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Study on impact assessment and mitigationstrategy of dam construction project onecological environment

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Abstract: *This paper aims to deeply explore the multifaceted impacts of dam construction on the ecological environment and put forward corresponding mitigation strategies. By analyzing the changes brought about by dam construction in geology, hydrology, vegetation, etc., this paper elaborates on the impact mechanisms, and introduces on-site investigation, model simulation, and social and economic analysis assessment methods. Furthermore, it puts forward mitigation strategies from the perspectives of engineering, construction period, and ecological restoration, with the goal of providing reference for achieving coordinated development of ecological and economic social benefits in dam construction.*

Keywords: *Dam Construction Project; Ecological Environment; Impact Assessment; Mitigation Strategies*

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I. Introduction

(1) Research background

With the rapid development of social economy, dam construction plays an extremely important role in flood control, power generation, irrigation, water supply, shipping and many other fields, providing a lot of convenience for human production and life, and creating considerable economic and social benefits. However, damming project is a human activity that has a major intervention in the natural ecosystem. It changes the original natural state of the river and the surrounding ecological environment, causing a series of ecological problems such as the change of geological structure, the imbalance of water ecosystem, and the damage of biodiversity. These problems are increasingly concerned by all walks of life. How to give full play to the advantages of dam construction, minimize its negative impact on the ecological environment, and achieve sustainable development, has become an important issue that needs to be further studied.

(2) Research purpose

The main purpose of this study is to comprehensively and systematically assess the impact of dam construction on the ecological environment, and analyze the specific manifestation, mechanism and degree of impact in detail. On this basis, combined with the actual situation, targeted and operable mitigation strategies are proposed, aiming at coordinating the relationship between dam construction and ecological environmental protection, promoting the development of dam construction towards a more ecological friendly and sustainable direction, and providing scientific reference for the decision-making, planning and implementation of related projects.

II. the impact mechanism of dam construction on ecological environment

(1) Impact on geology and ecology

1. Increased earthquake risk

DAMS create reservoirs that often store a large amount of water, which creates enormous water pressure on the bottom and banks of the reservoir. For some reservoirs located in areas with relatively active geological structures or areas with relatively developed rock cracks, these water pressures may cause water to penetrate deep underground along rock cracks, thus changing the original stress state of rock and increasing the pore water pressure of rock. When the pore water pressure increases to a certain extent, the friction between the rocks will be significantly reduced, and the structural balance of the rock mass that was originally in a relatively stable state will be broken, which will easily lead to the instability of the rock mass, and then increase the risk of earthquakes. Such earthquakes induced by reservoir impoundment are called reservoir-induced earthquakes. For example, China's Xinfengjiang reservoir after the completion of water storage, there have been many seismic activities, some of which are high magnitude, have a certain impact on the surrounding area of the seismic events, which fully shows that the dam construction project under

specific geological conditions may become one of the factors to induce earthquakes, to the regional geological ecological environment brings potential threats.

2. Landslides and surge hazards

After damming the reservoir, the groundwater level of the surrounding mountain will rise, and the mountain will be flooded for a long time. The physical and mechanical properties of the rock and soil will be changed, especially the shear strength will be greatly reduced, and the originally stable mountain structure will become fragile, which is easy to cause geological disasters such as landslides. Once the landslide occurs, a large number of rock and soil bodies rush into the reservoir at high speed, which will stir up huge surge waves in the reservoir. The surge will spread around at a very fast speed, which may not only impact the safety of the reservoir dam itself and threaten the structural stability of the dam, but also cause damage to the bank slope, buildings and water facilities around the reservoir, and may even endanger the life and property safety of downstream residents. For example, in the vicinity of some mountain reservoirs, landslides occur from time to time after the dam is built, and the surge results in some villages along the coast being inundated and farmland being washed away, which brings serious negative impact on the local ecological environment and people's life.

(2) The impact on the water ecosystem

1. Ecosystem succession

Damming changes the natural flow state of the river, and the original fast-flowing river becomes a relatively static or slow flow of the reservoir water body, which makes the water velocity, depth, temperature and light and other key environmental factors of the water ecosystem have significant changes. For example, after the reservoir is filled with water, the water depth increases, and the water temperature at the bottom becomes relatively stable and low, while the water temperature at the surface changes greatly under the influence of solar radiation. This stratification of water temperature is particularly obvious in some large reservoirs. This change will affect the living environment of aquatic organisms, organisms originally adapted to the river rapids environment, such as some benthic ephemeroptera insects, torrent fish, etc., may reduce or even disappear because the water flow slows down and the habitat changes; And some adapt to the still water or slow water environment of organisms, such as planktonic algae, carp fish, etc., may multiply, resulting in changes in the species composition of the water ecosystem, community structure, the entire ecosystem to adapt to the new environment in the direction of succession.

2. Water quality change

After the dam is built, the water flow speed slows down or even tends to be static, and the self-purification ability of the water body will be greatly reduced. On the one hand, the sediment and other particles carried in the river are easy to precipitate and accumulate in the reservoir, making the silt at the bottom of the reservoir gradually increase; On the other hand, various pollutants from the upstream, such as chemical fertilizers and pesticide residues in agricultural non-point source pollution, organic matter, nitrogen and phosphorus and other nutrients in domestic sewage, and heavy metals in industrial wastewater, are difficult to be diluted and taken away quickly in the reservoir, and are easy to accumulate in the water body. Over time, the accumulation of these pollutants may lead to water quality deterioration problems such as eutrophication in the reservoir water body, manifested by phenomena such as reduced transparency of the water body, algae blooms, and fluctuations in dissolved oxygen content, which in turn affect the health of the entire water ecosystem, resulting in the survival of aquatic organisms being threatened and biodiversity declining.

(3) The impact on vegetation distribution

1. Causes of vegetation degradation

Dam construction projects may lead to changes in the regional groundwater level, especially around the reservoir and in a certain range downstream, where the groundwater level tends to decline. For some plants that depend on groundwater for their survival, the lower water table means that their roots can't get enough water, which can lead to growth inhibition and vegetation degradation. For example, some herbaceous plant communities and riparian forests growing near the river bank originally relied on the lateral recharge of the river to maintain the stability of the groundwater level. After the dam construction, the water level and flow of the river are artificially regulated, and the lateral recharge is reduced, and the groundwater level decreases accordingly. These vegetation will gradually wither and die, resulting in the degradation of the original continuous vegetation cover in patches. The type and quantity of vegetation will be significantly reduced.

2. Examples of changes in vegetation distribution

Take the Hutuo River Basin in China as an example. After a series of dam-building projects were carried out in the basin, the hydrodynamic conditions of the river have changed greatly, and the groundwater

level has decreased to different degrees in many areas. Through long-term monitoring of the distribution of vegetation in the basin, it is found that the area of wetland vegetation such as reed and tamarisk, which were widely distributed on both sides of the river bank, has gradually shrunk. Some tree species with poor drought tolerance, such as poplar, have suffered poor growth and even died in the areas closer to the river bank, while some herbs and shrubs adapted to the drought environment have begun to invade these areas. The distribution pattern of vegetation has gradually changed from wetland vegetation and riparian forest to drought-tolerant vegetation, which has a more obvious impact on the ecosystem function and ecological landscape of the whole basin.

III. Ecological environmental impact assessment method of damconstruction project

(1) On-site investigation method

1. Water quality monitoring

By setting up multiple monitoring points in rivers, reservoirs and other water bodies where the dam construction project is located, water samples are collected regularly for laboratory analysis, and the monitored water quality indicators include water temperature, pH value, dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia nitrogen, total phosphorus, heavy metal content, etc. Through the long-term collection and analysis of these water quality index data, we can intuitively understand the change of water quality before and after dam construction, evaluate the impact of dam construction project on water quality and the trend of water quality change, and then judge its potential harm to water ecosystem. For example, if it is found that the contents of ammonia nitrogen, total phosphorus and other nutrients in the water body continue to increase after the dam construction, and the dissolved oxygen content shows a downward trend, it may indicate the risk of eutrophication of the water body, indicating that the dam construction project has affected the self-purification capacity and ecological balance of the water body to a certain extent.

