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Research Article

Eco-hydryological impact of bamboo plantation in river bank

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Abstract

The evaluation of bamboo's economic, social, and environmental impacts was required due to a change in global industry toward its production and use. Demand for wood and its products is on the rise, and as a consequence of the rapid loss of the world's forests, the majority of businesses are increasingly pushing for the use of natural materials in infrastructure projects. Since bamboo is an all-purpose, fast-growing, and renewable plant, it was looked at as a possible replacement for forest-derived wood. Because of its many applications as wood and wood products, it has had a significant impact on the agricultural economy, creating jobs and generating money for rural poor people who engage in its production. It has also helped communities flourish and governments generate revenue. Bamboo investment in a geographical area has an impact on people's livelihood, so the social assessment looked at how that investment affects local people's well-being in terms of benefits, risks, and threats; the environmental assessment looks at how that investment affects local forests, non-timber forest products, water resources, and biodiversity; and it considers how the two assessments are linked.

Key words: Eco-hydrological, Economic, Social, Environmental, Bamboo etc.

Introduction

As a renewable resource, bamboo is abundant in Africa, Asia, South and Latin America, where it has several benefits over softwoods. Aside from the beneficial effect on people's livelihoods, its present economic and social advantages to its farmers also serve as sources of employment for youth in the

regions where they are located, and they bring enormous development to the communities where they are grown commercially and processed. Bamboo takes 3-5 years from planting to harvest maturity, while softwood or hardwood takes 50-100 years. Bamboo may reach a height of 300 metres from sea level while taking 2 to 4 months to reach its maximum height. Humanity has utilised bamboo's culm/stem as a building material for millennia. Bamboo culms are being used in a wider range of goods, from everyday home items to those used in industry. As science and technology have progressed in recent years, farmers have been able to cultivate bamboo commercially, and businesses that use its products as raw materials for their production have been able to develop new processing and preservation processes. To name a few, bamboo is used in the manufacturing of anything from chopsticks to musical instruments to toys to food containers to skewers to weaponry.

Environmental benefits of bamboo

There are environmental and ecological advantages to bamboo plantations, including how they affect nearby forests, non-timber forest products, water resources, and biodiversity. Climate change, population growth, and other recent global environmental issues suggest that present development patterns cannot continue indefinitely. These findings show that the infusion of environmentally friendly growth patterns and procedures into industrial development must continue. Recent climate change-related catastrophes have caused floods in numerous nations, claiming lives and devastating property in the process. Climate change is rapidly becoming a worldwide reality in light of the aforementioned factors. Due to climate change rapidly becoming a worldwide phenomenon, patterns of production and consumption, including international commerce, are already being influenced. Deforestation, which is responsible for almost 20% of all human emissions, is a significant contributor to climate change. As efforts are directed toward production and use of fast growing high yielding alternatives like bamboo in industrial production processes, ITTO development initiatives worldwide tend to support activities that downplay the role of forest resources in industrial inputs, most notably slow growing soft and hard wood plant species.

Economic benefits of bamboo

There were both positive and negative impacts found in the economic evaluation of bamboo planting, harvesting, and processing. Bamboo growing provides rural people with a chance to generate money, as well as creating jobs for those who participate in its activities and for small and medium-sized businesses. Most rural people gain economically when they trade their bamboo products for other products. Commercial bamboo growers use locals to help with the labour. There is evidence to suggest that the majority of communities where bamboo is cultivated for commercial purposes benefit from basic infrastructure such as homes, roads, power, schools, and hospitals. These industries' community development initiatives have enhanced the life of the local community and the people who reside there. While it became profitable for farmers to transform their crop-growing farmlands into bamboo farms, most of them converted their land into bamboo farms instead, even though they did intercrop between the bamboos when the latter were young. Because of this, many species of birds, animals, and insects have been forced to migrate or have been destroyed, including beneficial ones like flies and plants that provide food and medicine to the community's residents.

