Article

Hierarchical biodiversity and environment impact assessment of South-to-North Water Diversion Project of China

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Abstract
In this brief review, the potential environmental and biodiversity impact of South-to-North Water Diversion (SNWD) project in China on regional environments was assessed. I used the hierarchical environmental impact assessment to classify the possible impacts into three orders caused by the construction of SNWD and then presented the current research advances on each order of the impacts. Further impact assessments should be reinforced during the construction period of SNDW project for the sustainable maintenance of regional environment.

Keywords environmental impact assessment; South-to-North Water Diversion; China.

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1 Introduction

The project of South-to-North Water Diversion (SNWD) is a key scheme in China for solving the distributional inequality of surface water and optimizing the use of water resources. It has been designated to relieve the water shortages in the north of the nation (Wang et al., 2009). The project is composed of the east, middle and west line sub-projects, together with the Yangtze, Huai, Yellow and Hai Rivers, forming four transversal and three longitudinal water routes (Jing and Cao, 2007).

Like China's another mega-project-Three Gorges Dam, the SNWD scheme has provoked many social, economic and environmental concerns, principally regarding the loss of antiquities, the displacement of people and the destruction of natural/agricultural land (http://www.water-technology.net/projects/south_north/). In this review, I used the environmental impact assessment (EIA) to simply assess the impacts of SNWD project on surrounding environmental conditions.

To reflect and minimize the environmental negative effects associated with huge projects, the environmental impact assessments (EIAs) have been incorporated into the planning process of the projects (Tullos, 2008). The EIA process was created in 1969 by USA and then gradually adopted by the governments of worldwide nations (Tullos, 2008).

This paper catalogued a hierarchy of environmental impacts on SNWD project and identified different impact types of SNWD project on regional environments in China through searching the peer-reviewed publications in recent time.

2 A hierarchy of Environmental Impacts on SNWD Project

According to the existing typologies (World Commission on Dams, 2000; Tullos, 2008), I constructed hierarchical impact orders for the SNWD project. In general, the environmental impacts can be classified into three orders.

The first order impacts include the primary effects that are directly associated with physical, chemical, and geomorphological consequences of the project, such as hydrology, sediment, geological structure, water allocation and water quality.

The second order impacts include those related to primary changes in the ecosystem, such as climate change, habitat quality, change of plankton and algae productivity and vegetation change. In this catalogue of impacts, most are related to ecosystem functioning. Different to the classification (Tullos, 2008), climate impact was considered to put into this order because the climate variability can be modeled through the hydrologic cycle alternation. In general, the second order impacts provide an intermediate link between the first and third order impacts.

The third order impacts are related to the change of biodiversity and the effects on the spreading of infectious diseases. The habitat shifts of hosts for zoonotic diseases are caused by landscape and habitat alternation due to the project.

3 Current Advances on the Hierarchical Impacts

Current progresses on the impact assessment of SNWD based on previous published literature are highlighted.

On the first order's impacts, a previous study (Wang and Ma, 1999) pointed out the possible geologic effects in the middle line of SNWD. The problems on slope stability of swelling clay and rocks and the soil salinization will emerge gradually due to the rise of groundwater tables as expected. Another study (Liu et al., 2007) analyzed the regional slope stability on the Daqu watershed, subject to the first stage of west line of SNWD. They identified the unstable areas based on a variety of factors such as gradient, slope type, earthquake and land use. The rationality was tested through the field work of slope failure hazards.

On the second order's impacts, several works have been focused on the impact of climatic variability. However, the climatic predictions are controversial. For example, a previous study (Chen et al., 2007) analyzed the historical temporal pattern of climatic variability in the Danjiangkou reservoir of Han River Basin, the source of middle route of SNWD. They found that in the reservoir basin, the ground temperate will increase significantly, while the mean annual, winter and spring runoffs will trend to decrease in response to the predicted climate of 2021-2050. These predicted impacts threw insights into the construction of the middle route of SNDW. Furthermore, another study (Wang et al., 2007) analyzed the regional climate effects caused by the agricultural irrigation related to SNWD project. They used a climate simulation model to reveal that the large-scale agricultural irrigation after the completion of SNDW will cause drastic climate change in North China.

On the third order's impacts, a previous work (Yun et al., 2007) argued that because of SNWD, the groundwater tables, the aquifer reserves and land subsidence will go to a good direction in the North. Therefore, SNWD will have great positive impacts on regional ecological environment. Some works have been paid to the impact of zoonotic diseases. For example, a previous study (Wang et al., 2009) assessed the impacts on the distributional shift of *Oncomelania hupensis*, an intermediate host of *Schistosoma japonicum*.

They found that unless the winter temperature in North China significantly increases, the SNWD is unlikely to contribute to the northward shift of schistosomiasis.

4 Perspective

I provide a brief hierarchical biodiversity and environment impact assessment for SNWD project and outline the current advances on different impacts. Based on the above mini-review, potential further works should be enhanced for the perfection of the hierarchical impact assessment (Zhang, 2013). For example, because the second order impacts provide connection between the first and third order impacts, further work can be focused on the prediction accuracy of the climate models and generating a reliable predicted results (Ferrarini, 2012; Nedorezov, 2012). These reliable climatic scenarios can provide solutions to assess the impact on biodiversity loss and infectious disease spreading due to SNWD construction. Besides, the environmental monitoring and management effects can be reinforced. For example, currently, the Chinese Ecological Research Network (http://www.cern.ac.cn) has set several stations to monitor and gauge the environmental impact of the implementation of SNWD. However, new stations are necessary to build because the existing ones are not enough to cover the whole regions affected by the scheme (Zhang, 2005).

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