insights into dynamic changes and potential stressors, fostering a resilient and sustainable aquaculture ecosystem. (Chen *et al.*, 2020; Svendsen *et al.*, 2020)

8. Disease Detection and Prevention:

Proactive Disease Management:

AI's role in disease management, transcends traditional diagnostic approaches. Through sophisticated image processing and machine learning techniques, AI systems identify subtle patterns and deviations in fish behaviour and appearance. This proactive approach enables the aqua culturist to detect potential issues before they escalate into full-scale outbreaks, contributing significantly to disease prevention. Safeguarding economic viability and promoting ecological sustainability, AI minimizes the need for antibiotics or other treatments. (Hitesh *et al.*,2018; Kelly and Renukdas, 2020)

9. Biomass Detection of Fish:

Precision in Population Assessment:

The application of AI and machine vision in biomass detection, revolutionizes the precision and depth of fish population assessment. Machine vision algorithms accurately gauge fish size, weight, and other crucial biological metrics, providing a non-invasive and ethical means of assessing biomass. Utilizing this data, aqua culturists can optimize feeding regimes, monitor growth trajectories, and tailor management practices for specific species. The granular insights provided by AI-powered biomass detection contribute to more efficient and sustainable aquaculture practices. (Su *et al.*, 2020; Zhao *et al.*, 2021).

10. Predictive Analytics and Big Data:

Anticipatory Management:

The fusion of AI, predictive analytics, and big data, propels aquaculture into anticipatory management. AI algorithms, fuelled by extensive datasets and environmental variables, forecast future outcomes and trends. This forward-looking approach enables aqua culturists to proactively adapt to changing conditions, optimizing resource allocation, refining stocking densities, and implementing strategic interventions. This data-driven decision-making enhances operational efficiency and positions aquaculture systems to thrive in a dynamic and evolving industry landscape. (Mair *et al.*,1997; Chen *et al.*, 2020)

Emerging Technologies

1.AI with Drones:

Cost-Effective Monitoring:

AI-equipped drones, leveraging cloud computing, offer cost-effective monitoring of aquaculture sites (Chen *et al.*, 2020). They play a crucial role in checking for holes and damages in cages, collecting valuable data, and providing insights for improving overall operational efficiency. These aerial systems, when coupled with AI, not only enhance monitoring capabilities but also contribute to precision farming practices in aquaculture. Drones, armed with sensors, efficiently gather and analyze a range of water quality data, encompassing turbidity, temperature, dissolved oxygen, and even fish heart rates—all conveniently accessible via a smartphone connected to the drone Drones play a crucial role in aquaculture by gathering unique and hard-to-obtain data, contributing to the creation of algorithms that enhance technology and boost the efficiency of aquaculture production. Drones can detect early signs of issues, enabling prompt intervention and minimizing the environmental impact of aquaculture operations. This integration exemplifies the intersection of cutting-edge technology and environmental stewardship in smart aquaculture practices.

2.**AI with Robotics for Labor-Intensive Tasks:**

Automating Routine Operations:

The integration of AI-driven robotics, signifies a paradigm shift in automating labour-intensive facets of aquaculture management. Equipped with AI algorithms, these robotic systems undertake tasks such as feeding, pond cleaning, and fish behaviour monitoring. Precision and adaptability enhance operational efficiency, reduce labour costs, and minimize human intervention in sensitive aquaculture ecosystems. Deploying these robotic solutions for precise and consistent execution of routine tasks allows human operators to focus on strategic decision-making and higher-level management. This transformative application of AI contributes to the sustainability and scalability of aquaculture operations. (Osaka *et al.*, 2010; Antonucci and Costa, 2020)

3. **Augmented Reality (AR) and Virtual Reality (VR):**

Interactive Simulation and Monitoring:

The integration of AR and VR technologies, introduces a multi-faceted dimension to aquaculture operations. Beyond visualizing data, these immersive technologies actively contribute to real-time monitoring and issue detection. AR and VR enable visualization of fish behaviour, detection of anomalies in nets, and simulation of environmental scenarios. These technologies find applications in education and training, offering realistic and interactive simulations for aquaculture practitioners. The synergy of AI with AR and VR enhances decision-making, improves operational efficiency, and cultivates a culture of continuous learning within the aquaculture industry. (Xi *et al.*, 2019; Jung ,2019).

4. **AI with smart phone**: In fish farming, using AI with smartphones is changing how we get and understand data. Smartphones, with AI, can quickly tell us about water quality, temperature, and fish health. This helps farmers act fast and run things better. Also, AI on phones helps spot and handle fish diseases early, so farmers can manage things well without using too many antibiotics.

