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Challenges and Protection Strategies for Rivers and Lakes

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Abstract. Rivers and lakes play a crucial role in freshwater supply, maintenance of ecosystems, and the sustainability of humans' society, economic activities and culture. However, these water bodies are often threatened by pollution, damming, and over-extraction, causing a series of problems for ecosystems and communities. The paper analyzes the challenges faced by rivers and lakes and proposes some measures to deal with these problems. The major challenges include the spread of pollutants, eutrophication, abnormal flow regulation, and lowering water levels, which lead to the loss of biodiversity, threat to human health and economic activities, and the collapse of culture and civilization. This study proposes solutions based on technologies and policies. The technique solutions include Variable Rate Technology and Precision Irrigation System for precision farming and buffer zones for water treatments. For the government, the withdrawal policies for water should be applied to prevent agricultural and industrial overuse and waste of water resources. Besides, the coordinated work between upstream and downstream communities and the participation of the government matters a lot to the conservation of rivers and lakes and the preservation of the cultural and historical legacies related to these water bodies.

Keywords: River; Lake; Challenges; Protection Strategies.

1. Introduction

Water resources, including lakes and rivers, are essential to the health of ecosystems, human livelihoods, and economic activities [1]. These water resources provide drinking water, support the environment and biodiversity, and offer sustainable economic opportunities. However, water resources are increasingly threatened by human activities, including pollution, over-extraction [1], and damming. These threats jeopardize the restoration of usable water resources and impact the related ecosystem, industry, and communities.

Lakes and rivers, both crucial to global water resources, have different characteristics and conservation strategies. Lakes are relatively enclosed, isolated, and vulnerable to nutrient overload and pollution, leading to environmental problems such as eutrophication. In contrast, rivers, which are relatively open and dynamic, face challenges related to flow regulation [2] and pollutants from upstream sources.

This study aims to analyze and compare different conservation strategies for lakes. By exploring certain challenges and successful approaches for preserving each type of water body, the passage aims to provide insight into accessible and effective water resource management. The discussion focuses on the main issues of preserving water resources, including pollution control, integrated management practice, and the differences and similarities in protecting these crucial water resources.

2. The Overview of Rivers and Lakes

Rivers and lakes are two of the most crucial water bodies in the earth's freshwater resources. Both play an indispensable role in ecosystems and societies, with many significant differences in their physical characteristics and functions.

2.1. Ecological Significance

Rivers are dynamic systems that flow across different landscapes and connect different ecosystems, such as lakes, wetlands and marshes. Rivers play an important role in shaping landscapes through processes such as flow deposit and erosion, which create a great number of habitats that support a wide range of species [3].

Lakes, on the other hand, are relatively stable water bodies covering different sizes, from small ponds to vast inland seas. They play a crucial part in supporting the ecosystems of the basin. Accordingly, lakes are particularly significant in maintaining the local biodiversity and providing species habitats that may not thrive in other ecosystems or natural environments. In addition, lakes are crucial to the water cycle— they store water and regulate the flow of rivers.

2.2. Social Importance

In history, rivers are humans' original settlements where civilization began, providing people with water for drinking, irrigation, and transporting [4]. In addition, rivers also offer hydropower, which contributes to the energy supply that supports economic growth.

Lakes, similarly, are important to the supply of freshwater resources. They contribute to the local economy through fishing, tourism (e.g., sightseeing), and related entertainment (e.g., boating and swimming). Lakes also have cultural and historical significance— in many civilizations, lakes hold important spiritual values and are often connected with the local traditions. For instance, in the Maya civilization, Lake Petén Itzá, located in Guatemala, was considered a habitant of gods. Maya people play dances and songs in honour of their ancestors and gods [5].

2.3. Key Difference Between Lakes and Rivers

While both lakes and rivers are essential to the sustainability of ecosystems and society, their conservation strategies differ due to their distinct characteristics. Rivers are more vulnerable to pollution spreading downstream due to their flowing nature. In contrast, lakes, as a relatively isolated system, are more likely to have problems like nutrient accumulation and even eutrophication. Understanding these differences is essential to tailor effective conservation strategies to challenges faced by lakes and rivers, respectively.

3. Threats and Conservation Strategies of Rivers

3.1. Pollutions of Rivers and Strategies

3.1.1. Pollutions of rivers.

Pollution is a major threat to the river ecosystem, caused by various factors such as industrial and domestic wastewater and numerous chemicals from agricultural systems. These pollutions can introduce harmful materials into the river, such as poisonous chemicals, heavy metals, and excess nutrients. The flowing nature of rivers can speed up the spread of these harmful materials, causing damage to the water quality downstream [6]. For instance, the pollution from upstream can affect the habitat of the fish downstream and threaten their survival, which has a negative impact on the fishery downstream [7].