Environmental degradation

Degradation of the environment has taken on a severe global dimension, particularly in most African countries, where it affects national security. Environmental security is concerned with environmental problems that in any way compromise the national security of a country. For example, deforestation,

water resource destruction, natural forest products and biodiversity losses have all taken on significant proportions and are capable of posing a serious danger to a nation's security. Environmental degradation is not the case for all environmental phenomena. If ambient pollution concentrations and other activities and processes like inappropriate land use or natural catastrophes cause the environment's quality to deteriorate, that is environmental degradation. Human actions contribute in both direct and indirect ways to the degradation of the natural environment. There are two kinds of environmental degradation: when natural ecosystems are destroyed or left useless as a result of pollution or contamination, and when natural resources are abused, overused, and made scarce to the point of depletion. Misuse of natural resources is a significant factor in environmental deterioration all over the world.

Review of literature

(Pertiwi et al., 2020) studied "*Four-M Model for Bamboo Conservation in Riverbanks Management"* and discovered a training model for bamboo conservation on the river's bank. In order to create a community empowerment paradigm, 20 farmers who manage land along the river's banks are participating in this experimental study. This mannequin was in training from May through August of this year. It was determined that the participants knew about rivers, erosion management in a non-structural way, and local vegetation along riverbanks, among other things Bamboo cuttings from branches, stems, and rhizomes were used in the assessment of abilities at a bamboo nursery. The study's result was that there was a substantial impact on bamboo conservation knowledge and abilities. As a result, the M Model contributes significantly to community knowledge and skill development.

(Akwada, D.R., Akinlabi, 2016) studied "*economic, social and environmental assessment of bamboo for infrastructure development* " The present high reliance on forest cover, deterioration of the environment, and rapidly deteriorating ecology threatens the very survival of humans and animals due to the negative effect on climate and ground water supplies, according to this study. Our natural forest resources are depleting at an alarming rate due to increased overuse and poor management, combined with an explosion in the human and livestock populations. This has disastrous consequences, including depletion of watersheds, disruption of the ecological balance, and a reduction in human well-being.

(Baseline, 2015.) studied "*Environmental Assessment for River Bank Improvement Program*" and found that In order to repair and enhance the right bank embankment of the Brahmaputra River, as well as undertake river bank protection and the building of a road across the embankment, the Government of Bangladesh plans to implement the River Bank Improvement Program (RBIP). The GoB is looking to the World Bank (WB) for financial help in putting this initiative into action. The RBIP is undergoing an environmental evaluation in accordance with national regulatory and World Bank policy criteria.

(FAO & INBAR, 2018) studied "*Bamboo for land restoration*" The loss of biodiversity, soil erosion and depletion, soil contamination and water scarcity are all contributing factors to land degradation worldwide. There are many negative effects of degraded land on the ecosystem, such as decreased soil quality, local water shortages, and a decrease in biodiversity. It also has an impact on the ecosystem's economic and social services by decreasing agricultural land's productive capacity, putting food security at risk and even raising disease outbreaks. It can grow in places where other plants can't, including in poor soil and on steep hillsides. The fact that it is a perennial monocot plant gives it the ability to stabilise sloppy soil and prevent soil erosion with its vast fibrous roots.

(Andersen et al., 2016) studied "*Research to inform the assessment of eco-hydrological responses to coal seam gas extraction and coal mining* eco-hydrological responses to coal seam gas extraction and coal mining not only provided information to support assessments of the water-related impacts of CSG extraction and coal mining but also provided a case study of inter-disciplinary working, discussed

suitable field methods and analyses and provided guidance on integrated ecosystem responses assessment and application of methods" and analyses in other regions and catchments.

(Tripathi, 2004) studied "*Soil Stabilization and River Bank Protection through Bamboo Based Biological Embankment around Majuli Island*" and discovered that the Island Embankment Project's particular scour and bank erosion control methods used a biological and mechanical approach. Majuli Island, in the middle of the Brahmaputra River, is one of India's most flood-prone regions. Heavy rains and high rivers have destroyed most of the island's forest cover, as well as the agricultural products that feed the region's economy. In the absence of adequate planning and administration, different authorities' attempts to address this issue have been fruitless.

