

An Overview of Sustainable Highway Infrastructure Development in Yunnan, China

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Abstract. Highway infrastructure development in Yunnan Province remains a top priority for the Chinese Government, the aim is to improve access to neighbouring countries and support economic growth and social development in the province. While the social and economic benefits of highway infrastructure projects are indisputable, sustainable performance still leaves room for improvement in Yunnan. In an effort to promote a more sustainable approach to decisions relating to highway infrastructure projects, this paper explore the critical issues associated with sustainable highway infrastructure. Firstly, reviewed the economic, social and environmental background of Yunnan, and explain the functions of highways in its socio-economic development. After a brief overview of the conditions and future demands for highway infrastructure in Yunnan, analysed the challenges of building highways in a sustainable way.

1. Introduction

Yunnan is a border province in southwest China, in the north it connects with the Silk Road Economic Belt, and it links the Maritime Silk Road in the south. Since China proposed Belt and Road Initiative (BRI), the government clearly defines the important position of Yunnan province in the BRI. It is regarded as the gateway of China connecting with South Asia and Southeast Asia [1]. It is known that Yunnan's bio-diversity, multiculturalism, frontier status and is less developed than other parts of China [2]. In order to improve access to neighboring countries and support economic growth and social development, the government remains the highway infrastructure construction on a top priority [3]. Meanwhile, the cost of a large number of highway construction on the environmental and social development has attracted the people's attention. The terms of sustainability and green-road have been widely promoted in the highway infrastructure development process. It is generally considered that build the sustainable highway infrastructure can not only supports to established the ecological civilization and promote local development, but also contributes to the implementation of BRI [4].

2. Overview of sustainable highway infrastructure development in Yunnan

2.1. The concept of sustainable highway infrastructure

The 1970s saw the expansion of the concepts of sustainable development and sustainability, with a series of documents, such as 'Rio Declaration' and 'Agenda 21' formulating sustainable development strategies. Since then, sustainability has become a widely recognised and accepted development consideration. Under the guidance of the sustainable development principles, the architecture



profession developed the 3Rs of building designing principles: reduce, reuse, and recycle, i.e. reduce the energy and material used, reuse or recycle waste materials [5]. The idea of the 3Rs provided a less environmentally damaging alternative to handle the growing wastes and the effects on the economy, ecological environment and society [6]. It aligned the ideas of green construction and sustainability, and demonstrated an increasing environmental awareness of the underlying dangers caused by construction.

Sustainable highway infrastructure projects share a common approach to sustainable construction used more generally for infrastructure projects [7]. According to Kibwami and Tutesigensi (2016), the sustainable construction can be found to manifest in economic, social and environmental sustainability, because it is a subset of sustainable development, its practices should address the three pillars of sustainability [8]. The idea is same as ISO Standard 15392 (2008) as sustainable construction considering development in terms of its three-primary aspect (economic, environmental and social), while meeting the requirements for technical and functional performance [9]. Hussin et al. (2013) proposed that it is important to balance the three elements of sustainable development - environment, economic and social aspects to achieve sustainability in construction. Economic sustainability involves increasing economic profits through using resources and energy efficiently, controlling lifecycle costs, considering alternative financing mechanisms and economic impacts on local community. Social sustainability meets the needs of stakeholders during the building lifecycle, which includes enhancing stakeholders' participation, promoting the development of appropriate institutional frameworks, and considering the impacts on health, quality of life and social framework. Environmental sustainability minimises construction waste, reducing the consumption of natural resource by using new technologies, and reducing the material demand and the energy required for transforming goods and supply services [10].

Based on the above ideas, Lu (2012) identified that the satisfaction of the public for highway infrastructure is based upon its characteristics and impacts and as a result, the development of infrastructure is measured to meet human social and economic needs [11]. A similar view is expressed by Martland (2012) who suggested that whilst highway infrastructure projects should be feasible from the engineering, financial and social perspectives, they should also be built to achieve economic benefits greater than the costs without negative externalities [12]. A successful infrastructure project must deliver economic benefits to the owners and investors, but also consider the concerns of the public and users in terms of environmental and social aspects.

2.2. Highway infrastructure development in Yunnan

Yunnan Province is on the Yunnan-Guizhou Plateau in China's southwestern region and has complex geographical conditions. The area of Yunnan Province covers 394 thousand square kilometres, 84% of the total area is mountain and hills, plateaus make up 10%, basins called 'Bazi' are only 6% of the province's total area. Yunnan is also home to 25 of the 56 recognised ethnic groups in China, 33.57% of its population are members of ethnic minorities [13]. The number of minority ethnic groups exceed all other provinces in China, and the multi-ethnic population makes for a distinct cultural diversity in this region [14]. From the 2019 statistics, GDP per capita is \$ 5.6 thousand in Yunnan which is lower than the national average of \$ 9.8 thousand. Despite annual GDP growth over 8.9% Yunnan Province started from such a low base that it is still ranked 30 out of China's 30 provinces for GDP per capita. In 2018, the poor rural population in Yunnan was 1.79 million, accounting for 10% of the country's total [1]. Although Yunnan has dramatically changed in the past 30 years, its overall development is still lower than the national average. The remoteness and poor road infrastructure are the main causes hampering the increase in the population's living standards and limiting economic growth in the Province.

