# Natural Impact Assessment of Laos-China Hydropower Projects in View of the Extension Theory.

**Received:** 9 July 2021
**Revised:** 30 July 2021
**Accepted:** 5 August 2021

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## Abstract

With its cleanliness and low price, hydroelectric power has gradually become one of the first choices for energy development around the world. Laos is rich in hydropower resources, attracting a large number of Chinese companies to invest in hydropower projects, making great contributions to social and economic development. However, the development and construction of the projects have both positive and negative impacts on the environment. The stability in the environment has a profound impact on the overall sustainable development of the region. This study, thus, aimed to assess the environmental effects of the Laos-China multinational hydropower projects. This paper designed a natural impact assessment index for hydropower projects from three sources: water resources, land resources, and atmospheric resources adopting the Nam Lik 1-2 hydropower station in Laos as a sample. The data related to impacts on the environment in Laos from 2009 to 2016 were analyzed in view of the extension theory. The results show that the construction of the Nam Lik 1-2 Hydropower Station has caused fluctuations in the environmental benefits in Laos. Controlling water resources by hydroelectric power station projects is the main driving force for sustainable development. At the same time, it is necessary to continuously strengthen pollution prevention and control in order to advance the security of the ecosystem.

**Keywords**: Transnational Hydropower Project, Environmental Impact Assessment, Extension Theory

## Introduction

Given that the shortage of traditional energy in various regions has been increasing, hydropower resources have been developed and utilized more extensively as pollution-free energy. Laos is located in the Mekong River basin, the largest river in Southeast Asia. It has more than 60% of the hydropower resources in the river. Laos is also the country with the richest hydropower resources in the lower Mekong River. The northern and southern regions of Laos have the most abundant hydropower resources, with the developable scale reaching 7405MW and 7201MW, respectively. With advantages in the location and resource conditions, Laos has made the hydropower industry gradually become a key industry in socio-economic development. For the time being, with the gradual advancement of the Lancang-Mekong Cooperation (LMC), China's direct investment in hydropower projects in Laos has increased year by year, and Lao-China transnational hydropower projects have gradually become the main carrier of China's direct investment in Laos. (Zhang et al., 2014)

Since the energy supply mainly comes from hydropower stations, the extensive development of hydropower projects will inevitably have an impact on the local environment in Laos. On one hand, hydropower infrastructure can effectively perform many functions, namely, flood control, water regulation, clean power generation, and environmental damages reduction. On the other hand, due to the long construction period of the hydropower project, the large scale of investment, the complexity of stakeholders, and the wide range of influence, the surrounding water source, geology, and climate environment may be damaged to a certain degree during the construction and operation of the project. These damages exceed the limited range of the environment control, which will lead to the ecosystem imbalance in Laos, and eventually may bring irreparable negative impacts on various systems such as nature, society, and economy. In July 2018, a hydroelectric power station in Attapeu province caused catastrophic floods, causing about 13,000 people to be affected. This major disaster severely affected Laotian livelihood and economic development, and it has also brought more challenges to the construction of hydropower development projects. Therefore, in the development process of hydropower projects, scientifically and reasonably environmental impact assessment is important to understand possible impacts of projects on the environment and is important for timely solving environmental problems in the process of project construction and operation. (He et al., 2018)

## Analysis

Concerning the environmental impact of multinational investment projects, many studies were conducted from different perspectives and employed different methods: system dynamics (Zhang et al., 2014), analytic hierarchy process (Wang et al., 2018), coordination (Xu et al., 2014), geographic information system (GIS) (Huang, 2018), to name but a few. It appears that there are two views on this field. One view is that multinational engineering investment projects have brought a burden to the local environment and have a certain negative impact. Peng Lin (2017) used the analytic hierarchy process and fuzzy comprehensive evaluation to evaluate the project of transnational oil and gas pipeline projects and found that it has certain natural environmental risks. Zhengqi He (2018) conducted a study from the perspective of the internal interaction of the "environment-economy-society" system, which found that multinational engineering investment projects may destroy the ecological environment and trigger the chain reaction in the complex ecosystem. NhuyenThi Thanh Huong (2018) studied the impact of foreign direct investment on Vietnam's environment and stated that foreign direct investment has caused significant water pollution in Vietnam. The other view is that multinational engineering investment projects have a certain positive impact on the local natural environment. Liu Xuancan (2020) believed that the host country has been often brought advanced concepts and technologies in international projects. Therefore, the construction process of engineering projects shall pay more attention to energy conservation, environmental protection, and pollution control, in line with local environmental management regulations.

Previous studies also focused on the potential positive and negative impacts that investment projects may have on the local natural environment. The construction and operation of reservoirs and dams will have certain negative impacts on local water spots, geology, and the ecological environment (Bruce Shoemaker, 1998). scholars admitted that hydropower projects did have a certain negative impact on the local and surrounding natural environment, but in a limited range (Zhao et al., 2012). In the long run, hydropower projects can have a positive impact on the local environment. Zhong Huaping (2010) used the data from the historical flood at the Yunjinghong gauging station and found that the dams on the mainstream of the Lancang River had a significant regulating effect on downstream runoff, which can effectively weaken the flood volume in the rainy season and reduce the occurrence of flood disasters.Zheng Tengfei (2015) conducted an externality analysis of transnational water conservancy projects, and the results showed that the biodiversity of the reservoir area has been enriched, the water quality of some sections has been improved, and the concentration of pollutants has been significantly reduced.

