AMRITA TEC
DST-AMRITA TECHNOLOGY ENABLING CENTRE

WASTE TO WEALTH
PRODUCTS FROM WATER HYACINTH

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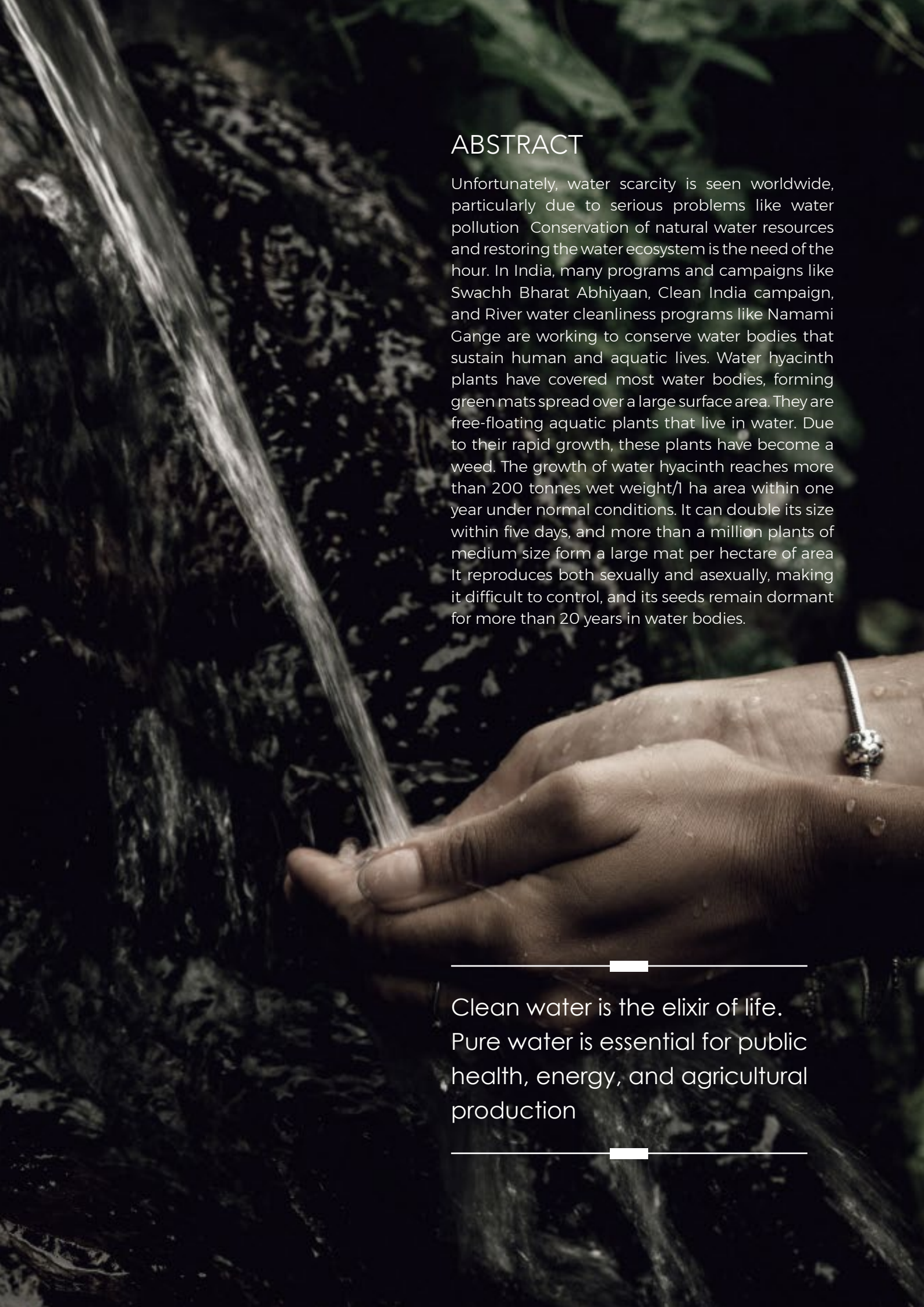