4. **Blockchain for Traceability:**

Revolutionizing Supply Chain Integrity:

The implementation of blockchain technology, revolutionizes traceability and transparency in the aquaculture supply chain. As a decentralized and tamper-proof ledger, blockchain ensures secure and immutable records of transactions. This technology enables end-to-end traceability of aquatic products, addressing concerns related to food safety, fraud prevention, and supply chain integrity. Establishing a verifiable and transparent system, blockchain builds consumer confidence and facilitates accountability throughout the aquaculture supply chain. This application fosters a culture of responsible and sustainable practices within the aquaculture industry, extending beyond mere traceability. (Drescher ,2017; Altoukhov ,2020)

Limitations of AI in Aquaculture

The effectiveness of AI systems in aquaculture is contingent on the reliability of data and sensors used (Altoukhov, 2020). Inaccurate or incomplete data can lead to erroneous outcomes.AI may struggle to handle unexpected scenarios requiring human intuition, judgment, or adaptability, such as sudden environmental changes or disease outbreaks (FAO, 2020).The adoption of AI in aquaculture may face barriers, particularly for small-scale farmers, due to high costs associated with components, installation, and maintenance (Altoukhov, 2020).The integration of AI raises ethical concerns, including the impact on human labour, data ownership, privacy, and potential risks of AI malfunction or misuse (FAO, 2020).

Future Prospects and Technologies in AI-driven Aquaculture

Future developments should focus on establishing reliable data-sharing mechanisms among aquaculture stakeholders, enabling improved AI algorithms (Altoukhov, 2020).Research and innovation should target the development of AI systems capable of adapting to unforeseen challenges, enhancing the resilience of aquaculture operations (FAO, 2020).Efforts should be directed towards making AI technology more accessible and affordable for a broader range of aquaculture producers, ensuring widespread adoption (Altoukhov, 2020).Future AI implementations should prioritize ethical considerations, addressing concerns related to labour impact, data privacy, and social implications (FAO, 2020).

Conclusion

The integration of Artificial Intelligence into aquaculture practices heralds a new era of efficiency, sustainability, and innovation. From optimizing feeding schedules to proactive disease management and anticipatory analytics, AI-driven solutions empower aqua culturists to navigate the challenges of a growing population and evolving environmental dynamics. As drones, robotics, AR, VR, and blockchain converge with AI, the future of smart aquaculture holds promise for a resilient, eco-friendly, and productive industry. To ensure the responsible implementation of AI in aquaculture, addressing challenges such as reliable data, affordability, and ethical considerations remains imperative. As the aquaculture sector embraces these technological advancements, the journey towards global food security and sustainable development takes a significant leap forward.

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WETLANDS AND ITS ROLE IN AGRICULTURE: UTILIZATION AND CONSTRAINTS

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Wetlands are the transitional land between terrestrial and aquatic ecosystems enjoying a great diversity and habitat of thousands of flora and fauna. The importance of wetlands lies in their values as wildlife protection areas as well as areas of water management and conservation for agricultural development. Wetlands have nurtured the development of many important cultures around the world. Wetlands contribute to global food security by supporting agriculture and providing livelihoods, as a source of water for crops and livestock, and as habitat for rice production and aquaculture, helping to meet the world's Sustainable Development Goals (SDGs) (FAO, 2019). Thus, wetlands are often a primary driver of economic growth and economic stability for poor rural households in many developing countries. However, the overall production and the economic output of the system are not always encouraging due to its ill adaptation, economic set back and technical know- how at the root levels. To increase the mass awareness among the people 2nd February in every year is celebrated as "World Wetland Day". So the wetland farming, as an applied science, requires an understanding of scientific aspects and economic realities to ensure proper utilization of such valuable ecosystems in developing countries like India where arable lands are decreasing and degrading over period due to increasing population pressure, industrialization and extensive agriculture (Rao and Hemant, 2003).

Wetlands by definition: Wetlands are areas of marsh, fen, peat land, or swamp, whether natural or artificial, permanent or temporary, with water that may be static or flowing, fresh, brackish, or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m (https://www.ramsar.org).

Some Important Features of Wetlands

1. Wetlands are **transitional land** between terrestrial and aquatic system described as **"the kidneys of the landscape"** for the functions they perform in hydrologic and chemical cycles.
2. They can be natural or man-made and found both in inland and coastal areas.
3. In wetland the water table is usually at or near the surface of the land.
4. The wetlands should be saturated with water or covered by shallow water at some time during the growing season each year.
5. The soil is predominantly un-drained hydric soil (saturated long enough to create an anaerobic situation in the soil environment).
6. At least periodically the land must support predominant hydrophytes.

Role of Wetlands in Agriculture

1. **Regulating functions**

i. **Water regulation-**Wetlands maintain the natural hydrological balance, store rain water for longer time and contribute to recharging of groundwater supplies.

ii. **Water purification-** Wetlands called 'natural filters' intercept runoff water allowing sediments and pollutants to settle down. Nitrogen & phosphorus are generally removed by vegetation. Heavy metals, pesticides and herbicide molecules can be removed from the water by ion exchange & adsorption in the organic and clay sediments and also uptake by the plants such as water hyacinth.

iii. **Erosion control-** Wetlands vegetations helps to control excessive erosion by dissipation of wave and current energy or by binding and stabilizing the soil.

iv. **Natural hazard regulation-** Wetlands prevent flooding by temporarily storing and slowly releasing storm water thus minimizes flood hazards in nearby areas.

2. **Provisional functions**

i. **Food-** Wetlands can be utilized for production of many types of food crops like deep water rice, water chestnut, makhana, etc. and various fishes by the resource poor farmers that can meet their nutritional demand and economic stability.

ii. **Fiber & fuel**- Many of the wetlands are being utilized for biofuel production.

iii. **Fresh water-** Wetlands are very good source of water that can be used for irrigation, households or many other purposes.

iv. **Natural habitat-** Wetlands provide habitat for many plants, animal and bird species being analyzed as "Biological Supermarket".

3. **Supportive functions**

i. **Carbon sequestration-** Wetlands have approximately 10% of global total carbon store.

ii. **Nutrient cycling-** Being natural filter, they can takes up excess nutrients and convert them into less harmful forms, and over time, the nutrients are recycled with in wetlands.

iii. **Organic matter addition-** Decomposition of the dead bodies or residues of various vegetation and animals in wetlands over time adds lots of organic matter in the bottom soil.

4. **Cultural functions**

A well-managed wetland may also provide cultural services, aesthetic and spiritual values, education and recreation. While these benefits are not directly relevant to agriculture, they constitute an important contribution for wider community and future generations.

Efficient Utilization of Wetlands in Agriculture

Wetland utilization for crop cultivation

Most of the wetlands experience a good portion of its area coverage to be contributed to intensive cultivation or to be cultivated in their natural form. The crops generally grown in wetlands or surrounding areas as follows:

- **Food crops:** Deep water rice, Jute, Water chestnut or Singhara, Makhana or Fox nut, *Colocasia sp* or Taro
- **Food cum ornamental plants:** Lotus and Water lily
- **Medicinal plants:** Brahmi, Kesut, Swamp cabbage or Kalmisak, Helencha, Kulekhara, Indian pennywort or Thankuni, Marselia or Susni, Water cress or Swamp forest
- **Non food commercial crops:** *Cyperus* spp, Hogla, *Calamus* or Bet, Shola plant *(Aeschynomene sp.)*, Shital pati (*Cyperus tegetum*)
- **Fodder crops:** Para grass or Water grass, *Coix* sp. Or Job's tears

Apart from the above crops, cucumber, mustard, wheat and other vegetables can be cultivated in the wetland bed and also in peripheral areas of the wetland.

Wetland Utilization for Fish Collection

Fresh water species such as Chanda (*Chanda nama*), Tangra (*Mystus tengara*), Punti (*Putinas sp.*), Magur (*Clarias batrachus*), Bacha (*Pangasius bocourti*), Bata (*Labeo bata*) etc. and small amount of commercially important fish like Kalbaush (*Labeo calbasu)*, koi (*Cyprinus rubrofuscus*), Khalisa or Indian glassy fish etc. are caught by the fishermen and sold to the local market that sustain the livelihood and economy. Apart from diverse fishes, gugli (*Teuthowenia pellucid*) and oysters/mollusks are important products collected from natural wetlands.

Wetland Utilization for Irrigation

Wetlands are chiefly used as a source of irrigation for the surrounding farm lands. Cultivators around the wetlands prefer to use small pumps or some manual lifting devices to tap the irrigation water from wetlands (Mukherjee, 2008). Thus, the benefit of the farmers around the wetlands is primarily due to the saving of cost of irrigation which can therefore be diverted to the cost of other allied inputs.

Wetland Utilization for Jute Retting

During monsoon, various wetlands are used for jute retting by large number of farmers from surrounding habitations which help them to save money from large amount of water expenses.

Rice Cum Fish Culture – An Effective Utilization of Wetland in An Integrated Way

Rice cum fish culture is a dual culture farming where rice is the main enterprise and fishes are taken as additional source of income using same resources and same area. It is in vouge in many areas in China, Vietnam, Thailand, Bangladesh, India, Japan. It is the most promising alternative for monoculture of lowland rainfed and flood prone (deep water) rice ecosystem to diversify the rice productivity. Out of 44.5 million ha of rice cultivated land in India, 20 million ha land is suitable for adoption of rice-fish integration system but only 0.23 million ha is under the culture. Genarelly three types of rice-fish farming predominate-

1. Shallow trench within the rice field (Philippines, China, Indonesia)

2. Pond refuge adjacent to the rice field (India, China)
3. Deep water rice field (mainly in Bangladesh)

Advantages of Wetland Farming

i. Wetland farming can meet the challenges of sustaining food security, economic stability, and resource utilization for the poor and marginal farmers without risking too much investment.

ii. Various utilization of wetlands can support year round employment opportunity for the farming family.

iii. It also helps to maintain a pollution free environment without much use of agro-chemicals, farm machinery and degradation of natural habitat.

iv. It helps to maintain marvelous nutrient dynamics in nature.

Constraints Related to Utilization of Wetlands

i. **Problems in crop cultivation**: Wetlands become out of cultivation during peak rainy months except some of the conventional practices like deep water paddy, fish culture etc. but economic output is not always encouraging.

ii. **Compaction or crusting surface soil**: This problem is very common in semi permanent *tal* wetlands due to heavy clayey soil which discourages emergence of seedlings.

iii. **Handling of implements:** Operating farm implements is very difficult due to excess water.

iv. **Lack of drainage facilities:** Due to saturated condition, draining out of excess water from wetlands is very important before utilization which involves huge expense initially.

v. **Post-harvest problems:** Harvested crops may be damaged in the threshing floor or due to transportation problem. The stored grains due to excess moisture content may become susceptible to further attack by pests.

vi. **Aquatic weeds:** They create a nuisance by blocking of drainage channels, rendering navigation and made fishing or other aquaculture impossible.

vii. **Fisheries constraints:** Poor quality water, siltation of wetlands, pollution of water, damping of waste materials, use of pesticides, unavailability of capital and among fishermen etc.

Threats to Wetlands

Urbanization	**Increasing developmental pressure for residential, industrial and commercial facilities**
Anthropogenic activities	Unplanned agricultural development, industries, road construction, impoundment, resource extraction and waste disposal
Agricultural activities	conversion of wetlands into paddy fields, construction of reservoirs, canals and dams for irrigation, over with drawl of groundwater leads to salinization, eutrophication
Deforestation	soil erosion and siltation
Pollution	Unrestricted dumping of sewage and toxic chemicals from industries
Aquaculture	Over cultivation of shrimps, fishes and overfishing
Introduced species	Plant species like water hyacinth and *Salvinia* clog waterways and compete with native vegetation.
Climate change	Increased air temperature; shifts in precipitation; increased frequency of storms, droughts, and floods; increased atmospheric carbon dioxide concentration, sea level rise

Impacts Due to Degradation of Wetlands

i. Serious reduction of natural indigenous fish habitat, their population and diversity
ii. Extinction and reduction of indigenous aquatic herbs, shrubs, wildlife, aquatic birds and reptiles
iii. Extinction of many indigenous varieties of rice with the propagation of high yielding varieties
iv. Loss of natural soil nutrition
v. Increase in the recurrence of flash flood due to loss of natural water reservoirs
vi. Degradation of wetland-based ecosystems, occupation, socio-economic institutions and cultures

Conclusion

Despite the importance of the range of resources and services which wetlands provide, inadvertence over the years and anthropogenic squeezes pose serious threat to the survival of this precious ecosystem. Therefore, the conservation of wetlands should be given prime importance from the point of global and local perspectives. So, a robust policy relating to mass awareness, participation of local people, use of indigenous knowledge and scientific techniques in the management strategies are urgently needed to keep this valuable ecosystem sustainable. The synergistic effects of hydrology, chemical inputs and climatic conditions on wetland productivity and on how plants and animal adapt to stressful situation in various wetland types has provoked ideas for further research on wetlands where there is need of integration of several disciplines (Irrinki and Irrinki, 2006).

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