3.1.2. Solutions for pollution.

To solve the pollution problem, all regions along the river should take measures against the sources and spread of pollutants because of the broadly flowing nature of the river. The upstream regions should focus on reducing the sources of contaminants from the very beginning. From the perspective of the farmers in the upstream area, they can reduce the agricultural runoff by reducing the use of fertilizer and pesticides. For instance, they can adopt precision farming techniques, such as Variable Rate Technology (VRT), a machine to control the amount of the inputs (fertilizers, pesticides, and

water). Therefore, the VTR can help farmers avoid the overuse of fertilizers and pesticides [8]. From the perspective of the upstream industries, they should treat the wastewater before discharge to rivers to reduce the poisonous chemicals and excessive nutrients. For instance, the activated sludge process can remove the organic pollution from the wastewater to avoid excessive nutrients in the industrial discharge. Not less importantly, for both agricultural and industrial conservation strategies, regulation and enforcement are crucial to ensuring the wastewater comply the standards.

Downstream regions can set up water quality monitoring systems to collect data on the level and ingredients of the pollution. This information can be applied to take action against pollution in the river more quickly. For instance, the Real Time Water Quality Monitoring AI Buoy System can detect and analyze different aspects of river pollution in real-time, such as some ions and organic molecules [9]. Additionally, the downstream area can deal with the pollutants in the river by filtering the water both naturally and artificially. For instance, downstream regions can preserve or create wetlands, which play a significant role in filtering water bodies, preventing the pollutants from spreading to a larger water body [10]. It is also important to organize some clean-up programs, such as removing the trash from rivers and banks and filtering the sediments. These programs are direct and effective methods to reduce the amount of pollution.

Coordinated work of the upstream and downstream countries is of great importance in preserving rivers. For example, the governance of the Rhine is a typical successful case. The littoral counties organized the international commotion for the protection of the Rhine (ICPR), which includes Switzerland, France, Germany, the Netherlands, and Luxenbourg. The members of ICPR reached some agreements to preserve the Rhine together, such as the Rhine Action Programme (1987), the Convention on the Protection of the Rhine (1999), and the Rhine 2020 Programme. These agreements allocate the rights and duties of the ICPR countries on the conservation of the Rhine. For example, the upstream countries, like Switzerland and Germany, are required to invest in pollution source control and environmental restoration; the downstream countries, like the Netherlands and France, are asked to take action on the management of the flood and the use of water [11].

3.2. Impacts of Damming on Rivers and Strategies

3.2.1. Impacts of damming on rivers.

The damming has a great impact on the flow of rivers, which can influence the ecosystem, agriculture, and economy. Damming limited and changed the rivers' flow patterns, affecting the seasonal migration of fish and even threatening their survival. It caused the number and diversity of the fish species are likely to decline,

Damming also impacts sediment accumulation, leading to a sediment buildup in the reservoir and dams and a reduction in the sediment (soil) supply downstream. Therefore, the area and fertility of the downstream could decrease, and the riverbanks may even get eroded

The construction of the dams would cause a rise in water levels, which may flood the communities. This can lead to property loss and force people living here to immigrate to other areas. For instance, the construction of the Three Gorges Dam flooded over 600 km2 of land and forced over 1 million people to relocate. The submerged area includes villages, cultural sites, and farmlands, representing the great economic damage due to the dam construction [12].

3.2.2. Solutions for damming.

To deal with the ecological, agricultural and social problems mentioned above, this study proposes some possible conservation strategies. First, the construction of fish ladders and bypass channels can cope with the disruption of fish migration. This can help certain fish pass obstacles, including dams and reach their destinations. For instance, the Bonneville dam on the Columbia River in the USA includes a famous fish ladder consisting of conscious pools. Fish can pass by the dam by leaping from one pool to another step by step. This matters a lot, particularly to salmon— a local fish that needs to migrate upstream for spawning [13]. In addition, there are several bypass channels in the River Severn

in the UK. They mimic the conditions of the normal rivers unaffected by the dams, including the flow speed, and then help fish cross the obstacle [14].

The sediment management strategies are essential to downstream agriculture. The sediment flushing techniques can release the sediment through the dams. This technique plays a crucial role in maintaining the sediment (soil) supply, which can keep the soil fertility of the downstream farmland and prevent the erosion of riverbanks. For example, the Glen Canyon Dam on the Colorado River in the USA applies a sediment strategy—High Flow Experiments (HFEs) [15]. This strategy involves releasing large volumes of water at a certain frequency to flush the sediment accumulated in the dam. HFEs allow sediment flow through dams to downstream areas to extend the riverbank and fertilize the farmland along the river.

The wise implementation of the immigrant policies is of great importance to deal with the migrants after the construction of dams. As mentioned above, the construction of the Three Gorges Dam flooded over 600 km2, forcing over 1 million people to leave their hometowns. The resettlement programs were organized for those whose house was submerged. The immigrants can relocate to urban areas like Chongqing or rural areas to continue their agricultural production. The Chinese authorities offered them new houses. In addition, the compensation and financial support were provided by the Chinese government. The money can cover the costs of relocation, traffic, the establishment of the new house, and the daily necessities, etc [16]. These policies minimized the damage to the property and livelihoods of influenced residents.

4. Threats and Conservation Strategies of Lakes

4.1. Pollutions of Lakes and Strategies

4.1.1. Pollutions of lakes.

Like rivers, pollution is also one of the most important issues for lakes, with similar pollutants such as agricultural runoff and industrial sewage. However, the problems pollution brings to rivers and lakes are different. As a relatively isolated system, lakes have limited capacity for water renewal.