ABSTRACT

Unfortunately, water scarcity is seen worldwide, particularly due to serious problems like water pollution Conservation of natural water resources and restoring the water ecosystem is the need of the hour. In India, many programs and campaigns like Swachh Bharat Abhiyaan, Clean India campaign, and River water cleanliness programs like Namami Gange are working to conserve water bodies that sustain human and aquatic lives. Water hyacinth plants have covered most water bodies, forming green mats spread over a large surface area. They are free-floating aquatic plants that live in water. Due to their rapid growth, these plants have become a weed. The growth of water hyacinth reaches more than 200 tonnes wet weight/1 ha area within one year under normal conditions. It can double its size within five days, and more than a million plants of medium size form a large mat per hectare of area It reproduces both sexually and asexually, making it difficult to control, and its seeds remain dormant for more than 20 years in water bodies.

Clean water is the elixir of life. Pure water is essential for public health, energy, and agricultural production

The water hyacinth is categorized among the world's top ten worst invasive —plant species of aquatic ecosystems.

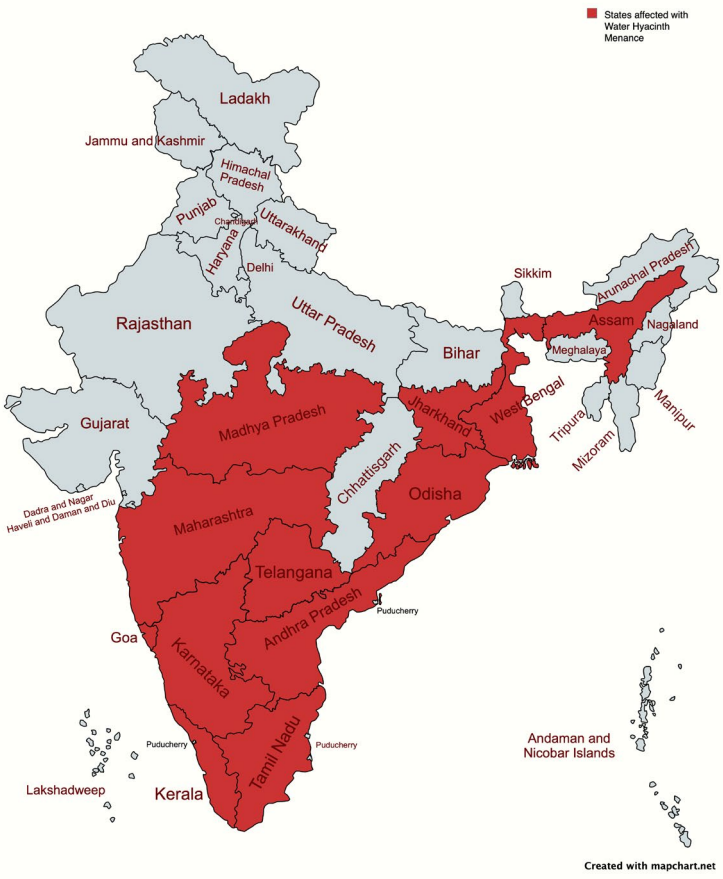

Figure 1: Indian States affected by Water Hyacinth

INTRODUCTION

Interestingly, the Water Hyacinth was a gift of the British to India, introduced towards the end of the 18th century. Lady Hastings, the wife of the First British Governor-General, who was enchanted by the beauty of the flowers, brought it to India, which has now spread to most water bodies. Water Hyacinth (Eichhornia crassipes) from South America has become a notorious invasive aquatic plant, spreading globally across tropical and subtropical regions. Invasive aquatic plants are non-indigenous or non-native to the habitat which they have invaded. In the new habitat, the invasive aquatic plants lack natural enemies threaten the habitat and can harm or displace native species. The invasive aquatic plants become established because they possess the following traits:

- Rapid growth
- High reproductive potential
- Highly efficient dispersal mechanisms
- Ability to alter growth in response to environmental conditions
- Capacity to tolerate a wide range of environmental conditions

