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Value of ecosystem hydropower service and its impact on the payment for ecosystem services

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HIGHLIGHTS

- Ecosystem hydropower service is irreplaceable due to high cost of dams.
- Hydropower PES requires a transition from passive protection to active protection.
- A differential PES standard should be implemented for cascade development.

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ABSTRACT

Hydropower is an important service provided by ecosystems. We surveyed all the hydropower plants in the Zagunao River Basin, Southwest China. Then, we assessed the hydropower service by using the InVEST (The Integrated Value and Tradeoff of Ecosystem Service Tools) model. Finally, we discussed the impact on ecological compensation. The results showed that: 1) hydropower service value of ecosystems in the Zagunao River Basin is 216.29 Euro/hm^2 on the average, of which the high-value area with more than 475.65 Euro/hm^2 is about 750.37 km^2, accounting for 16.12% of the whole watershed, but it provides 53.47% of the whole watershed service value; 2) ecosystem is an ecological reservoir with a great regulation capacity. Dams cannot completely replace the reservoir water conservation function of ecosystems, and has high economic and environmental costs that must be paid as well. Compensation for water conservation services should become an important basis for ecological compensation of hydropower development. 3) In the current PES cases, the standard of compensation is generally low. Cascade development makes the value of upstream ecosystem services become more prominent, reflecting the differential rent value, and the value of ecosystem services should be based on the distribution of differentiated ecological compensation.

1. Introduction

As a renewable energy source, hydropower has attracted worldwide attention (Huang and Yan, 2009; Yüksel, 2008). The demand for energy due to China's rapid economic development has stimulated hydropower development, and thus China has become a typical one of the developing countries in energy development. Southwest China has abundant water resources, and it is becoming one of the important hydroelectric bases. Eight of the thirteen planned hydropower bases are located in this region. Of them there are large plants like those over the Jinsha River, but there are also medium-sized hydropower stations like those over the Daduhe River (Huang and Yan, 2009). Cascade development has become the main mode of hydropower development.

Hydropower development has not only brought about huge economic benefits, but also has caused environmental impact which cannot be ignored, involving river health (Kibler and Tullos, 2013), biodiversity conservation (Grumbine and Xu, 2011) and water safety. The most important problem is immigration (MA et al., 2011). These problems make the current hydropower development model suffer more increasing doubts, which is not conducive to the healthy development of hydropower industry.

In the context of climate change, hydropower as a clean energy source to meet the energy needs of economic development has a great potential (Akpınar et al., 2011), but in order to establish a harmonious hydropower development model which can balance ecological conservation and economic development it is also needed to comprehensively understand the positive and negative effects brought about by hydropower development in the perspective of regional sustainable

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development. The key is to scientifically assess the impact of hydropower development on various stakeholders.

Payment for ecosystem service (PES) is a powerful tool which provides an excellent idea for the coordination of the relationships among different interest groups in hydropower development, but the prerequisite is the scientific understanding of the relationship between ecosystem services and hydropower benefit. However, most researches put their focus on the impact of hydropower development on river ecosystem or on the assessment of ecosystem service losses (Dugan et al., 2010; Wang et al., 2010; Ziv et al., 2012). As for forests and other terrestrial ecosystems, there is a lack of quantitative evaluation of all kinds of service utilization, which thus has led to such a result that current policy and management are merely focused on how to reduce the environmental impact, as well as damages, but cannot effectively promote an integrated watershed protection, nor establish the sustainable hydropower development mode.

In this paper, we surveyed the hydropower plants in the Zagunao River Basin, a main tributary of the Minjiang River in Southwest China with earlier hydropower development, and using GIS models we assessed the ecosystem function and value for hydropower, then identified the high-value area, and proposed recommendations for PES.

2. Study area

2.1. Overview of the Zagunao River Basin

The Zagunao River is located in the north-central Sichuan Province, a tributary of the Minjiang River with a drainage area of 4632 km^2. The administrative divisions include Miyaluo, Zagunao, Xuecheng townships etc., with a total population of about 50,000. Land use of the Zagunao River Basin is dominated by forest, shrub and grassland, with cropland and construction land accounting for 2% only (Fig. 1). Due to abundant rainfall and undulating terrain, hundreds of rivers run through this area, including the Mengtun River, the Suoluogou River and the Banzigou tributaries. So this area has become the earlier hydropower development area in Southwest China.

