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Valorization of Invasive Species into Sustainable Fertilizer

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Introduction

Agriculture is a very important part of Bangladesh's economy by helping more than 40% of the people earn a living and playing a big role in the country's overall growth. But keeping agriculture productive is becoming harder because of two main problems. First the farmers are using too much chemical fertilizer, which has gone up a lot. Around 60 to 70% of the farmers rely on artificial fertilizers to get better crop harvests in the short term [2], [3]. Though these fertilizers help crops grow quickly, using too much of them harms the soil by making it less fertile over time, also it causes nutrient imbalance, pollutes groundwater, and weakens crops over time. Also, farmers have to pay more for these fertilizers by spending 3000 to 8000 taka each growing season. This high cost puts a lot of pressure on small farmers and makes it harder for them to make a profit [2].

Alongside this, harmful plants and animals from other areas have become a big problem for Bangladesh's farmland and natural habitats. These invaders include water plants like water hyacinth (Eichhornia crassipes) and land weeds such as Chromlaena odorata, Mikania scandens, and Parthenium Hysterophorus. They grow quickly and spread over fields and water areas. These plants stop native plants from growing and block canals and waterways, making it harder for crops to get enough water [4], [5]. "Water hyacinth grows in thick layers that stop sunlight and oxygen from reaching underwater which harms fish and other animals and messes up the environment." [4]. "Water hyacinth grows in thick layers that stop sunlight". "Invasive Alien plant species (IAPS) are considered to be one of the major drivers of biodiversity loss and thereby altering the ecosystem services and socio-economic conditions" [3]. There are also invasive fish species like Hypostomus Plecostomus, Pterygoplichthys paradalis, and Clarias gariepinus. These fish species harm local fish populations by eating them or their food and changing the habitats. Their activities mix up the water, makes it dirtier and causes bank erosion which also harms the water ecosystem and fisheries [6], [7]. "These fish harm local fish populations by eating them or their food and changing the habitats." [7]. Also insects such as whiteflies and the fall armyworm damages crops and spread plant diseases that leads to big losses in harvests which increases the use of pesticides which brings in environmental and health problems [8],[9]. "Invasive plants, fish, and insects cause big losses in harvests which increases the use of pesticides which brings in environmental and health problems." [8]. The stress from invasive species and using too much chemical fertilizer causes problems like soil breakdown and lose organic material in soil and disrupt the natural flow of nutrients and it leads to less sustainability farming [1]. Using invasive species biomass as an organic fertilizer offers a sustainable alternative for agriculture. By composting invasive plants harmful biomass can be converted into beneficial fertilizer that enriches soil and mitigates plant damage [10]. Turning invasive fish into fish emulsion which makes a liquid fertilizer high in nitrogen and other needed nutrients [11]. By using insect waste or frass from invasive insects help boost soil bacteria and makes plants more resistant to diseases beacause it has a lot of chitin [12], [13].

The success of this method relies a lot on how much farmers get involved. Wheater they understand the situation and how they see risk and benefits and if they are ready to use eco-friendly fertilizer. This will all affect how well this plan works in practice. This proposal looks at both the technical and economical sides of using invasive species as fertilizer in Bangladesh.

Research Questions

1. How well do Bangladeshi farmers know about invasive species and how they affect farming?

2. What problems do farmers face because of invasive plants, fish, and insects in their fields?

3.Are farmers open to using fertilizers made from invasive species, and what factors make them decide to use or not use them, like price, how well they work, and if they are safe?

4. Can fertilizers made from invasive species help lower farming costs and increase soil health and crop production compared to regular chemical fertilizers?

Literature Review

Invasive species are becoming a big problem for farming and nature in Bangladesh and around the world. Bangladesh has many invasive plants like Chromolaena odorata, Mikania scandens, Parthenium hysterophorus and water Hyacinth which take over both water and land areas [4], [5]. Water hyacinth grows in thick layers that stop sunlight and oxygen from reaching underwater which harms fish and other animals and messes up the environment [3]. At the same time Parthenium Hysterophorus grows quickly in fields and overtakes crops and releases bad chemicals that can harm plants [4]. "Allelochemicals are basically secondary metabolites; mostly phenolics, terpenoids and sesquiterpenes that affect native plant species adversely" [3].

Some invasive fish that are not native to an area like the Plecostomus and the African sharptooth catfish were brought in through fish farming and pet trade. This fish has become established in new areas and are causing problems for local fish population. They dig into the bottom of water bodies which makes the sediments move around and it can lead to erosion [6], [7]. This kind of problem happens in many parts of the world. For example in New Zealand invasive carp have been turned into fish meal to help improve soil [10]. "Chromolaena odorata secretes odoratin, a novel allelochamical, which imparts the ability to defend against enemies, especially soil borne pathogens, and thus provides the invasive alien plant species a competitive edge over the native species" [4]. Insect pets like the fall armyworm are causing big problems in South Asia. In Bangladesh farmers have seen losses up to 50% in their corn crops because of these pests [8]. Whiteflies also harm vegetable crops and spread viral diseases to plants. "parthenium hysterophorus L. and Chromolaena odoreta L. are well known for their allelopathic potentiality. These two weeds are invasive types and can be new threat to Bangladesh agriculture" [6].

