Issues and Challenges Associated with Farming of Pangasius in Nepal

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Abstract

This paper's goal is to review the literature on pangasius in several sustainability challenges that must be addressed for long-term viability. To compile this review article, information were collected from secondary sources, such as research journals. A total of 19 research papers were reviewed to ensure comprehensive coverage of the topic. Key issues include reliance on imported Pangasius seeds from Bangladesh and India, which complicates local farming efforts. The availability of feed pellets is also problematic, exacerbated by inadequate market infrastructure and poorly managed marketing channels, resulting in high spoilage rates after harvest. Small-scale farmers face significant barriers due to the high initial investment required for infrastructure such as ponds and water supply systems. Environmental issues, including water pollution, improper waste management, and fluctuating water parameters, can negatively impact fish health. Common challenges include low dissolved oxygen levels, leading to stress and disease, and high biochemical oxygen demand (BOD), indicating organic pollution. Future advancements should prioritize Recirculating Aquaculture Systems (RAS) and Integrated Multi-Trophic Aquaculture (IMTA) to boost environmental sustainability and reduce water use. Additionally, Biofloc technology can improve water quality and lower feed costs. Further research and policy support are needed to address the challenges and enhance the positive impacts of Pangasius farming in local societies. Addressing these challenges through research, policy support, and capacity building is crucial for the future of Pangasius farming in Nepal.

Keywords: Challenges, Environment, Issues, Pangasius, Sustainable

Introduction

One of the agricultural subsectors in Nepal that is expanding at the fastest rate is aquaculture. Because the land is landlocked (Chaudhary et al., 2023). Presently, the nation produces 104,623 MT of fish, with 75% coming from fish farming and 25% from fish caught by fishermen (Pathak et al., 2023). The industry has a significant

part in the economy of South Asia, accounting for 98% of the physical export commodities in the Maldives, which make up 6% of the nation's GDP, 24.41% of Bangladesh's agricultural GDP, 5.23% in India, 4.2% in Nepal, and other nations (Sharma et al., 2018). The phrase "Thai Pangas" describes cultivated pangasius, which were brought to Bangladesh in 1990 by the Ministry of Fisheries and Livestock after being initially imported into Thailand. In 1993, this species was successfully bred in hatcheries in Bangladesh. The fish became more popular than other species because of its large size, mouthwatering flavor, and quick growth, all of which were attained by extensive artificial reproduction throughout the nation (Haider et al., 2023).

Pangasius farming is one of the forms of aquaculture that is expanding the fastest in the world. It has been demonstrated that Pangasius are especially versatile for intense manufacturing systems. This particular species of catfish is indigenous to Vietnam's Mekong River, although it has been introduced as an aquaculture species throughout the region. A highly migratory species of riverine fish, *Pangasianodon hypophthalmus* travels hundreds of kilometers from upstream to downstream during its migrations (Gurung et al., 2017). Basa is the favored type of imported Pangasius. The product is now being sold in more than 100 countries around the world because of its gentle taste, lighter meat color, and flasky texture when cocked. Pangasius is a species with a high production rate, but it is not selling for a good price in the market (Kumar et al., 2022). In Nepal, intensive aquaculture systems, pangasius are typically raised solely on additional feed. This particular fish holds significance in Nepal's aquaculture due to its rapid growth, ability to be produced year-round, and high productivity (Chaudhary et al., 2023). Pond fish farming in the terai region accounts for the majority of aquaculture production. Bara, Dhanusha, Saptari, Rupandehi, Mahottari, and Chitwan are the main fish-producing regions in Nepal's terai region. There are seven species of carp included in the cultured species. Additionally, Pangasius (Pangasius hypophthalmus) is also farmed in the country. The larger ponds and more productive fish raised in them have led to an increase in the nation's fish production (Husen, 2019). Moreover, the fish production mainly comes from aquaculture in the Terai region. There are 44,722 ponds spread over 11,895.31 hectares in Nepal, with an average productivity of 4912 kg per hectare. The largest production of pond aquaculture comes from Madhesh Province (Subedi & Shrestha, 2020). The demand for fish has increased as a result of increased knowledge of its health benefits. Location, input costs, and market accessibility can all affect fish farming's profitability and production costs (Poudel et al., 2022). Over the last ten years, there has been a notable increase in Pangasius farming in Nepal. Pangasius is a valuable source of animal protein. Approximately 92 kcal of energy, 15g of protein, 3.5g of fat, and 80mg of cholesterol are provided by every 100g of Pangasius. With this nutritional composition, the