While considered a serious waterway weed, it exhibits phytoremediation potential by absorbing harmful substances such as heavy metals, ammonia, and phosphorous from water bodies. Despite this benefit, the environmental repercussions of water hyacinth necessitate rigorous control measures, including mechanical removal, biological control, and herbicide application. Balancing its invasive nature with its phytoremediation capabilities poses a challenge, requiring integrated management approaches and technological interventions to mitigate its impact on aquatic ecosystems. They can form dense mats that block waterways, hindering navigation, reducing oxygen levels, and harming native plants and animals. Disrupts fishing, tourism, and water transportation. Dense hyacinth mats can provide breeding grounds for mosquitoes and other disease vectors. Rapid growth consumes large amounts of water, potentially impacting surrounding areas from water depletion. The physical removal of the water hyacinth is laborious, and subsequent disposal and decomposition pose serious environmental health concerns. Water hyacinth needs a sustainable strategy for its uncontrolled growth and management, and preventing sewage from entering water bodies is the best and single most permanent solution to prevent it from invading water bodies.

IMPACT OF WATER HYACINTH

Unsurprisingly, water hyacinth has spread to more than 80 countries over the past century with its remarkable ability to multiply. Ten water hyacinth plants can reproduce into 655,360 plants, covering approximately half a hectare in 8 months.

It enhances water loss by 2.5 to 3 times due to evaporation. Reduction of Bio-diversity: Other aquatic plants have difficulty surviving. The proliferation of water hyacinths often affects the diversity of fish stocks.

Sediment level increases with the increase of water hyacinth. Source of breeding ground for mosquitoes and other parasites. Hindrance to water transport.

Figure 2: Impact and Benefits of Water Hyacinth

IMPACT OF WATER HYACINTH

The Biochemical composition of the water hyacinth plant is shown in Table 1. Several value-added products can be produced from water hyacinth residue. Various research has been conducted, and value products that can be produced with water hyacinth include different enzymes, cellulose xanthogenate, levulinic acid, shikimic acid, biogas, bioethanol, biohydrogen, biopolymer, biobutanol, composites, biofertilizers, fish feed, high calorific value fuel, fuel briquette, superabsorbent polymer and xylitol. In addition, water hyacinth can also be used as a substrate for mushroom cultivation and for the treatment of various industrial effluents for the removal of heavy metals.

Parameter	Value (%)	Parameter	Value (%)
PH	5.5--6.5	Carbon	11-50
Water content	65-90	Nitrogen	1.1-3
Cellulose	17-35	Oxygen	30-50
Hemicellulose	17-45	Hydrogen	5-6
LigninAsh	1.1-15	SulphurPhosphorous	0.1-1.5
	1.5--30		0.2-0.7
Crude Protein	5-20	Calcium	0.5-5
		Magnesium	0.1-2
		Potassium	2.5-8