2. Biodiversity investigation

The biodiversity of aquatic organisms and terrestrial organisms in the dam construction area shall be investigated, and field sampling shall be carried out by sample method and line transect method. For aquatic organisms, the species and quantity of plankton can be analyzed by collecting water samples, and the species identification and population statistics of benthic organisms such as fish, shrimp and crabs can be carried out by fishing with nets. For terrestrial organisms, a quadrat is set around the reservoir and within a certain range in the upper and lower reaches of the reservoir to investigate the vegetation characteristics such as plant types, coverage and height, and the species and population number of birds, mammals and other animals are counted by trap method and mark recapture method. By comparing the changes of biodiversity before and after dam construction, such as the increase or decrease of species richness and the replacement of dominant species, we can accurately assess the extent of damage to biological habitat and the impact on biological survival and reproduction of dam construction project, and provide a basis for ecological environment protection.

(2) Model simulation method

1. Application of hydrological model

With the help of hydrological models, such as MIKE series, SWAT and other commonly used hydrological simulation software, and the input of basic data such as terrain and geomorphology, meteorological data, soil characteristics and river flow in the dam construction project area, hydrological elements such as water level change, flow velocity distribution and runoff change of the river before and after dam construction can be simulated. For example, the simulation can predict the fluctuation range of water level in different seasons and under different working conditions after the reservoir is impounding, analyze the impact of such water level change on the ecosystem of riparian zone and the satisfaction degree of the ecological water demand of downstream rivers, etc., so as to evaluate the possible ecological environment impact of the dam construction project in terms of hydrology in advance, and provide references for the planning and operation management of the project.

2. Application of ecological model

Ecological models, such as individual-based fish growth model and ecosystem dynamics model, can simulate and predict the change trend of biological population size, distribution range and ecosystem structure and function after the implementation of dam construction project according to the biological characteristics, behavior habits and the relationship between environmental factors. Taking fish as an example, the ecological model can consider the impact of factors such as blocking of migration channels and changes in water temperature on the reproduction, growth and migration of fish caused by dam construction, and then predict the rise and fall of fish populations, and help managers to formulate appropriate fish protection

measures, such as setting fishways and implementing proliferation and release, so as to mitigate the impact of dam construction on aquatic biodiversity.

Examine the social impact of the dam construction project on local residents' life, employment, culture and other aspects. For example, the construction of the dam may require the occupation of some residents' land, leading to the relocation of residents and affecting their living environment and lifestyle; In the process of operation of the project, it may change the local industrial structure, have an impact on employment opportunities, and may also involve some changes related to local traditional culture and folk customs. Collect relevant information through social survey, public opinion interview and other means to evaluate the social acceptability of dam construction project and its impact on social harmony and stability, so as to take appropriate measures to protect the rights and interests of local residents and promote the sustainable development of society.

IV. Mitigation strategies for ecological environment of damconstruction projects

(1) Engineering measures

1. Reasonable site selection

In the planning stage of the dam construction project, factors such as regional geological conditions and distribution of sensitive ecological environment should be fully considered, and ecological sensitive areas such as seismically active zones, areas prone to landslides and debris flows, important nature reserves, and habitats of rare and endangered species should be avoided as far as possible. For example, for some rivers with important fish migration channels, DAMS should be avoided at their key migration nodes, or special engineering design should be adopted to ensure smooth migration of fish. In areas with karst development, sites should be carefully selected to prevent geological disasters such as karst collapse caused by reservoir filling. Through scientific and reasonable site selection, the potential damage risk of dam construction to the ecological environment should be reduced from the source.

2. Optimization of engineering scheme

In the process of engineering design, attention should be paid to optimizing the engineering scheme, using environmentally friendly building materials and construction techniques to reduce the consumption of natural resources and environmental pollution. For example, a new type of concrete material can be used to improve the durability of the dam and reduce the environmental disturbance caused by later maintenance; In the design of the dam structure, ecological dam can be considered, such as setting ecological holes, fish channels and other facilities in the dam to provide habitat space and migration channels for aquatic organisms. At the same time, parameters such as the height and storage capacity of the dam should be reasonably determined to avoid over-exploitation of water resources and ensure that the river ecosystem has enough ecological water demand to maintain its normal operation.