2.2. Hydropower development in the Zagunao River Basin

The Zagunao River Basin is a region where there are more abundant hydropower resources in the upper reaches of the Minjiang River Basin. The early history of hydropower development can go back to 1958, in which the Xiazhuang plant was set up as the first hydropower station over the Mingjiang River. By now, there are more than 40 hydropower plants in this river basin (Fig. 1), with a total installed capacity of 1.12 million kilowatts. The hydropower plants are mainly located in the mainstreams and main tributaries like the Mengtun River and the Suoluogou River. The Shiziping Hydropower Station built in 2012 is the largest plant, with an installed capacity of 200,000 kW and a regulating capacity of 119 million cubic meters. In this river basin there are still five power plants under construction.

3. Methods

This study is based on the Integrated Valuation of Ecosystem Services and Tradeoffs-InVEST model ecosystem utility services. The research framework is shown in Fig. 2.

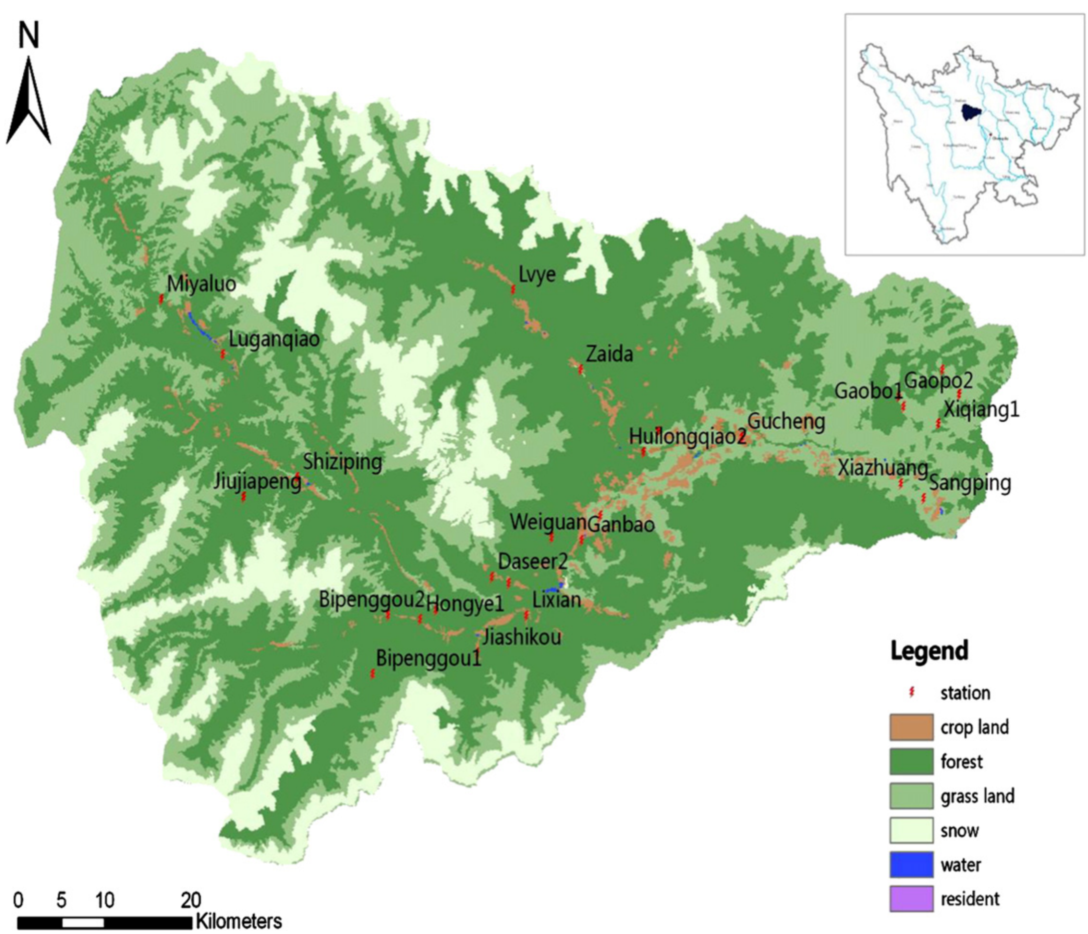

Fig. 1. Land use in the Zagunao River Basin and the hydropower stations used in this study.