production of Pangasius can help fulfill the increasing need for fish within the country and combat protein deficiencies (Haider et al., 2023). Moreover, fish production per person in Nepal lags significantly behind that of most other countries (Gurung, 2014) and it is brought on by exotic species, parasites, overfishing, illegal fishing practices, and habitat degradation (Khanal et al., 2020). Nevertheless, there aren't many publications on Pangasius farming in Nepal, and research on the problems and difficulties with fish survival hasn't gotten enough attention there. In order to understand practices and solutions over issues and challenges on fish will enhance fish farming successfully. Consequently, this study focusing on Pangasius farming will help to provide necessary information for all the producers of Nepal. This study will also support to guide the decision making of producers and which will be crucial for ensuring the long-term viability of fish farming in Nepal. If farmers with limited resources perceive the potential for profit from fish farming, they may engage in fish production as an agro-business. The farmers will be aware of potential investment opportunities as well as the fish species that are flourishing in Nepal. Important information regarding fish farming in Nepal may be gathered by learners who are interested in undertaking research. At present, Pangasius farming is a significant issue. Thus, this review was conducted to analyze environmental sustainability issues, economic sustainability issues and sustainable practices and solutions comprehensively for sustainable Pangasius farming in Nepal.

Results and Discussion

Issues with Economic Sustainability

Price fluctuations and market access

The effective and profitable distribution of fishery products now depends on fish marketing. However, Nepal hasn't been able to witness a consistent increase in fish commercialization. Due to a lack of suitable storage facilities in the market, whatever the farmers produce is sold as soon as it is harvested. As a result, producers are compelled to sell their fish products at unfairly low prices (Khanal et al., 2020). Nepal's main problems is the large-scale importation of seed from Bangladesh and India for high-yielding species like African catfish and pangas (Ranjan, 2019). Similar findings were reported that the main obstacle to pangasius fish farming is the availability of fish seed, which is still entirely dependent on India (Khanal et al., 2019). However, there may be illness with seed obtained from natural breeding areas because the majority of laborers are not well-versed in the scientific data on hatchery operations (Smrity et al., 2016). The study revealed that fish marketing system is not systematic due to lack of sanitation and cold storage facilities. Similar results were found, indicating that Nepal's marketing system is not very organized because there are no roads linking fish-producing regions, no

cold storage facilities to hold the harvest and control supply, and no insulated vehicles to keep fish from spoiling during market sales (Husen, 2019). This finding brought attention to the volatility of fish prices in the fish market. The main factors impeding a profitable and competitive market are a scarcity of fish seeds, inadequate marketing infrastructure, poor postharvest management, poorly managed marketing channels, intense competition from Indian fish, and poorly designed ponds. Inadequate local infrastructure makes it difficult to regulate trade and increase demand for produced fish in both home and foreign markets.

High Beginning Cost

Pangasius aquaculture has great returns but requires substantial running expenditures (Khanal et al., 2019). *Pangasius hypophthalmus* is similar to with a recirculation system, brood stock takes care of everything from spawning to feed management, water quality control, pond preparation, brood stock maintenance, and overall stock selection (Wardani et al., 2021). Establishing a Pangasius farm requires substantial initial capital investment in infrastructure, including ponds, water supply systems, and feed storage facilities. The reason for small-scale farmers, securing this investment can be a significant barrier.

Feed Price

Pellet feed is used to raise pangasius. Feed accounts for 65–85% of the total production costs in this fishery. Instead of using domestic feed, pangasius should be fed industrially produced pellet feed based on size for two months in the production pond. However, if pellet feed is provided to the fish during its growth, the fish will produce more. The supply of feed might be a challenge for small farms (Gurung, 2016). New technology and management approaches for feed production are not widely adopted because of inadequate expansion and information distribution networks (FAO, 2016). Feed is one of the major cost components in aquaculture. The major study was due to lack of availability of fish meal within the country. The rising prices of commercial feeds, driven by the increasing demand for fishmeal and fish oil, can squeeze profit margins. The lack of technical innovation, low funding availability, insufficient training, and ignorance of feed formulation and processing are some of the issues limiting the small-scale industrial industry. Developing cost-effective and sustainable feed alternatives is essential to ensure economic viability.

Insufficient Economic Availability

Due to their lack of access to finance and financial services, rural communities are frequently unable to make the essential investments in technology and infrastructure. This budgetary restriction may make it more difficult to start sustainable practices and have an impact on the sector's overall productivity.

Challenges of Environmental Sustainability

Sources of oxygen in water

Oxygen is mainly comes from air and photosynthetic plankton. It is less soluble in water, and availability drops with high temperature, salinity, low pressure, humidity and plankton blooms. Algal scums block sunlight, causing anoxia in deeper waters, leading to fish death (Verma et al., 2022). Similar findings were reported that eutrophication may arise from the presence of algal blooms. The dead algae's release of different toxic gasses created a challenging environment for the species being raised (Anka et al., 2014). Algal blooms in ponds can be a serious problem for fish farming. Low dissolved oxygen levels caused by algae's nighttime oxygen consumption can stress or even kill fish. The probiotic is crucial to the growth, survival, and resistance to disease of the aquatic animal because it maintains appropriate parameters for the quality of the soil and water during the culture of *Pangasius hypophthalmus* (Bazar et al., 2022). The growth of pangasius is good if maintained quality of the water has water temperature: 25 to 30 degrees Celsius; water depth: 1.5 to 2 meters; water pH: 6.5 to 7.5; dissolved oxygen in water: 1 ppm. It is 14 degree centigrade in this fish. Compared to other carp species, this species of fish can survive on less oxygen because it can absorb oxygen from the air (Gurung, 2016). DO should be at least 5 ppm or higher in the fish pond. Summer time is when oxygen deficiency is most frequently seen. DO depletion is also caused by prolonged overcast weather that collapses phytoplankton blooms. Supersaturation levels may occasionally be reached by the dissolved oxygen content. This could result in gas bubble illness (Gupta, 2016). The study's main goal was to gain a better understanding of dissolved oxygen for Nepal's pangasius production. Water will have less dissolved oxygen and more nitrogen compounds as a result. The high concentrations of nitrogen compounds in the rearing media, such as ammonia (NH_3), nitrate (NO_3), and nitrite (NO_2), have an adverse effect on fish health and appetite, which can impede fish growth and survival. Farmers will have a better understanding of dissolved oxygen and be more motivated to participate in fish farming, which will benefit them financially.

Biochemical oxygen demand (BOD)

The total dissolved oxygen that microorganisms need to biodegrade organic compounds, including food particles or sewage, is measured by the BOD. An excess of phosphate, additional residential and cattle sewage from outside sources, and a high amount of organic matter may lead to higher BOD levels in rural ponds (Verma et al., 2022). When evaluating the quality of water, biochemical oxygen demand (BOD) is a relevant measurement especially for aquaculture environments

like pangasius farming. The following are some consequences of BOD on pangasius:

Oxygen Depletion: A high BOD level is an indication that there is an abundance of living things in the water, and as microorganisms break down this biological material, oxygen levels may drop. Stress from low dissolved oxygen levels may cause pangasius to grow more slowly and die more frequently.

Stress and Health Issues: Elevated BOD can create an environment that is stressful for pangasius. Stress can weaken their immune systems, making them more susceptible to diseases and infections.

Water Quality Deterioration: High BOD levels can lead to poor water quality, which can affect the overall health of the fish. Poor water quality can result in harmful conditions such as increased ammonia and nitrite levels, further impacting fish health.

Behavioral Changes: Pangasius may exhibit altered behavior in response to poor water quality associated with high BOD, such as reduced feeding activity or increased aggression.

Growth Impairment: The combination of low oxygen levels and poor water quality can impair the growth of pangasius, leading to lower yields in aquaculture operations.

Ecosystem Imbalance: High BOD can disrupt the aquatic ecosystem, affecting not only pangasius but also other species and the overall health of the water body.

Carbon-dioxide (CO_2)

The primary source of carbon cycle is free carbon dioxide from animal respiration. It dissolves in water as bicarbonate or carbonates and exists in limestone and the earth's crust. Carbon dioxide forms carbonic acid in water, lowering pH, and harming aquatic life in poorly buffered systems (Verma et al., 2022)**.** Carbon dioxide significantly influences pH, alkalinity, and hardness (Gupta, 2016)**.** Carbon dioxide (CO_2) can have several effects on pangasius, which are commonly known as pangasius. Here are some key impacts:

Oxygen Levels: Increased CO_2 levels can lead to a decrease in dissolved oxygen in the water. Pangasius, like many aquatic species, require adequate oxygen levels for respiration. Fish that have low oxygen levels may experience stress, stunted growth, or even die.

Acidification: Elevated CO_2 levels can cause water acidification, which can affect the physiological processes of pangasius. Acidic conditions can impact their ability to regulate internal pH, potentially leading to metabolic stress.

Behavioral Changes: High CO_2 concentrations can alter the behavior of pangasius, affecting their feeding, schooling, and predator avoidance. This can impact their growth and survival rates.

Growth and Development: Prolonged exposure to high CO_2 levels can negatively affect the growth and development of pangasius. Stress from poor water quality can lead to stunted growth and lower reproductive success.

Disease Susceptibility: Stress from high CO_2 levels can weaken the immune system of pangasius, making them more susceptible to diseases and infections.

Impact on Aquaculture: In aquaculture settings, managing CO_2 levels is crucial for maintaining healthy fish stocks. High CO_2 can lead to poor water quality, affecting the overall productivity of pangasius farming.

Alkalinity

The ability of water to neutralize strong acids is known as alkalinity, and it is defined by the presence of hydroxyl. A pH of greater than 9.0, or excessive alkalinity, can also be detrimental to fish life (Gupta, 2016). The growth and well-being of pangasius in aquaculture are greatly influenced by alkalinity. Some key effects are as follows:

pH Stability: Sufficient alkalinity contributes to steady water pH levels, which are essential for pangasius metabolism.

Nutrient Availability: Higher alkalinity can enhance the availability of essential nutrients, promoting better growth and health of pangasius.

Stress Reduction: Proper alkalinity levels can reduce stress in fish, leading to improved immune responses and overall well-being.

Water Quality: Alkalinity contributes to better water quality by buffering against acidification, which can be harmful to fish.

Growth Rates: Optimal alkalinity levels can lead to improved growth rates and feed conversion efficiency in pangasius.

Hardness

The term "hardness" describes the concentration of several ions in a body of water, such as hydrogen, iron, manganese, strontium, calcium, magnesium, and zinc, along with many other alkaline earth elements. Fish need calcium and magnesium for metabolic reactions including the formation of scales and bones (Verma et al., 2022)**.** It is not necessary to add lime to pond waters if the hardness is 15 ppm or more because this is sufficient for fish growth. Fish experience delayed growth

problems and eventually dies in waters with less than 5 ppm $CaCo_3$ equivalent (Gupta, 2016). Here are some effects of water hardness on pangasius:

Bone Development: Adequate hardness levels are crucial for the proper development of bones and scales in pangasius. Calcium, a key component of hardness, is essential for skeletal health.

Growth Rates: Optimal water hardness can positively influence growth rates. Fish in water with appropriate hardness levels tend to grow faster and more efficiently.

Reproductive Health: Hardness can affect the reproductive success of pangasius. Proper mineral levels are necessary for successful spawning and the development of eggs.

Stress Resistance: Fish exposed to suitable hardness levels are generally more resilient to stressors in their environment, leading to better overall health and immune responses.

Water Quality: Hardness contributes to the overall quality of water in aquaculture systems. It helps buffer against pH fluctuations, which can be harmful to fish.

Behavioral Aspects: Changes in water hardness can influence the behavior of pangasius, including feeding habits and social interactions.

pH

A solution's acidity is determined by the quantity of hydrogen ions it contains, whereas an alkaline solution is determined by the quantity of hydroxyl ions it contains. Water with a pH of 6.5 to 8.5 is thought to be ideal for aquaculture. While low-calcium and high-humic-acid soils are widespread in freshwater environments, low-pH waters are not. Acidic water (pH 5.0–5.5) may be detrimental to adults, fry, and eggs. Acidity inhibits and negatively impacts the rate at which organic matter decomposes and fixes nitrogen. Its detrimental effects on fish and other biota lead to a decrease in growth, appetite, and toxin tolerance. Fish are more vulnerable to parasite and disease attacks. Copper, heavy metals, and H_2S all have enhanced toxicity (Gupta, 2016). Water quality is a critical factor in aquaculture. Fish excreta, uneaten feed, and organic waste can accumulate in pangasius, or high fish density, ponds used for fish farming. As a result, the water quality may deteriorate and fish death may occur due to increased levels of ammonia, nitrites, and other dangerous compounds. The pH level of water significantly affects pangasius in several ways:

Health and Survival: Optimal pH levels (typically between 6.5 and 8.5) are crucial for the health of pangasius fish. Stress, lowered immunity, and heightened illness vulnerability can result from extremely high or low pH levels.