(Beyene, 2017) studied "*review on socio-economic and environmental benefits of bamboo for rural communities in ethiopia* " They discovered that Ethiopia has abundant natural resources, including wood and non-timber natural forests, due to its arid environment. Although bamboos have enormous potential as non-timber forest resources, nothing has been done to make them useful for rural livelihoods, youth employment, and as a strategic resource to help disadvantaged people improve their economic well-being.

(Atanda, 2015) studied "*Environmental impacts of bamboo as a substitute constructional material in Nigeria*" and discovered that Bamboo has been used as a natural raw material from the dawn of humankind on the planet. Nigeria's building industry relies heavily on wood and steel as raw resources. Due to the forest being depleted year after year for construction logs, experimental studies have revealed that bamboo is a natural raw material with similar strength to that of wood, bricks, and steel, and it is environmentally friendly, inexpensive, and readily available where it can be used as a substitute for steel in buildings for flooring, roofing, and reinforcement.

(Bowyer et al., 2014) studied "*bamboo products and their environmental impacts: revisited* " and came to the conclusion that Many areas of the globe still utilise bamboo as a major construction material, as they have for the past 5,000 years . Traditional bamboo homes are now home to over a billion people worldwide . Bamboo stalks 4-5 inches in diameter offer structural support and may also be lashed together to create panels used for roofing, flooring, external walls and partitions, doors and window frames. They are lightweight and high strength. Mats and window coverings may be made from bamboo strips.

(Shen et al., 2019) studied "*The Benefits and Barriers for Promoting Bamboo as a Green Building Material in China— An Integrative Analysis*" and discovered that Bamboo is widely regarded as an eco-friendly and green building material. However, it seems that bamboo is being used sparingly in the Chinese construction industry as green building materials. This research highlights the advantages of using bamboo materials and provides an analysis of obstacles preventing the successful use of bamboo materials in this particular construction sector in order to explain this occurrence and encourage the use of bamboo materials.

(Li & He, 2019) studied "*Research on the Utilization and Development of Bamboo Resources through Problem Analysis and Assessmen*t" and discovered that plant resources serve as the basis for human civilization. Plant resources have been utilised to sustain human life and development since ancient times, and the gathering and use of plant resources has played an important role in advancing human civilisation and economic growth. development. Ancient people gathered wild plants for food and heated their homes with wood fuel.

(Ben-zhi et al., 2005) studied "*Ecological functions of bamboo forest: Research and Application*" Throughout tropical and subtropical regions, bamboo forests are an important forest type. For these reasons and more, bamboo is a great investment that can be put to many various uses while also having tremendous promise for resolving many of the global environmental issues we face today.

(Canavan et al., 2019) studied "*Does origin determine environmental impacts? Not for bamboos*" the effects of non-native species on natural ecosystems and discovered that they may have significant detrimental effects. They have such severe negative consequences because these animals inhabit environments where evolution has not occurred. Biogeographical origin was not a strong predictor of the kind and degree of environmental effects produced in bam-boos, contrary to the case in many other plant groupings.

(Raj & Agarwal, 2014) studied "*Bamboo as a Building Material* " Bamboo is a classic construction material that dates back to the dawn of humankind. They are the world's biggest and fastest-growing grass species. Bamboo may really grow four feet in a day. As a source of construction materials as well as food and a versatile raw commodity, bamboos have enormous economic and cultural importance in Southeast Asia and East Asia.

(Emamverdian et al., 2020) studied "*Application of Bamboo Plants in Nine Aspects*" Among the Poaceae family and the Bambusoideae subfamily, and discovered that Bamboo is one of the most common plants in tropical and subtropical areas between 46°N and 47S.. For the people that live in this region, bamboo may be the most valuable economic resource.

(Lugt & Vogtlander, 2015) studied "*The environmental impact of industrial bamboo products Life-cycle assessment and carbon sequestration*" The International Network for Bamboo and Rattan (INBAR) is a multilateral development organisation with 41 member states dedicated to promoting the use of bamboo and rattan in the manufacturing and construction industries. INBAR encourages its members to include bamboo and rattan into their action plans for sustainable development and green economy. There is an emphasis on promoting new uses for bamboo and rattan to help rural communities prosper while also protecting the environment and combating climate change.

Bamboo plantation in river bank

Streams clash with river banks or the banks are eroded by water from agricultural land above the affected region, resulting in natural riverbank cutting in Nepal's Chure range foothills. When riverbanks are cut, a tiny cliff-like eroded region is left behind. Erosion occurs as a result of the lack of natural vegetation on the land, and it is impossible to halt it. It's critical to adopt conservation measures to prevent agricultural land from being harmed and soil fertility from being reduced as a result of riverbank erosion. In areas where most people are subsistence farmers, decreasing land productivity has a negative impact on their lives and livelihoods.

Problems with river bank erosion caused by water flow result in lower yields and diminished land value. Conservation may help to mitigate erosion, which occurs naturally as a result of river dynamics. Vegetation along riversides has been demonstrated in a number of studies to act as a defender of river banks by creating firmness in the land's substance. Thus, tree planting is a critical part of the endeavour to maintain the quality of the river. Bamboo is able to thrive because to the wide range of uses for which it is used by humans. These plants are very beneficial in preserving the health of riverbanks and avoiding erosion in river environments. The root system of the bamboo plant is extensive and thick. Additionally, bamboo plants have deep roots that help the soil absorb water, making the system helpful for riverbank stability. Bamboo has a remarkable capacity to collect rainfall and store it for later use. The use of bamboo therefore helps to minimise the amount of water that ends up in streams and rivers, as well as

erosion. According to earlier research, planting bamboo on riverbanks for five years reduces soil erosion by 85%. The growth of bamboo as a crop has been linked to a reduction in greenhouse gas emissions. The capacity of this flora to sequester up to 62 tonnes of carbon per ha per year is the basis for its preservation. Furthermore, the significance of bamboo conservation initiatives is bolstered by the usage of bamboo crops for a variety of human needs.

EROSION AND WIND CONTROL

Bamboo provides significant "ecosystem services, making it an important plant for agroforestry. Bamboo is extremely excellent as it keeps the soil together which assist prevent erosion owing to its vast rhizome system, especially in places prone to high levels of run off such steep slopes, river banks or degraded fields. As a consequence, the root system provides an efficient mechanism for watershed protection, sewing the soil together along vulnerable river banks, deforested regions and in locations prone to earthquakes and mud slides. Unlike with most trees, correct harvesting does not harm bamboo plants, thus the top soil is kept in place. The extensive root system, distinctively shaped leaves, and thick litter floor, the total of stem flow rate and canopy intercept of bamboo is 25 percent , which indicates that bamboo significantly slows run off, avoiding major erosion and holding up twice as much water in the watershed Pandey and Shyamasundar (2008) In Philippines, Kenya and Andes area bamboo is widely recognised for its ability to prevent erosion. In Punjab, India, approximately 62,000 clumps were stubbed in 1980 in order to stabilise 311ha of embankments Andam (1995). These clumps began production with 5 culms per clump in year 5 and were anticipated to achieved full growth of twelve (12) bamboo culms per clump after ten (10) years forward – generating an annual profit of as high as U$70,000 Environment act 2003. Bamboos are evergreen plants and the dense canopy and soil cover provided by fallen leaves minimises splash erosion and promotes infiltration Alfonso (1987). Bamboo culms are extremely elastic. They bend in strong gusts, but generally do not break since they are utilised as windbreaks to protect cash crops, especially, in coastal regions where high winds occur frequent Pandey and Shymasundar (2008). Planting bamboo may assist speed the conversion of degraded areas into productive and economically viable systems, decreasing erosion and increasing water table following extraction of minerals. This will assist to increase production of other commercial and food crops.