In 2015, the Chinese Government launched the 'Belt and Road' initiative to develop infrastructure and inter-connections amongst neighbouring countries, with the important role of Yunnan being emphasised by the Government [15]. The cross-border cooperation strategy has resulted in pressure for highway infrastructure but has also intensified the effective demand for highway transportation

[16]. The Province shares a border with the provinces of Guizhou, Guangxi, Sichuan, Chongqing, and Tibet Autonomous Prefecture of China. It is also borders on Burma (Myanmar), Laos and Vietnam. Since ancient times, Yunnan has been an important route to Southeast Asia. The Central People's Government (CPG) is trying to use Yunnan's location to maximum advantage by pushing a regional integration scheme with neighbouring countries [17].

2.3. Challenges of building sustainable highway infrastructure

As a Chinese proverb says, 'want to be rich, first build road', and this proverb is particularly important in Yunnan. Because the province is located on the plateau, with an average elevation is 2000m, the high elevation plus various forms of geological conditions have limited the development of railways and waterways, leaving road transportation as almost the only approach for transportation development in Yunnan. Table 1 compares five years' freight movement by the three main transportation modes in Yunnan.

Table 1. Freight by railway, highway and waterway.

	2018	2017	2016	2015	2014
Railway freight volume (Ten thousand tons)	4661	4568	5372	5108	4823
Highway freight volume (Ten thousand tons)	135321	124064	109487	101993	103161
Waterway freight volume (Ten thousand tons)	688	667	646	507	560
Total (Ten thousand tons)	140670	129298	115505	107608	108544

Source from: National Bureau of Statistics of China (2019)

The data shows that more than 90% freight in Yunnan is dependent on road transportation which illustrates the dominant position of highways in the province's transportation system [16]. By the end of the nation's 12th Five – Year Plan (2011-2015), the total highway mileage reached 236 thousand kilometres, an increase of 26 thousand kilometres from the 11th Five – Year Plan (2006-2010). In the 13th Five-Year Plan (2016-2020), the CPG intends to build and re-build 74 highway infrastructure projects in Yunnan amounting to a total mileage of about 6,640 kilometres, when the plan is completed, the coverage rate of the national highway will increase to 100% from 54%. The highway network will cover all 129 cities and districts throughout the province [14]. As Table 2 shows, the highway mileage has had solid growth in the past five years.

Table 2. Highway mileage in Yunnan (Year 2011-2015)

	2018	2017	2016	2015	2014
Highway Mileage (Ten Thousand Kilometre)	25.29	24.25	23.81	23.60	23.04

Source: National Bureau of statistics of China (2019)

In 2013, the Ministry of Transport (MOT) issued the 'Guidance of Implementing Green Highway Construction' to apply the requirements of good construction quality, environmental protection, saving energy and resources, high efficiency and improvement of service to highway infrastructure project plans, construction, operation, maintenance and management processes, and ultimately achieve sustainable development of highway infrastructure projects [18] (MOT, 2013). Since then, the idea of the 'Green Highway' has become the imperative for building highway infrastructure projects.

In the past ten years, there has been a notable advance in the development of highway infrastructure in Yunnan, which in turn, has supported significant gains in economic and social development [14]. In 2018, Yunnan invested \$ 27.1 billion to build new highway with total 253,000 kilometres length. But the highway network is far from meeting the demands of social development in Yunnan. The rural population accounted for 52.19% of the population in Yunnan [1], and communities have remained relatively isolated due to poor road conditions in mountainous areas with people unable to access health facilities because of the poor infrastructure in these areas [19] (Li et al.,

2015). Currently in Yunnan, National-Grade and Provincial - Grade highway accounts for 27.05% of the road network, rural roads account for more than 49.05%, showing that the proportion of high-grade highway is low [14]. Meanwhile, the construction of highway infrastructure projects in Yunnan tends to emphasise short-term profits rather than long-term benefits, and this tendency is not consistent with the idea of sustainable development.

The main problems hampering highway infrastructure projects' sustainability in Yunnan including imbalanced development between different regions, unsuitable road network, lack of coordination among transportation modes, and poor serviceability rating of highways due to construction quality. Highway infrastructure is entering a fast-developing period and faces new challenges in Yunnan, but there is still a large gap between total highway infrastructure network size, population increase and economic growth. The diverse climatic and special geographic conditions and social features challenge the development of sustainable highway infrastructure projects in Yunnan. Meanwhile, the Government is also faced with tackling rising pollution problems through a series of strategies and initiatives such as the carbon tax initiative.

3. Conclusion

Highway infrastructure is the critical component for development in Yunnan, and it has gradually started to incorporate sustainability considerations into its provision. This paper firstly provided a brief overview of the concept of sustainable construction, and identified the ultimate goals of sustainable highway infrastructure. Then reviewed the local factors considered within the context of current highway construction in Yunnan.

Acknowledgments

I gratefully thank the Dr. Stuart Allan from the University of Greenwich for his useful comments and kind helps.

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