Generally speaking, previous studies selected different projects and used different evaluation methods to evaluate the environmental impact of multinational engineering investment projects. However, due to the different types of investment projects and the conditions of the host country, different conclusions have been drawn. At present, global hydropower development is of great urgency and importance, and the Mekong River Basin is rich in hydropower resources that can be developed, and transnational hydropower projects are booming.

## Analysis

The Nam Lik 1-2 Hydropower Station is the first BOT hydropower project in Laos invested by a Chinese company. The construction of the Nam Lik 1-2 Hydropower Station project started in September 2007 with which a construction period of four and a half years, with a total investment of 142 million U.S. dollars and a total installed capacity of 100 MW. It is a first-class (I) type project. Since it officially entered commercial operation in August 2010, the actual power generation of hydropower stations has exceeded the design power generation by more than 20% each year. The total power generation accounts for nearly one-third of the total installed capacity of the central Laos power grid, and the cumulative power generation exceeds 5 billion kWh. After the completion of the Nam Lik 1-2 Hydropower Station, it maintains stable and high-quality power output, providing sufficient power for Vientiane and significantly improving the local power shortage problem. At the same time, the hydropower station also relies on an inventory capacity of 1.4 billion cubic meters to implement dynamics on the river. The adjustment effectively solved the local flood control problem. In recognition of its outstanding contribution to Laos' social economy, the Lao government awarded the Nam Lik 1-2 Hydropower Station a National Labor Medal. The Nam Lik 1-2 Hydropower Project has gradually become a model and benchmark for guiding subsequent Chinese companies to enter the Laos hydropower market.

The three most weighted indicators are the percentage of freshwater extraction, the number of freshwater resources per capita, and the area of arable land. Through the construction of the Laos-China transnational hydropower project to regulate water volume and control disasters, the supply and demand of water resources can be adjusted, the occurrence of floods can be reduced, and the overall environmental benefits can be improved. In addition, the weights of the three first-level indicators indicate that the changes in water resources in Laos have the most significant impact on environmental benefits, while changes in land resources and atmospheric resources have less impact on environmental benefits. This is also closely related to the innate natural conditions of Laos with developed water systems and sufficient water sources.

From 2009 to 2016, the overall environmental benefit level of Laos was mainly concentrated on the three levels of a poor, medium, and excellent. On the whole, there was a trend of increasing volatility. During the early period of 2011-2013 when the project was completed, the environmental benefits of Laos were improved. The construction of hydropower projects played an active role in flood control and irrigation and clean power generation, which made the level of environmental benefits change from poor to medium. At the same time, although the project was put into operation, the environmental benefit level is not high, but its comprehensive relevance has been greatly improved compared to before the completion of the project. From 2014 to 2015, the level of environmental benefits of the project has been reduced, and the grade has deteriorated from medium to poor. Analysis of the reasons is mainly due to the sudden increase in CO2 emissions during the same period, resulting in low overall environmental benefits. Since the project has been put into operation for a short time and the operator has not yet fully understood the local production activities and environmental capacity, pollution prevention, and control measures have not yet been put in place. This resulted in a deepening of the pollution. In 2016, the level of environmental benefits has improved again, and the level has changed from poor to excellent, gradually approaching the ecological stability of sustainable development.

## Conclusion

The development and construction of the Laos-China transnational hydropower project have an impact on the water, land, and atmospheric environment in the region. The purpose of environmental benefit evaluation is to analyze and predict the possible impact of project implementationon the local natural environment. This paper establishes a natural impact evaluation system for Laos- China multinational hydropower projects, adopting Laos' Nam Lik 1-2 hydropower station as a sample and analyzes the impact of the project on the natural environment before and after the completion of the project in view of the extension theory. The results can be concluded as follows:

First, as an objective weighting method, the entropy method determines the index weight according to the amount of information provided by the observation value of each index, which can intuitively reflect the degree of influence of each index on the natural system; and the extension theory is used as a base of the interdisciplinary innovative method. The natural environment before and after the completion of the project

can be divided by calculation; the in-depth comparison can further evaluate the impact of the project on the natural environment.

Second, the construction and operation of the Nam Lik 1-2 hydropower station took the project construction and commissioning period as the node. The environmental benefits of Laos during the initial period of completion (2011-2013) have improved, which indicates that the project has improved the natural environment of Laos during the initial period of completion. It has a certain regulating effect, and the environmental quality has been improved; after 2013, the environmental benefits of Laos have been reduced for a short time and then improved again. The reduction of benefits has a certain relationship with the pollution discharge of the project construction and operation, and it is necessary to continue to monitor pollution in the further period, which should strictly abide by local environmental protection standards and promote ecologically sustainable development.

Third, from the perspective of water resources, land resources, and atmospheric resources, water resources indicators have the greatest impact on environmental benefits, reflecting that the construction of the Nam Lik 1-2 hydropower station has an orderly adjustment to the locally available water resources to promote the steady-state of the natural environment. The weighting results show that the construction and operation of the project mainly maintain the steady-state of the regional natural environment through the orderly adjustment of water consumption and control of exhaust gas emissions.

## Acknowledgment

This Work was Partially Supported by a research grant from Jiangsu Provincial Collaborative Innovation Center of World Water Valley and Water Ecological Civilization, Nanjing, China and Thank you for the research target group. and all research participants

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