ROLE OF BAMBOO IN BIODIVERSITY CONSERVATION

Bamboo is utilised as industrial raw material in a number of industries. Bamboo is utilised in the pharmaceutical, cosmetics, building, wood, pulp and paper, textile industries, etc. In these sectors, bamboo has substantially replaced some of the traditional raw materials. These have resulted to saves of many plant species that would have been harvested and processed into different goods. For instance, in wood and wood products sectors, bamboo is preserving forests by substituting excessive exploitation of conventional wood species being transformed to plywood, particleboard, block board, floor tiles, etc. Of different areas in India, more than one thousand (1,000) homes of bamboo are constructed yearly using materials acquired from bamboo planting. If an identical operation utilised wood, it would need five hundred (500) hectares of declining tropical forests. Consequently, adopting bamboo to substitute wood protects the rainforests. With a 10 to 30 percent yearly growth in biomass, compared to 2 to 5 percent for trees, bamboo produces higher yield of raw material for utilisation. Apart from this, the use of bamboo as an industrial raw material for manufacture of ply bamboo, bamboo pulp, briquettes for fuel, construction of homes and rebar for reinforced concrete beams yearly contribute to significant savings of forest and biodiversity.

Govt. initiative

As many as 1,038 village panchayats across 27 districts of UP have been earmarked for promotion of bamboo plantation on the banks of river Ganga under Namami Gange flagship scheme, National Baans (bamboo) Mission Yojana. According to officials, the bamboo plantation is aimed at augmenting income of marginal farmers. Each district has been allocated Rs 91 lakh and a target of bamboo plantation has been set by the forest department.

The bamboo is a versatile group of plants which is capable of providing ecological, economic and livelihood security to the people. India is the second largest country after China in growing bamboo. The plantation along Ganga will help prevent erosion during monsoon. It can also be grown in barren land and low-lying areas. Known as green gold, this hardy variety of the grass family can withstand temperature variations and is resistant to disease, requiring no pesticides or herbicides for its upkeep. When cut, it grows back again, making the plant reusable".

Methodology

We created a small questionnaire relating to awareness of bamboo plantation, its ecological, economic and livelihood benefits in selected villages which are on the bank of river Ganga in Bijnor District of Uttar Pradesh.

We have randomly selected 50 farmers who have farms on the bank or near the bank of the river Ganga.

City Profile :

"Bijnor occupies the north-west corner of the Moradabad Division (historically, Rohilkhand or Bareilly region), and is a roughly triangular stretch of country with its apex to the north. The western boundary is formed throughout by the deep stream of the river Ganges, beyond which lie the four districts of Dehradun, Saharanpur, Muzaffarnagar and Meerut, all belonging to the Meerut Division.

Map Source : Google Maps

The extreme parallels of north latitude are 29° 2' and 29° 58' and of east longitude 78° 0' and 78° 57'. The total area of the district is liable to change slightly from time to time by reason of the erratic action of the Ganges and Ramganga: in 1906 it amounted to 1,145,272 acres (1789.5 square miles, 4634.75 km²) the average for the last five years being 1,147,967 acres (4,645.66 km²). There remains the low fringe of Khadir along the Ganges to the west. This generally resembles the lowlands that skirt the rivers of the interior, the low flats which adjoin the stream itself being purely alluvial in character, while above

them rises a terrace of higher ground extending inland as far as the chain of stagnant morasses lying immediately under the Bangar cliff.

Geology

The study area is dominated by the alluvial sediments of quaternary period which is formed due to the deposition processes of Ramganga and Ganga drainage system. Here we find Siwalik formation which is belong to tertiary time period and exposed in the northwestern part of the Najeebabad block. The entire river stretch from Bijnor to Narora is shallow with only intermittent small stretches of deep water pools and reservoirs upstream barrages. The banks of the entire river stretch up to Narora are sandy and muddy. The general stratigraphic sequence of the area is given as under:

Climate

Period	Formation	Lithology	Age
Quaternary	Alluvium	Sand of various grades clays & kankar	Recent
	Terai	Alternate bands of sand & clays.	
	Bhabhar	Boulder, pebbles, sand & thin clays intercalation	
Disconformity			
Tertiary	Upper Siwaliks	Greywaeke & conglomerates	Lower Pleistocene to Lower Pliocene
	Middle Siwaliks	Shale sand & greywaeke	Lower Pliocene to upper Miocene

During the major part of the year the climate of the total river stretch is influenced largely by the prevalence of dry air, extreme temperatures in summer and winter. It is only during the monsoon months that air of oceanic origin reaches, bringing with it increased humidity, cloudiness and rain. Climatologically, the year may be divided into three seasons. The cold season, from about the end of November to the beginning of March, followed by the hot season, which continues till about the end of June where the south-west monsoon arrives. The monsoon
season lasts until September and the next two months forming the transitional period.

Hydrology

Between Brijghat and Narora, both the banks are embanked with boulders to check erosion. The depth varies between 300-362 cm. and transparency ranges between 3-5 cm during monsoon season.

Hydrological values:

Describe the functions and values of the wetland in groundwater recharge, flood control, sediment trapping, shoreline stabilization, etc.

During dry season the stretch has low quantity of water with a depth ranging from 50 cm to 150 cm. Irregular water flow from the reservoirs in the upper reaches and inconsistent rainfall in the area are responsible for the irregular flow of the Ganga River. The discharge record from the barrages shows a regular fluctuation in the water level causing disturbance to the natural habitat of different aquatic animals.

Soil Type

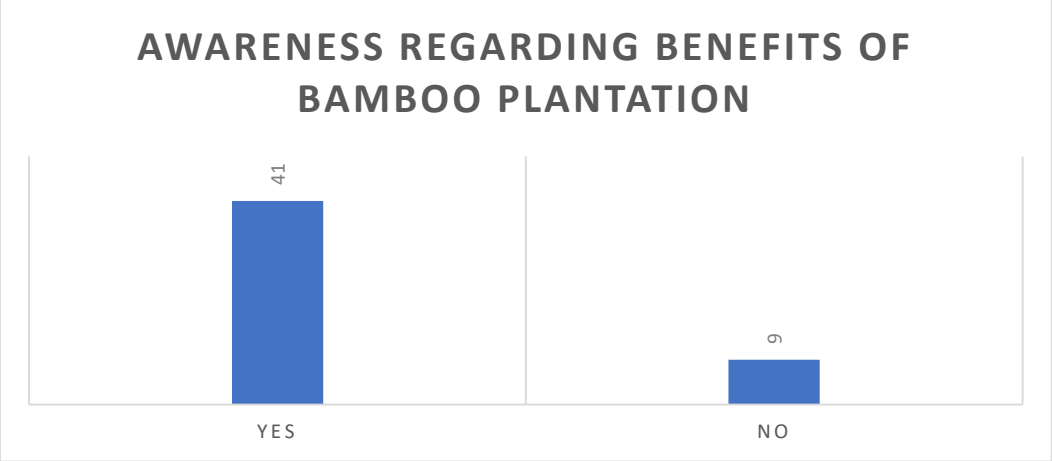
Predominant soil types found in the basin are sand, loam, clay and their combinations, such as sandy loam, loam, silty clay loam and loamy sand soils. Fertile soil with rich nutrient, organic matter medium to high suitable for all arable crops".

Suitability for bamboo plantation:

Known as green gold, this hardy variety of the grass family can withstand temperature variations and is resistant to disease, requiring no pesticides or herbicides for its upkeep. When cut, it grows back again, making the plant reusable.

