Habitat International 73 (2018) 65–78

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Constraints to achieve infrastructure sustainability for mountainous townships in China

Yujuan She[a,b,*], Liyin Shen[a,c], Liudan Jiao[d], Jian Zuo[e], Vivian W.Y. Tam[f], Hang Yan[a,c]

[a] School of Construction Management and Real Estate, Chongqing University, Chongqing, China
[b] School of Civil Engineering and Architecture, Chongqing University of Science & Technology, Chongqing, China
[c] International Research Center for Sustainable Built Environment, Chongqing University, Chongqing, China
[d] School of Economics and Management, Chongqing Jiaotong University, Chongqing, China
[e] School of Architecture & Built Environment, The University of Adelaide, Adelaide, Australia
[f] School of Computing, Engineering and Mathematics, Western Sydney University, Locked Bag 1797, Penrith, NSW 2751, Australia

ARTICLE INFO

Keywords:
Mountainous townships
Infrastructure sustainability
Constraints
Exploratory factor analysis
Structural equation modeling
China

ABSTRACT

This paper investigates the constraints to achieving optimal infrastructure sustainability for mountainous townships in Southwest China. Although such townships are relatively less developed, it is well recognized that investment in infrastructure projects in less developed townships plays a vital role in China's sustainable development mission. While the benefits of infrastructure investments are usually measured by means of economic performance, their long-term sustainability performance is largely overlooked. It is therefore imperative to understand the constraints that impede infrastructure sustainability and what corrective actions can be taken. The constraints are identified in this study via exploratory factor analysis and structural equation modeling. Twenty-one townships in the mountainous regions of Southwest China were investigated by means of a questionnaire survey. The study reveals that the major constraints include four dimensions: "Economic Capacity", "Governance and Management", "Policy Instrument and Public Participation", and "Local Geographic Characteristics". Identification of these constraints provides a valuable reference for local governments to take adequate measures to ensure that their infrastructure sustainability can be improved.

1. Introduction

China's mountainous areas cover a total of 6.636 million km^2, accounting for 69.1% of the national land area (Liu, Lei, & Fu, 2006; Qin & Wang, 2012; Wu & Cui, 2016). The mountainous regions include mountains, hills and plateaus (Qin & Wang, 2012). Mountainous regions share the common features of poor transport accessibility, poor education level, and extremely unstable ecological environment (Liu et al., 2006; Qin & Wang, 2012). As a result, the natural ecosystem in these regions is vulnerable to any carelessness during construction and economic activities (Fan, Wang, Zhou, & Chen, 2013; Kumar, 2016). The UN suggested that sustainable development of mountainous regions presents a significant challenge to human beings (United Nations, 1992), while (Kumar, 2013) claimed that the pursuit of sustainability is one of the biggest challenges for mountainous regions due to difficult terrain, steep gradients, complex geological structures, extreme climatic conditions, and rich flora. As a result of these barriers, mountainous regions are considered not suitable for large-scale urban construction (Fan et al., 2013; Kumar, 2016). Therefore, the more than 10,000 townships located in China's mountainous regions (Liu et al., 2006) play a significant role in those regions (Gu, Li, & Han, 2015).

Mountainous townships, as the subject of this study, are towns listed in official documents such as Statistical Yearbook released by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD), and are located in mountainous regions. A simplified administrative structure of townships in China is showed in Fig. 1. As shown in the Figure, townships are the lowest administrative units, normally controlled by county/district government, and consist of several villages. The population size of townships is usually small with about 6000–8600 people on average in built-up areas (Gu et al., 2015). Townships are the link between the urban and rural areas and play an important role in the rural development in China.

The development of mountainous townships relies largely on the improvement of infrastructure conditions (LI, 2004; Shen, Jiang, & Yuan, 2012; Zhang, Wu, Skitmore, & Jiang, 2015). Shen, Asce, Wu, and Zhang (2011) suggested that infrastructure projects are for the public

* Corresponding author. School of Construction Management and Real Estate, Chongqing University, Chongqing, China.
E-mail addresses: 1999005@cqust.edu.cn (Y. She), shenliyin@cqu.edu.cn (L. Shen), 396732441@qq.com (L. Jiao), jian.zuo@adelaide.edu.au (J. Zuo), V.Tam@westernsydney.edu.au (V.W.Y. Tam), 630539886@qq.com (H. Yan).

https://doi.org/10.1016/j.habitatint.2018.01.009
Received 5 May 2017; Received in revised form 17 January 2018; Accepted 30 January 2018

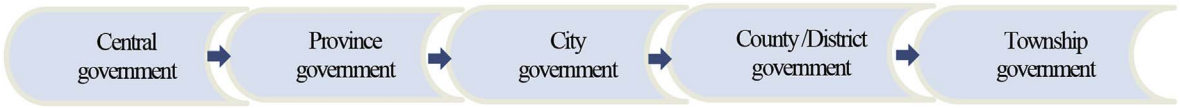

Fig. 1. The administrative structure in China.

good and have a considerable influence on economic development and social needs. Indeed, the deteriorative or unsuccessful remote regions could have significant impact on the regional and national economy (Ryser & Halseth, 2010; Tonts, Plummer, & Argent, 2014). Infrastructure sustainability therefore has a major effect on the performance of sustainable development in these townships (Liu et al., 2006; Shen et al., 2011). In line with the principle of sustainable development, it is well recognized that infrastructure projects have significant impacts on the economy, society and environment (Liu & Li, 2011; Shen et al., 2011). Infrastructure sustainability is the performance of the infrastructure in contributing to the coordinated development of economic, social and environmental dimensions. It is also the result of implementing a "sustainable infrastructure", which involves three project planning life stages, i.e. project planning, construction, and operations (Dasgupta & Tam, 2005). In this study, infrastructure in townships refers to all types of public facilities sponsored by township governments, including roads, power, telecommunications, water supply, sanitation and sewerage, solid waste collection and disposal, and piped gas (Shen et al., 2011).

