

# *The Challenges of Yunnan's Engagement on Sustainable Highway Infrastructure project in the Context of Belt and Road Initiative*

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**Abstract**—Yunnan is regarded a hub reaching out to Southeast and South Asia within the China's Belt and Road Initiative. But the shortage of highway to restrict its function as an international transport corridor connecting China with neighboring countries, develop the sustainable highway infrastructure will support the economic cooperation with other countries. Take considering of local conditions, this paper analyzed the challenges to build sustainable highway infrastructure in Yunnan.

**Keywords**—sustainable; highway infrastructure project; challenges

## I. INTRODUCTION

With the Belt and Road Initiative, infrastructure investment needs in Sian and the pacific will exceed \$26 trillion through 2030. In a long history, the shortage of transportation in Yunnan has become to be the bottleneck for economic growth and social development, also influencing the business and trade cooperation with Southeast Asian and South Asian counties. Therefore, the central government and local government prioritize the development of highway infrastructure in Yunnan. The 'Yunnan Provincial Government Working Report 2017' pointed out that it is necessary to build Yunnan into a radiation center of Southeast Asia and South Asia on the 'One Belt, One Road' strategy, and proposed to strengthen infrastructure construction and continuously improve the conditions for development. Efforts to speed up the construction of transportation networks. However, the investment on highway infrastructure given the increasingly pressing challenges presented by environmental problems, climate changes and social tensions. The sustainable-led approach to develop highway infrastructure projects has been promoted, and it has been regarded as an important way to pave the global sustainable development.

Yunnan Province is on the Yunnan-Guizhou Plateau in China's southwestern region and has complex geographical conditions. It is known for its bio-diversity, multiculturalism, frontier status and is less developed than other parts of China [1]. The area of Yunnan Province covers 394 thousand square kilometre, 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 [2]. Yunnan is also home to 25 of the 56 recognised ethnic groups in China, 33.57% of its population are members of ethnic minorities [3]. 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 [4]. From the 2015 statistics, GDP per capita is 29.1 thousand Yuan in Yunnan which is lower than the national average of 53.0 thousand Yuan. Despite annual GDP growth over 8.7 % Yunnan Province started from such a low base that it is still ranked 23 out of China's 31 provinces for GDP per capita [5]. In 2015, the poor rural population in Yunnan was 5.74 million, accounting for 10% of the country's total [5]. Although Yunnan has dramatically changed in the past 30 years, its overall development still lower than the national average. The remoteness and poor road infrastructure are the main causes hampering the increase in population's living standards and limiting economic growth in the Province [6].

## II. OVERVIEW OF SUSTAINABLE HIGHWAY INFRASTRUCUTRE DEVELOPMENT IN YUNNAN

### A. Highway Construciton in Yunnan

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 [7]. 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). As Table 1.shows, the highway mileage has had solid growth in the past five years.

TABLE I. HIGHWAY MILEAGE IN YUNNAN (YEAR 2011-2015)

(Ten Thousand Kilometre)

	2015	2014	2013	2012	2011
<b>Highway Mileage</b>	23.60	23.04	22.29	21.91	21.45

Source: National Bureau of statistics of China [8]

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In the 13th Five-Year Plan (2016-2020), the Central People's Government (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% [7]. The highway network will cover all 129 cities and districts throughout the province [8].

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, the average elevation is 2000m, the high elevation plus various forms of geological conditions have limited the development of railways and waterways, road transportation in Yunnan is almost the only approach for transportation development [4]. Table 2 compares recent four years' freight movement by three main transportation modes in Yunnan.

TABLE II. FREIGHT VOLUME BY RAILWAY, HIGHWAY AND WATERWAY

(Ten thousand tons)

	2016	2015	2014	2013	2012
<b>Railway</b>	5372	5108	4823	5146	5031
<b>Highway</b>	109487	101993	103161	98675	63239
<b>Waterway</b>	646	507	560	508	465
<b>Total</b>	115505	107608	107608	108544	104329

*Source: National Bureau of statistics of China [1]*

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 [9].

In 2012, the CPG officially declared Yunnan as the bridgehead (Qiaotoubao) for 'opening the country' to south and southeast Asia [10]. In 2015, the Chinese Government launched 'Belt and Road' initiative to develop infrastructure and inter-connections amongst neighboring countries, with the important role of Yunnan being emphasized by the Government [11]. The cross-border cooperation strategy has resulted in pressure for highway infrastructure but has also intensified the effective demand for highway transportation [9].

After ten year's development, 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 [12]. Meanwhile, the Government is also faced with tackling rising pollution problems through a series strategies and initiatives such as the carbon tax initiative. 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 [13]. Since then, the idea of 'Green Highway' has become the imperative for building highway infrastructure projects. However, the highway network is far from meeting the demands of social development in Yunnan [14]. From the research report of Li [15], the rural population accounted for 73.4% of the population in Yunnan, and communities have remained relatively isolated due to poor road conditions in mountainous areas. People are unable to access health facilities because of the poor infrastructure in the mountainous areas [16]. 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 [9]. Meanwhile, highway infrastructure projects construction in Yunnan tends to emphasize short-term profits rather than long-term benefits, and this tendency is not consistent with the idea of sustainable development [9]. The report from Transport Department of Yunnan [9] disclosed the main problems hampering highway infrastructure projects' sustainability in Yunnan including imbalanced development between different regions, unsuitable road network, lack coordination among transportation modes, and poor serviceability rating of highway due to construction quality. The following section will illustrate the challenges for the sustainable highway building in the province and an expanding road network in Yunnan.

### B. Challenges of Building Highway Infrastructure Projects

In the past three decades, and in particular over the last ten years, highway infrastructure construction in Yunnan has seen rapid expansion [9]. The population size, urbanisation level and traffic density are increasing and serve as a driver of demand for new highways, and with it, the construction tasks and management abilities require higher standards [12]. