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A benefit-sharing model for hydropower projects based on stakeholder input-output analysis: A case study of the Xiluodu Project in China

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ABSTRACT

The rich hydro resources and global pressures of greenhouse gas emission have promoted the rapid development of hydropower projects in China. However, the benefit distribution unfairness in hydropower projects leads to problems such as resettlement conflicts, which significantly hinder the sustainable development of hydro resources. In order to determine a reasonable benefit sharing policy system, this study employs a new perspective, which treats the reservoir migrants as a formal project stakeholder rather than the passive "compensation receivers" previous practices have considered them to be. From this perspective, this study 1) identifies the stakeholders of hydropower projects and their input/output factors based on stakeholder theories, and highlights the four most important core stakeholders, i.e., government, hydropower generation enterprises, reservoir migrants, and power grid enterprises; 2) designs a specific calculation method for the four core project stakeholders' cash flows and establishes a quantitative benefit-sharing model based on the input-output analysis; and 3) employs the Xiluodu Project in China as a case study to demonstrate the feasibility and effectiveness of the proposed method. Theoretically, the change in reservoir migrants' status in the project delivery framework provides a new perspective for benefit sharing and resettlement studies. Practically, this study establishes a feasible quantitative tool for the description and assessment of benefit sharing systems, and the overall assessment of hydropower projects. The results of the case study show that, under the current benefit distribution policy of China, yields of reservoir migrants are significantly lower than those of other core stakeholders. The results also indicate that, by increasing resettlement compensation standards and slightly adjusting the electricity generation price, all core stakeholders' yields can reach a more rational and fair level.

1. Introduction

China has the richest hydro resources in the world (Chang et al., 2010; Huang and Yan, 2009). In recent years, faced with a rapid increase in energy demand (Liu et al., 2013) and global pressure to reduce greenhouse gas (GHG) emission (Lewis et al., 2015), China's demand for non-fossil energy has rapidly increased (Dai et al., 2011). Hydropower, owing to its huge potential and mature technology, has earned high development priority in China's energy plans (Chang et al., 2010; Jiang et al., 2016; Kirchherr et al., 2016; Randell, 2016). It is estimated that China's total installed hydropower capacity will reach 0.36 billion kilowatts by 2020, and 0.45 billion kilowatts by 2030 (CEC, 2015). This means that China's installed hydropower capacity will increase by about 13 million kilowatts per year from 2016 to 2020, and by 8–10 million kilowatts per year from 2020 to 2030.

However, the social, cultural, and environmental problems associated with the development of hydropower plants are gradually replacing technical problems as the main factors constraining the development of hydropower in China (Chen, 2008; Grumbine et al., 2012; Kittinger et al., 2009). According to a comprehensive framework analysis conducted by Kirchherr and Charles (2016), the five most widely applied theoretical frameworks of the social impacts of dams either directly focus on displacement and resettlement, or take resettlement as an important framework dimensions. By 2006, China had resettled over 22.8 million people to make room for hydropower projects (Wang et al., 2013b). Some of these reservoir migrants have faced poverty risks such as landlessness, unemployment, and social marginalization pointed out by Cernea (1997) in the Impoverishment Risk and Reconstruction (IRR) model, and other influences such as emotional stress and livelihood resource loss after being resettled (Cernea, 2003; Hwang et al., 2010; Webber and McDonald, 2004; Xi and Hwang, 2011; Zheng et al., 2016). The large number of resettled people and the unsolved poverty risks

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and dam-induced influences have led to continuous conflicts between reservoir migrants and project developers (Magee and McDonald, 2006; Wang et al., 2013a; Wilmsen, 2016), calling for solutions to the unfair distribution of benefits in hydropower development.

In hydropower projects, the unfair benefit distribution among project stakeholders has gained consensus (Egre, 2007; Milewski et al., 1999; Missonier and Loufrani-Fedida, 2014; Pohlner, 2016; Skinner et al., 2009). In most cases, hydropower development enterprises and power grid enterprises obtain considerable profits from plant operation. Power users obtain cheap and clean electricity, and downstream residents benefit from hydropower plant functions such as flood control, provision of water, and navigation promotion. However, the reservoir migrants lose benefits and become poor. The World Bank and Asian Development Bank, as well as researchers, have paid special attention to the theoretical mechanism and real-world policies of hydropower project benefit sharing (Egre et al., 2002; Goufo and Liu, 2006; Wang, 2012). In many cases, the beneficiaries of a hydropower project are geographically far away from the site of the project, while the nearby residents are negatively impacted. Therefore, project stakeholders who receive large benefits from hydropower projects have an obligation to share those benefits with people who suffer as a result of the projects (Egre, 2007).

Scholars have discussed and analyzed the effectiveness of a variety of hydropower benefit sharing policies applied all over the world; however, most of these studies have been qualitative. The quantitative analysis of policy effectiveness and the influences of policies on different stakeholders is still limited (Fan, 2010). Furthermore, scholars and policy-makers generally use the “Lose-based Compensation” (LBC) principle to analyze the benefits earned by reservoir migrants who lose their lands and other livelihood resources (Wang et al., 2013b), instead of taking them as equal formal project stakeholders. Studies based on the LBC principle help scholars and policy-makers to understand reservoir migrants’ lives and promote policy modification in different countries, including China, but the scope of loss continues to grow as scholars continue to take non-economic factors such as social and psychological losses into account (Hwang et al., 2010; Kittinger et al., 2009). In addition, the monetary calculation of non-economic losses is extremely difficult, which is why the compensation amount is always considered as “not enough”.

This study changes the traditional research perspective by regarding the reservoir migrants as an equally formal project stakeholder, on the same level as governments or enterprises, and establishes a quantitative benefit-sharing model to assess the existing benefit distribution system and to explore more scientific and reasonable benefit-sharing policies in hydropower development. This paper is organized as follows. In Section 2, the conceptual framework of the benefit-sharing model is introduced, which includes the identification of core stakeholders, the description of benefit distribution among stakeholders, and the principle of benefit sharing used in this study. In Section 3, the mathematical model is presented, specifically the quantitative methods for calculating the internal rate of return of each core stakeholders. In Section 4, the Xiluodu Project in China is used as an example to demonstrate the feasibility and effectiveness of the proposed model. A discussion of the model and the case study are given in Section 5, and conclusions of this study are summarized in Section 6.

2. Conceptual framework

2.1. Core project stakeholder identification

In a hydropower project, various stakeholders take part in the planning, construction and operation phases. Among them, some stakeholders directly engage in the project and are highly concerned about project outcomes, while others may only be indirectly or occasionally involved in the project and pay limited attention to the project outcomes. The first step to establish a benefit-sharing model for hydropower projects is to identify the proper stakeholders for the benefit sharing analysis.

In a project, core stakeholders refer to those who make significant investments in the project and have high power on the realization of the project, and those who have a strong reliance on the benefits they get from the project outputs (Freeman and Reed, 1983). Their decisive influence on the smooth development of a project and their concern about project outcomes make their satisfaction to a project’s development process and the benefit distribution crucial for a project. Thus, these core stakeholders should be the main actors in the benefit sharing process of a project.

As all the input factors of a hydropower project are from its stakeholders and all the output factors of a project will be delivered to its stakeholders, the input/output analysis of a project is a widely acknowledged way to analyze the roles and needs of different stakeholders in a project and is the basis to identify the core stakeholders. Thus, this study first summarized a stakeholder list of hydropower projects based on previous studies (Fan, 2010; Rosso et al., 2014; Watkin et al., 2012), and then analyzed each one for their input factors to and output factors from a hydropower project. As these stakeholders of hydropower projects get involved in project development during different project phases and their input factors to and output factors from a hydropower project also vary during time, the results are organized in Tables 1 and 2 in three columns of project phases for a clear comparison among the stakeholders and among project phases.

Based on the input/output analysis, core stakeholders of hydropower projects can be identified by the widely acknowledged Influence/Interest Matrix, which is a stakeholder classification tool that groups stakeholders based on their active involvement (“influence”) in the project and their level of concern (“interest”) regarding the project outcomes (PMI, 2013). By analyzing the significance of different factors in Tables 1 and 2, all stakeholders listed in the tables were categorized into a qualitative Influence/Interest Matrix. The results are shown in Fig. 1. Among all the project stakeholders, reservoir migrants, hydropower development enterprises, investors, power grid enterprises, central and local government were categorized as high influence and high interest because these stakeholders are directly involved in the project development (invest important factors into the projects such as capital, labor, land and etc.) and typically very concerned about project outcomes for their own welfare. Downstream residents and power users were categorized the opposite (low influence and low interest) as they were neither actively involved in project development nor highly concerned about the economic, social and environmental outcomes. Loan bank, designers, contractors, supervisors and suppliers were categorized as high influence and low interest for their active involvement into the projects and low concern about risks of project outcome fluctuation as their returns are determined by contracts. Residents close to project, Native residents in resettlement site and environmentalists were categorized as high interest and low influence for their concerns about the resettlement and environmental protection and indirectly involvement into the projects. Supplementary interviews with professionals and hydropower project managers confirmed the above classification results.

Among the four groups of stakeholders in an Influence/Interest Matrix, core stakeholders refer to those grouped as high influence and high interest (PMI, 2013; Rosso et al., 2014). To simplify the further quantitative analysis, the six core project stakeholders in Fig. 1 were further sorted into four categories based on their roles in the hydropower projects: governments (central and local), hydropower generation enterprises (hydropower development enterprises and other investors), reservoir migrants, and power grid enterprises. The four core stakeholders of hydropower projects either invest important assets or play an important role in the hydropower development process. Their inputs into and influences on projects make them eligible to participate in benefit sharing of the projects. They will be the main actors in the hydropower project benefit-sharing model in the following analysis.