Mountainous regions in China are usually located at the boundary between provincial areas and remote rural areas (Fan et al., 2013), which are often underdeveloped and where the infrastructure is delivered with a lack of policy support (Yao, Shen, Tan, & Hao, 2011; Zhang et al., 2015) and limited financial capacity (Lu, Peña-Mora, Wang, Shen, & Riaz, 2015). As a result, infrastructure sustainability in China's mountainous region townships is poor (Liu et al., 2006), which is evidenced by a shortage of new infrastructure, a lack of maintenance for existing infrastructure, and infrastructures' relatively small contribution to the coordinated development of economic, social, and environmental issues (Liu & Li, 2011). According to official statistics from the MOHURD (2016), the road surface area per capita was as low as 5.94 m^2 and the green coverage rate on average was only 7.76% in mountainous townships in Chongqing in 2015. Similarly, the national average value for these two attributes were 12.79 m^2 and 16.63% respectively. The fiscal investment on average in infrastructure in mountainous townships in Chongqing was only half of the national level, resulting in a level of infrastructure development in these townships that was much lower than that in other regions of China. According to the official statistics (MOHURD, 2015), the gap between mountainous townships and townships in other regions has become larger.

The issues associated with poor infrastructure sustainability in mountainous regions cannot be ignored. Liu & Li (2011) suggested that poor infrastructure sustainability typically leads to issues such as short life-span and serious environmental pollution. Shen et al. (2011), Ryser and Halseth (2010)argued that poor infrastructure sustainability is the major impediment to social and economic development. Although it is undoubtedly important to investigate the factors that constrain the improvement of infrastructure sustainability in mountainous townships, there have been few such studies conducted in the context of China.

There are a number of constraints to infrastructure sustainability in mountainous townships that have largely been overlooked in previous studies. Without proper understanding of these constraints, it is difficult to develop and undertake effective measures for promoting infrastructure sustainability in these townships. This paper therefore identifies the constraints and analyzes their impact on the infrastructure sustainability in the context of mountainous townships in Southwest China.

Southwest China is a mountainous cluster because most of the region is covered by mountains which account for over 90% of the land area (Fang, Zhao, & Wei, 2014). There are a large number of mountainous townships in Southwest China, with outstanding cultural characteristics and ecological landscape. The sustainable development of such townships will play a vital role in not only the rural development but also the national urbanization and modernization (Gu et al., 2015; Ryser & Halseth, 2010).

2. Literature review

Researchers have introduced various methods for assessing infrastructure sustainability. Shen et al. (Shen, Wu, & Wang, 2002; Shen et al., 2011) introduced models to incorporate key assessment indicators for attaining infrastructure sustainability. Zhang et al. (2015) developed a more recent model to quantify the effect of sustainable infrastructure projects on urban-rural balance (e-UR) by focusing on two attributes, i.e. efficiency and equity. There are other models to evaluate the infrastructure sustainability from different aspects (Sun, Liu, Li, Tao, & Song, 2015; Ugwu, Kumaraswamy, Wong, & Ng, 2006; Yao et al., 2011).

Studies have also highlighted various factors which imped the infrastructure sustainability. Ezeah & Roberts (2012) claimed that weak legal frameworks, funding limitations, unreasonable planning, poor pay, poorly trained workers, and insufficient operation management are the major constraints to the infrastructure development. Studying the influence of administrative management on infrastructure sustainability, Chen and Liu (2004) found that constraints include complicated administrative processes, weak operability of administration means, and a lack of knowledge of sustainable construction. Other researchers have identified various constraints to infrastructure sustainability from management perspective. These include lack of maintenance (Shen et al., 2011), mismatch between supply and demand (Qin & Wang, 2012), and redundant construction (Ezeah & Roberts, 2012). However, it is not necessary that these results are applicable to study infrastructure development in townships.

Studying infrastructure sustainability in townships or rural regions, Jones, Bernhardt, Kennedy, Lantz, and Holden (2013) found that socio-economic and financial challenges are responsible for failing to deliver sustainable infrastructure. Zhang et al. (2015) argued that insufficient funding is one of the biggest challenges for developing infrastructure. Through providing financial and policy support, the upper-level government acts as the critical mechanisms for the administration of townships. However, as Ryser and Halseth (2010) critiqued, upper-level government did not serve these functions very well in practice. Therefore, it is necessary for upper-level government to provide incentive mechanisms (Shen, Song, Wu, Liao, & Zhang, 2016) and other supporting policy (Yao et al., 2011; Zhang et al., 2015) to improve the economic conditions of townships.

Furthermore, focusing on examining impeding factors to the township development, Visvaldis, Ainhoa, and Ralfs (2013) ascribed the constraints to sustainable development of townships to economic downturns and industrial recession. Gu et al. (2015) indicated that economic strength of townships is limited by fiscal mechanics of separation between revenue and expenditure. This is due to unequal resources distribution between urban areas and townships (Visvaldis et al., 2013; Zhang et al., 2015). According to economic geography (Tonts et al., 2014), there is uneven development between townships and cities in terms of geography. Undoubtedly, townships are on the