Growth Rates: pH affects metabolism and nutrient uptake, imbalance slows growth and development.

Behavior: Changes in pH can affect the behavior of pangasius fish, including feeding patterns and social interactions, potentially leading to increased aggression or stress.

Oxygen Availability: The ability to dissolve of oxygen in water, which is essential for pangasius respiration, is affected by pH levels.

Salinity

An aboitic parameter called salinity determines how much salt is dissolved in water (Lingam, 2015). Water with a salinity of 7–10% is suitable for pangasius (Gurung et al., 2016). Salinity affects pangasius in several ways:

Growth Rates: Optimal salinity levels promote healthy growth, while extreme salinity can stunt growth or lead to mortality.

Stress Levels: High or fluctuating salinity can increase stress, making fish more susceptible to diseases.

Reproductive Success: Salinity impacts spawning behaviors and fertilization rates, potentially reducing reproductive success.

Oxygen Availability: Elevated salinity can decrease oxygen solubility in water, affecting the fish's respiration.

Resource Management

Efficient management of resources, including water and feed, is essential but can be challenging due to limited availability and high costs. Effective management of natural resources, especially water and feed, is crucial for sustainable farming. Over-extraction of groundwater for pond filling and maintenance can lead to a decline in water tables. Inefficient feed practices can cause wastage and increase production costs, while over-reliance on fishmeal and fish oil in feed can contribute to the depletion of wild fish stocks.

Biodiversity Impact

Nepal's ecosystem is at risk from a variety of sources. The primary threats to natural ecosystems are habitat loss, alteration, and degradation; overexploitation; invasion by alien organisms; and contamination by pollutants. Climate change and its consequences pose a significant threat to biodiversity and ecosystem services. Many species are considered to have a high risk of becoming extinct, including those with limited climatic ranges and habitat needs. Several attempts were undertaken in recent years to improve and expand biodiversity-related research

and education (GoN, 2014).The primary, serious issues are habitat loss, parasites, invasive species, illicit fishing, overfishing, and environmental degradation. Although poorly managed fish ponds can serve as breeding grounds for disease vectors that impact both humans and animals, organized fish ponds can be utilized as a means of managing disease vectors. Therefore, effective agricultural management decreased detrimental consequences on the ecology (Khanal et al., 2020). Without any safety precautions, farmers were discovered to be handling medications and chemicals intended for disease prevention or treatment. Antibiotic resistance would result from this, and it might have a significant negative influence on the ecosystem (Anka et al., 2014). This study aims that introduction of non-native species can impact local biodiversity and disrupt the ecosystem balance. Similarly, a diverse environment supports healthy populations of prey and reduces disease risks, ultimately contributing to the overall health and productivity of pangasius in aquaculture.

Disease and Antibiotic Use

The challenges that Bangladesh's aquaculture is facing are demonstrated by the high concentrations of microcystin producers and fecal coliforms in several of the fish farms (Islam et al., 2021). Numerous bacterial disease outbreaks have increased pressure on farmers to employ a range of pesticides and antibiotics in hatcheries (Lakra, 2012). The study's main goal was to gain a better understanding of disease for Pangasius fish farming. Bacterial disease is due to high stocking densities in this fish farms can facilitate the rapid spread of diseases. To combat these outbreaks, farmers often resort to the use of antibiotics. This fish are susceptible to various diseases, and managing these outbreaks requires proper knowledge, timely intervention, and sometimes expensive treatments. The use of antibiotics to treat these diseases can help manage outbreaks but may also lead to antibiotic resistance, impacting both fish health and human consumers. Overuse of antibiotics can disrupt the aquatic ecosystem and harm beneficial microorganisms, ultimately affecting the sustainability of this fish farming.