One of the most common problems caused by pollution is the eutrophication of the lake, which occurs especially when excess nutrients (e.g., Nitrogen and Phosphorus) are in the lakes. This large amount of nutrients is likely to cause the over-spawning of algae, which decomposes the oxygen in the water after death, leading to challenges in the survival of other species and the loss of biodiversity.

The toxic subsidences are also a severe pollutant problem for the lake. The toxic subsidences, such as heavy metals (e.g., mercury, barium), pesticides, and other poisonous chemicals, accumulate in both water bodies and sediment of lakes. This can damage the lake’s ecosystem, causing threats to the survival and recreation of the species (e.g. fish, shrimp) in the lake. Furthermore, these subsistences are likely to influence human health by influencing the sources of the drinking water. About 2.3 billion people are suffering from water-related diseases all over the world. In developing countries, there are over 2.2 million casualties every year because of unclean water and inadequate sanitation. Water-related infectious and parasitic diseases account for about 60% of infant mortality in the world [16].

4.1.2. Solutions for lake pollution.

Nutrient management can effectively deal with the eutrophication of lakes. The management strategies include precision farming techniques (e.g., the VTR [8] mentioned above) to reduce the use of pesticides and fertilizers and the buffer zone. The buffer zone is a vegetation strip (e.g., trees, grasses, shrubs), planted between the lakes and farmland/industrial areas? The vegetation strip can absorb the excess nutrients in the water before entering into the water. For instance, the buffer zone constructed in the lakes of the Suwalki Landscape Park in north-eastern Poland is planted with shrubs and grasses along the banks of lakes [17]. This significantly reduces nutrient materials like nitrogen

in the lakes and successfully addresses eutrophication. In addition, with more vegetation on the lake bank, the buffer zone also creates more habitat for the local species.

Water treatment technology is a crucial strategy to improve the water quality in the lakes. This can transform polluted water into high-quality purified water through filtering, dredging, and capping. These direct approaches efficiently reduce the number of heavy metals like mercury in the lakes. For example, capping and removing the sediment composed of heavy metals like barium and lead from the water body is an efficient method. It was successfully applied in Victoria Lake in East Africa, which was seriously polluted by heavy metals, to address the pollution [18]. It means that removing the sediment effectively reduces the concentration of the heavy metal ions in the lake, significantly improving Victoria lake's water quality.

4.2. Impacts of Over-Extraction on Lakes and Strategies

4.2.1. Impacts of over-extraction on lakes.

Over-extraction of water from lakes can lead to a series of environmental and social problems, which seriously affect the health and sustainability of the ecosystem and communities around the lakes.

The over-extraction reduces the water level of lakes, especially in tropical regions where the evaporation effect is significant. This can lead to the loss of habitats for aquatic plants and animals. For example, the wetlands around the over-extracted lakes may shrink and even disappear. Hence, species living here lose their habitat for survival and breeding, which means the decline of biodiversity. In addition, the lowering water level could reduce recreational and cultural activities around and, in the lake, which negatively affects the tourism industry [5].

The reduction of the water level also represents the reduction of water volume, which is likely to increase the concentration of pollutants. This may change the eco-condition of the lakes, endangering the survival of of aquatic species in the lakes.

4.2.2. Solutions for over-extraction.

To avoid the over-extraction of the water, water withdrawals and water conservation strategies should be applied. One measure is to limit the extraction of lake water for farmland and industrial usage. This limitation is essential to maintaining the sustainability of the lakes' water resources and prioritizing the necessary use, such as drinking water. Furthermore, the efficiency improvement of water used in agriculture and industrial production can reduce lake water extraction. This includes precision irrigation, reuse of wastewater, and input monitoring. For example, the Precision Irrigation System (PIS) is widely used for crop farming. The PIS can monitor and analyze conditions such as temperature and humidity and aid in determining the amount of water used according to the selected data. This technique significantly increases the efficiency of agricultural water use [19].

5. Conclusion

The construction of rivers and lakes is essential not only for the maintenance of ecosystems but also for the sustainability of human societies, economies, and cultures that depend on these water bodies. The threats from pollution, damming, and over-exaggeration of rivers and lakes can negatively affect ecosystems and the environment, economic activities, and cultural heritage.

A lot of strategies are proposed to deal with these challenges. For pollution from agricultural runoff and industrial sewage into rivers and lakes, techniques such as VTR and PIS are applied to improve the efficiency of pesticides and chemical reagents. In addition, water treatment strategies, such as buffer zones, removal of sediments, filters, and reuse of wastewater, can improve water quality by reducing poisonous substances like heavy metal ions.

For damming in rivers, sediment strategies like (HEFs) can allow the sediment to continue to flow down to fertilize and expand the downstream farmland. Fish ladders and bypass channels can help fish get across the dams and reach their destination to live and breed. For over-extraction in the lake,

the withdrawal policies of the water should be applied to prevent agricultural and industrial overuse and waste of water resources. The combination of these wise strategies can achieve long-term success in the preservation and maintenance of the water resources in both rivers and lakes.

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