Table 1: Biochemical composition of water hyacinth plant

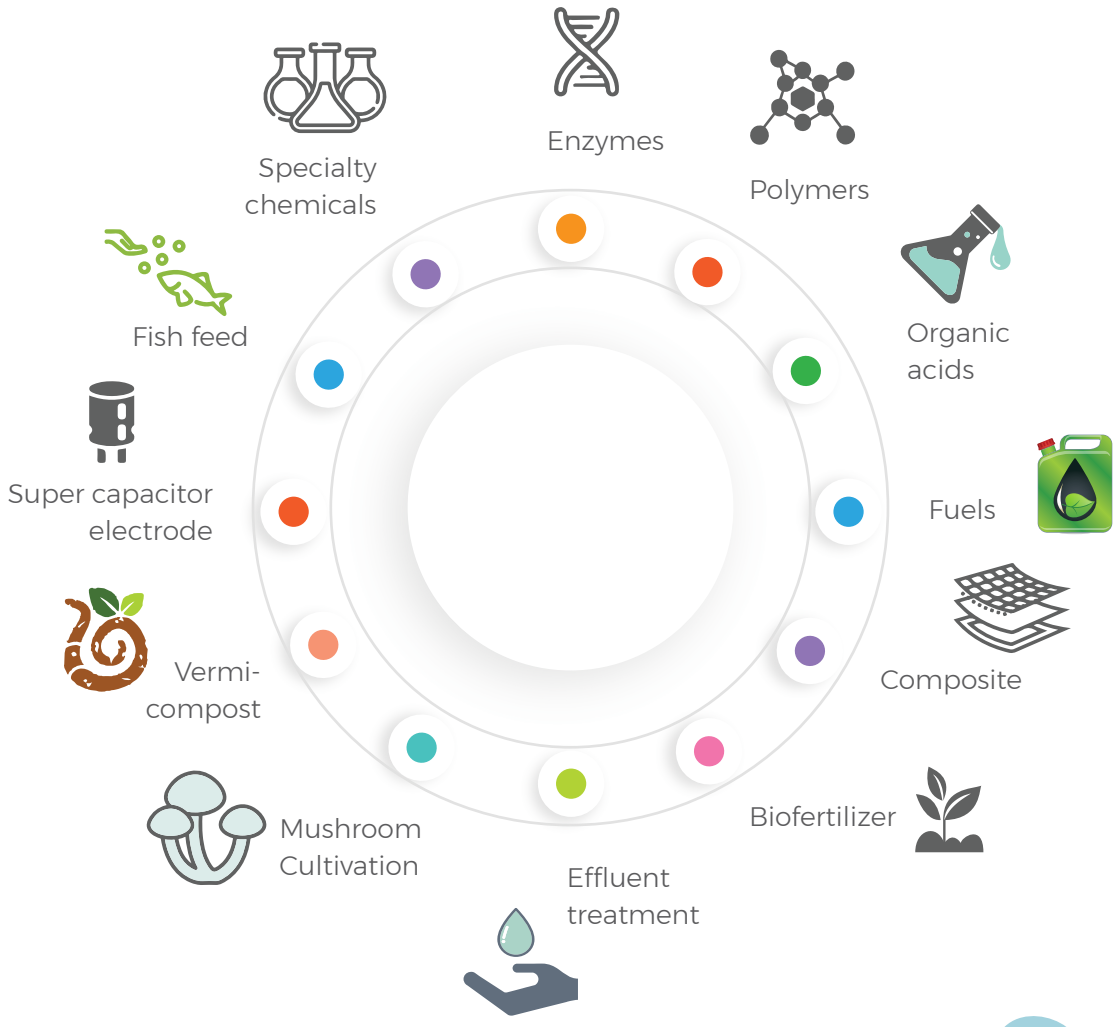

Figure 3: Waste to Value Products using Water Hyacinth

NEED FOR WATER HYACINTH CRAFT

Although water hyacinth holds potential for diverse product development, including enzymes, cellulose xanthogenate, levulinic acid, shikimic acid, biogas, bioethanol, biohydrogen, biopolymer, and biobutanol, these technologies remain in early research stages. However, various consumer goods derived from water hyacinths, such as composites, biofertilizers, fish feed, high-calorific value fuel, fuel briquettes, and substrates for mushroom cultivation, offer immediate economic opportunities. Water hyacinth crafts involve local workforces, providing economic value to communities and controlling water hyacinth growth. These initiatives demonstrate the potential for sustainable economic development while addressing environmental challenges. The following are the advantages of the water hyacinth craft.

- Its removal helps to conserve water and rejuvenate the environment.
- Sustainable Livelihood & Inclusive Growth in Rural Areas.
- Opportunity to earn as per the skill level of the artisan: Semi Skilled:- Braid & Rope: Rs. 2 to 3.5 per meter -Skilled: Finished Products with value from Rs. 40 in a coin purse to Rs. 30,000/- in furniture set.
- Raw Material is free and abundant.
- An eco-friendly product for consumers.
- Empowering women in rural India.

Government and NGOs have spearheaded numerous initiatives like capacity building programs, R&D projects, financial support and grants to transform water hyacinth waste into valuable products, resulting in varying degrees of success. However, beneficiaries often struggle to establish market linkages and adopt sophisticated technologies to standardize and scale up production. Some of the initiatives implemented by states and NGOs include:

Water hyacinth craft activities in Assam state

- Manufacture of paper and paper boards from water hyacinth plant, Hyderabad.
- Production of organic fertilizers from water hyacinth plants, Jharkhand.
- Biodegradable products from water hyacinth stem, West Bengal.
- Biodegradable products from water hyacinth pulp, Centre for research on aquatic Resources, Kerala