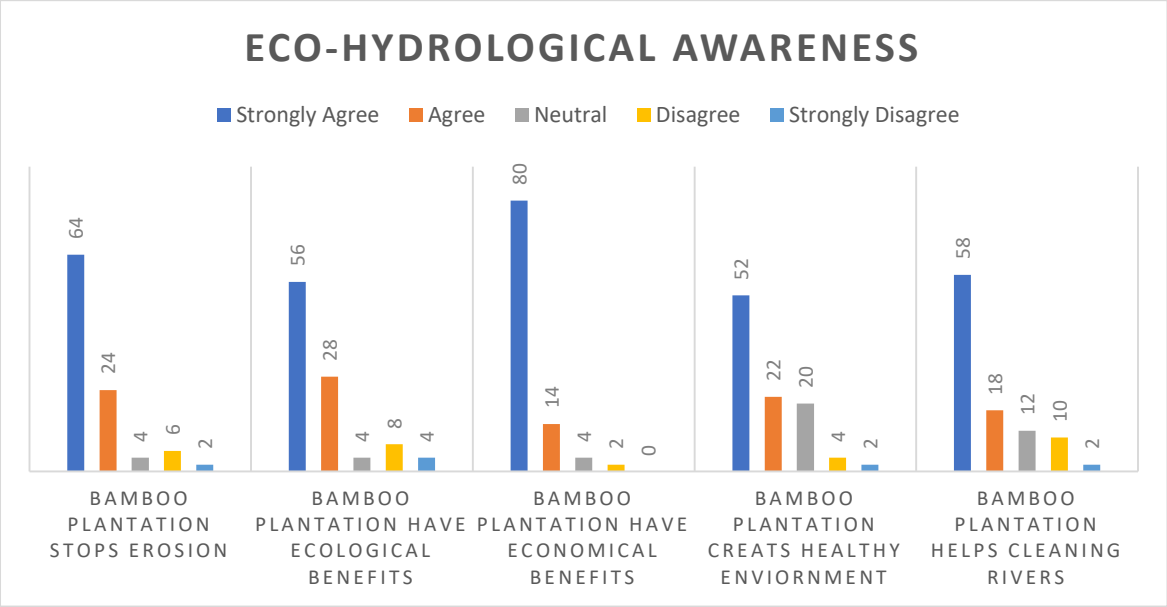
The plantation along Ganga will help prevent erosion during monsoon. It can also be grown in barren land and low-lying area.

Data Analysis



When discussed regarding awareness regarding bamboo plantation benefits 41 farmers said that they are aware about benefits of bamboo plantation.

Eco-hydrological Awareness	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Bamboo plantation stops erosion	64	24	4	6	2
Bamboo plantation have ecological Benefits	56	28	4	8	4
Bamboo plantation have economic benefits	80	14	4	2	0
Bamboo plantation creates healthy environment	52	22	20	4	2
Bamboo plantation helps cleaning rivers	58	18	12	10	2



When discussed regarding Eco-hydrological benefits of bamboo plantation 64% of the respondents said that Bamboo Plantation Stops Erosion 24% respondents said that they agree with this point where as only % of the respondents said that they are not agree with this. When talked about ecological benefits of bamboo plantation, 56% of the respondents said that they strongly agree as compared to only 4% of the disagreed respondents. Also majority of respondents almost 80% of the total respondents said that bamboo plantation has lots of economic benefits. 52% of the respondents said that Bamboo plantation creates healthy environment. Majority of respondents 58% agreed upon that Bamboo plantation helps cleaning rivers.

Conclusion

Bamboo plantation or bamboo forests creates an ecological system that helps in multiple ways. Apart from generating employment it creates an ecosystem for the preserving the rivers, river banks, wildlife and cleaning the rivers. In tropical and subtropical regions, bamboo forest is a significant forest type. For these reasons and more, bamboo is a great investment that can be put to many various uses while also having tremendous promise for resolving many of the global environmental issues we face today. In the research region, riverbank erosion is devastating for the local people. An enormous quantity of arable land is lost to erosion each year. The agricultural land's cropping pattern has shifted dramatically, and parts of it are now bare. The damage to the local infrastructure has also been severe. An approach to balance development, environment impact and wellbeing of society is the need. Sustainable development, along with sustainable manufacturing strategies and sustainable performance measures, is required to facilitate and monitor the infrastructure growth, manufacturing growth and use of goods and services to keep a balance between environment and growth.

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