Sustainable Practices and Solutions for Pangasius farming

Aquaculture with Integrated Multi-Trophic (IMTA)

Growing species from several trophic levels in the same system is known as IMTA. For example, combining Pangasius farming with aquatic plants or filter-feeding bivalves can help utilize waste nutrients, improve water quality, and increase overall system productivity.

Recirculating Aquaculture Systems (RAS)

RAS technology allows for the continuous recycling of water within the farming system, reducing water usage and minimizing environmental discharge. In terms of sustainability and resource efficiency, RAS provides long-term advantages despite requiring a larger initial investment.

Sustainable Feed Alternatives

Developing sustainable feed alternatives, such as plant-based proteins, insect meals, and algae-based feeds, can reduce reliance on fishmeal and fish oil. These alternatives can help lower feed costs and mitigate the environmental impact of feed production.

Best Management Practices (BMPs)

Implementing BMPs in Pangasius farming can enhance productivity while minimizing environmental impact. BMPs include strategies for water quality management, disease prevention, efficient feed utilization, and waste management.

Certification and Eco-Labeling

Certification programs and eco-labeling schemes, such as the Aquaculture Stewardship Council (ASC) certification, can promote sustainable farming practices and provide market incentives for farmers to adopt environmentally friendly methods.

Community-Based Resource Management

Conflicts can be avoided and the demands of various stakeholders can be balanced by involving local populations in the management of biodiversity. For instance, community-based methods of managing water resources can ensure sustainable use and fair access.

Financial Support and Access to Credit

Training and information sharing with farmers are issues that must be addressed, especially for small-scale farmers who have limited access to the newest advances in technology and management (FAO, 2016). Providing financial support and improving access to credit for small-scale farmers can facilitate investment in sustainable practices.

Capacity Building and Extension Services

Many farmers lack the technical knowledge and skills required for effective Pangas fish farming, including disease management, optimal feeding practices, and

breeding techniques. Access to high-quality seed (fingerlings) and feed is crucial for successful farming. Inconsistent availability and high costs can hinder production. Strengthening extension services and providing regular training programs can enhance farmers' knowledge and skills. Topics such as sustainable farming practices, disease management, and market access should be included in training curricula.

Policy and Regulatory Frameworks

Developing and enforcing robust policies and regulatory frameworks is essential to ensure the sustainability of Pangasius farming. Policies should address issues such as water use, environmental protection, disease control, and market regulation. There is often a lack of government or non-government extension services to provide training and support to farmers, leading to gaps in knowledge and practice. Inadequate regulatory frameworks and policies can result in issues such as overuse of antibiotics, environmental degradation, and unregulated market practices.

Research and Innovation

New technology and methods that improve the sustainability of Pangasius farming can be developed through research and innovation investments. Collaboratively, government agencies, educational institutions, and the private sector can promote and embrace innovative ideas.

Conclusion

Pangasius farming in Nepal holds significant potential to contribute to the country's aquaculture industry, enhance food security, and generate employment. However, the sector faces numerous challenges, including inadequate access to quality fingerlings, limited technical knowledge among farmers, poor water quality management, and insufficient government support. Additionally, market volatility, lack of infrastructure, and environmental concerns pose critical barriers to sustainable development. Addressing these issues is crucial for unlocking the full potential of Pangasius farming and ensuring it becomes a reliable source of livelihood and nutrition.

Recommendations

1. Establish hatcheries for producing high-quality fingerlings locally.
2. Facilitate access to affordable and high-quality feed to ensure healthy growth of Pangasius.
3. Organize training programs for farmers on advanced farming techniques, water quality management, and disease control.
4. Promote the adoption of modern aquaculture practices to improve productivity.

5. Invest in building cold storage facilities and transportation networks to maintain fish quality and reduce post-harvest losses.
6. Develop accessible marketplaces for Pangasius products to ensure fair prices for farmers.
7. Implement supportive policies, including subsidies for small-scale farmers and soft loans to encourage investment in Pangasius farming.
8. Introduce insurance schemes to protect farmers from losses caused by natural disasters or market fluctuations.
9. Promote eco-friendly farming practices to minimize negative impacts on local ecosystems.
10. Monitor water sources to prevent pollution and ensure sustainable water use.
11. Encourage research on disease-resistant strains and better farming technologies.
12. Collaborate with academic institutions to provide evidence-based solutions to challenges.

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