Both government bodies and NGOs are actively exploring the potential of leveraging this seemingly problematic plant to create value from waste. Instead of resorting to costly and potentially harmful eradication methods, the focus has shifted towards sustainable harvesting and utilizing water hyacinths to craft eco-friendly handicraft products. Water hyacinth boasts remarkable qualities that render it ideal for such endeavours: its sturdy fibres make it well-suited for crafting durable bags, baskets, and other utilitarian items. Moreover, its utilization promotes the adoption of a readily available, renewable resource, reducing reliance on virgin materials and minimizing environmental impact. Additionally, water hyacinth crafts are biodegradable, contributing to waste reduction efforts by decomposing naturally over time. This shift in approach yields many benefits: it fosters economic activity within local communities, offering new opportunities for income generation through harvesting, processing, and crafting activities. Furthermore, sustainable harvesting helps manage the spread of water hyacinths, facilitating the restoration of natural ecosystems and enhancing water quality. Additionally, by utilizing water hyacinths, governments can significantly reduce spending on traditional eradication methods, reallocating resources towards other critical environmental and social initiatives.

Ultimately, the transition towards a circular economy centred around water hyacinth represents a win-win scenario. By harnessing the potential of this abundant resource, we can create environmentally friendly products, empower local communities, and pave the way for a more sustainable future. Let's embrace innovation and transform what was once perceived as an environmental challenge into an economic and environmental well-being opportunity.

CHALLENGES IN WATER HYACINTH CRAFT & THE NEED FOR TECHNOLOGY DEVELOPMENT

Harvesting water hyacinth demands a meticulous approach, emphasizing the importance of stem size, quality, and processing techniques, particularly when targeting the stems for handicraft items. Unlike simply clearing away the plants, harvesting for stem utilization necessitates careful selection and handling. The size and condition of the stems significantly impact the final product's quality, requiring precision during harvesting and subsequent processing. By prioritizing these factors, we ensure the production of high-quality handicraft items from water hyacinth, highlighting the importance of a thoughtful and methodical approach to harvesting.

1) Harvesting: Employ a systematic approach to harvest the plants, ensuring thorough area coverage. Employ tools such as nets or rakes to gather water hyacinth efficiently, minimizing disturbance to the surrounding ecosystem.
2) Cleaning: Employ a high-pressure water spray or agitation method to dislodge dirt and debris from the water hyacinth. Implement a rinsing process to ensure thorough cleaning, utilizing clean water sources to prevent contamination.
3) Separation: Employ sharp cutting tools such as knives or shears to separate water hyacinth meticulously stems from leaves. Execute precise cuts to facilitate optimal separation and subsequent processing. Implement proper handling techniques to avoid damage to the plant material.
4) Transportation Challenges: Address logistical challenges associated with transporting harvested water hyacinth, including the bulkiness of the plant material.
5) Quality Control: Implement stringent quality control measures to assess the cleanliness and condition of harvested water hyacinth. Conduct regular inspections to identify contaminants or bug attacks that may compromise product quality.
6) Preservation Techniques: Employ preservation techniques to extend the shelf life of harvested water hyacinth during transportation and storage. Utilize methods such as drying, curing, or chemical treatment to prevent spoilage or degradation. Implement proper packaging and storage practices to protect the plant material from environmental factors and pests.

Figure 4: Manually Cultivated Water Hyacinth Stem (Left) Water Hyachinth Stem dried in a solar dryer facility.

Figure 5: Dried stem using solar dryer.

TECHNOLOGY REQUIREMENTS

- Sustainable technologies to harvest the water hyacinth stems by minimising manpower requirements.
- Innovation and technologies for the Handicrafts and Artisanal Products.
- Technologies for creating value-added products from water hyacinth in Biomass for Composting, Fibre Extraction for Textiles, Floating Gardens and Agriculture, Animal Feed Production, Paper and Pulp Production, Biofiltration for Aquaculture and others.

CONCLUSION

The future scope of the study lies in exploring advanced techniques and technologies for managing and utilizing water hyacinths effectively. This can be done by integrating artificial intelligence and remote sensing to enhance management methods. Evaluating the success of current management policies in Indian states and identifying areas for improvement is crucial. Utilizing water hyacinth for fuel and value-added products can mitigate socio-economic issues linked to its proliferation. Globally, research focuses on converting water hyacinth waste into wealth for sustainable management of this invasive weed.

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