2. Environmental protection measures during the construction period

1. Standardized operation

In the process of dam construction, it is necessary to establish strict construction operation standards, control the scope and intensity of construction activities, and reduce the damage to the surrounding ecological environment. For example, the width of the working belt of the construction machinery should be stipulated to avoid large-scale land rolling and vegetation destruction; Waste residue, waste and other solid waste generated in the construction process should be collected and properly handled to prevent soil pollution caused by random discarding; For construction waste water, special treatment facilities should be set up and discharged after reaching the standard to avoid pollution to surface water and groundwater.

2. Rationalization of construction scheme

According to the ecological environment characteristics and seasonal changes of the construction area, make a reasonable construction plan. For example, underwater construction should be minimized during fish breeding period to avoid disturbing fish spawning and young fish growth; In the rainy season, it is necessary to strengthen the soil and water conservation measures of the construction site, by setting up interception ditches, sedimentation tanks, retaining walls and other facilities, to prevent soil erosion, reduce sediment flow into rivers, reservoirs and other water bodies resulting in siltation and water quality deterioration. At the same time, the construction schedule should be reasonably arranged, the construction period should be shortened, and the ecological environment of the construction area should be restored as soon as possible.

(3) Ecological restoration measures

1. Ecological flow release

In order to ensure the normal operation of downstream river ecosystems, dam construction projects should release ecological flow to the downstream regularly and quantitatively in accordance with ecological water requirements during operation. Through scientific calculation to determine the ecological

flow standards of different seasons and different river sections, the use of reservoir water release facilities for accurate scheduling, to ensure that the downstream river has enough water to maintain the form of the river, dilute pollutants, meet the needs of aquatic organisms survival and reproduction and vegetation growth along the riverbank. For example, in the dry season, the release of ecological flow should be appropriately increased to maintain the basic ecological functions of the downstream river, prevent the interruption of flow, dry up and other situations, and protect the integrity of the river ecosystem.

2. Fishway construction

For those dam construction projects that block the migration passage of fish, it is necessary to design and construct the fishway reasonably according to the types of fish, the migration habits and the specific structure of the dam body. Fishway in various forms, there are vertical slit, chute, pool and other different types, its purpose is to simulate the flow conditions of natural rivers, for fish to provide a upstream or downstream channel, to help fish to complete reproduction, foraging and other migration behavior. At the same time, it is necessary to strengthen the operation management and effect monitoring of the fishway, timely adjust and optimize the fishway design, improve the efficiency of the fishway, and protect the biodiversity of fish.

V. Conclusion and prospect

(1) Summary of research conclusions

Dam construction, as a kind of human activity with significant intervention in natural ecosystem, has a multi-faceted impact on ecological environment, covering geology, water ecology, vegetation and other fields. These impacts may not only cause geological disasters such as earthquake and landslide, destroy the balance of water ecosystem, lead to negative effects such as biodiversity decline and vegetation distribution pattern change, but also bring significant economic and social benefits in flood control, power generation and other aspects. Through field investigation, model simulation, social and economic analysis and other assessment methods, we can fully and accurately grasp the degree of ecological environmental impact of dam construction projects, and then provide scientific basis for formulating corresponding mitigation strategies. The mitigation strategies proposed from the perspectives of engineering measures, environmental protection during construction period and ecological restoration can help to reduce the negative impact of dam construction on ecological environment to a certain extent, and promote the coordinated development of dam construction engineering and ecological environment.

(2) Prospect of future research direction

Although some research results have been achieved in the assessment of the impact of dam construction on ecological environment and mitigation strategies, there are still many problems worthy of further exploration. For example, how to more accurately quantify the impacts of dam construction on various aspects of ecological environment, especially some long-term and cumulative impacts; How to establish a more complete comprehensive evaluation index system of ecological environmental impact, so that it can cover more ecological environmental factors and be more scientific and practical; In terms of mitigation strategies, how to further improve the effectiveness and sustainability of ecological restoration measures, and how to better coordinate the relationship between different stakeholders to ensure that various mitigation strategies can be effectively implemented. Future research needs to combine multidisciplinary theories and methods, and continue to explore in depth, so as to provide stronger support for the eco-friendly construction and sustainable development of dam construction projects.

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