Chemical fertilizer are widely used in Bangladesh farming with more than 60% of farmers relying on them as their main source of nutrients [1], [2]. Using too much of these fertilizer causes the soil to become more acidic leads to an imbalance in nutrients and increases the cost of farming. Some farmers use organic materials like cow dung or compost but these are not used as much as the chemical fertilizers. Studies show that compost made from invasive plants can improve soil quality and help crops grow better [10]. "A field experiment was finally conducted to reveal the effects of uncomposted and composted Ageratina adenophora debris on barley seed germination and young seedling growth, showing that the in-situ composting sharply decreased phytotoxic compounds from 2096.3 and 743.7 mg kg^-1 in uncomposted samples to much lower levels in composted samples."[10]. "Turning invasive fish into fish emulsion which makes a liquid fertilizer high in nitrogen and other needed nutrients."[11]. similarly turning invasive fish into fertilizer gives nutrients that are released slowly over time [11]. "By using insect waste or frass from invasive insects help boost soil bacteria and makes plants more resistant to diseases because it has a

lot of chitin." [12]. Insect waste or frass also adds important nutrients like nitrogen, phosphorus, and potassium and helps support the growth of helpful microbes in the soil [12],[13]. Even though there is some evidence there are still gaps in knowing the best ways to process invasive species from Bangladesh into safe and effective fertilizers. More focus is needed on how farmers feel about using these fertilizers its costs and its benefits for crop yields [12]. This research focuses on addressing these gaps through a combination of technical validation with socio-economic understanding to support real world use.

Methodology

This research will use a combination of different methods including surveys with people, lab work and field tests to check the feasibility of producing safe, eco-friendly fertilizers from invasive species in Bangladesh. The approach also make sure that both the science and the need of farmers are considered.

Study Area: The study will look at farming areas in northern Bangladesh that are very active with farming such as Rangpur Sadar, Nilphomari, Dimla, Joldhaka, Chapani, Panchagarh, Kurigram and Badargonj. It will also include nearby farming areas where people mainly grow rice and vegetables. These places were selected because they use a lot of chemical fertilizers which is something that has been well known in farming in northern Bangladesh [2], [3]. In these areas harmful plants like water hyacinth (Eichhornia crassipes) [4], Mikania scandens, Chromolaena odorata [5], as well as pests like whiteflies and fall armyworm (Spodoptera frugiperda) are already common in fields and water channels [7], [9]. Farmers who own small farms in these regions are spending more help from cheaper better alternatives for fertilizer.

Research Design: The study will proceed in three phases:

1. Farmer survey and awareness assessment
2. Fertilizer preparation and nutrient analysis
3. Field application and evaluation

Data Collection Methods

Farmers Survey: A planned survey will be done with about 100 to 200 farmers in the study area. The survey will look how much fertilizer they are using now, the cost of that fertilizer, the problems they face with invasive plants, how much they know about eco-friendly options and if they are willing to use fertilizers made from invasive species.

Specimen Collection: The invasive plants selected for this study are ones that are common in Bangladesh and have the possibility of being used in new ways.

- Plants: Mikania scandens, Chromolaena odorata, Parthenium hysterophorus, and water hyacinth (Eichhornia crassipes) [4], [5]. These plants grow quickly and can block irrigation channels and compete with crops but they have lot of organic material which makes them good for making compost.
- Fish: Hypostomus plecostomus (suckermouth catfish), Pterygoplichthys pardalis (Amazon sailfin catfish), and Clarias gariepinus (African catfish). These fish harm aquatic environments,

compete with local fish and are not permitted or encouraged in fish farming. However they are rich in nutrients and can be used to make fish based liquid fertilizer [7].

- Insects: Whiteflies and fall armyworm (Spodoptera frugiperda) are harmful pests that affect rice, maize and vegetables. The waste the produce are called frass contain chitin which helps increase soil bacteria activity and can be used as a natural pesticide [9]

Fertilizer Preparation

- Plant-Based Fertilizer (Compost): Invasive plants will be cut uo and mixed with cow dung and leftover plant parts then left to decomposed for 8 to 10 weeks in a way that allows air flow. This process breaks down harmful substances and creates a compost that is full of nutrients for soil.
- Fish-Based Fertilizer (Fish Emulsion): Invasive fish will be broken down into a liquid fertilizer through a process called fermentation that uses molasses. This takes 2 to 3 weeks as a result this fertilizer has lot of nitrogen and other important nutrients.
- Insect-Based Fertilizer (Frass): Insect frass from invasive insect will be gathered and dried. This frass can be spread directly onto the soil. It helps plans resist pests and helps with soil growth.

Field Trials: Field trials will test fertilizers on two types of crops:

- Rice: it is the main crop in Bangladesh that grown over 70% of the farmlands and farmers rely heavily on chemical fertilizers.
- Vegetables (e.g., brinjal, cabbage, spinach): these are valuable crops for small farmers and are easily affected by soil quality and pests.

Five treatments will be compared:

1. Chemical fertilizer (control)
2. Invasive plant compost
3. Invasive fish emulsion
4. Insect frass fertilizer
5. Combination of all three organic treatments

Crop performance will be checked based on yield, soil fertility, pest resistance and total input costs. The study will last ten months and the first two months will involve surveys and collecting invasive species. The next three month will be used for preparing fertilizer and doing lab tests. Then field trals will take place in the ninth month and final month will be for writing the report.

Data Analysis: Quantitative analysis will look at crop yields, soil fertility results and cost-benefit comparisons using statistical methods like ANOVA. Qualitative analysis will group farmer feedback into themes to understand their views, how well they accept new practices and the challenges they face.

Ethical Considerations: All farmers who take part will agree to take part after being given all the information. Their names and other personal details will not be shared and the information collected from the survey will only be used for research.

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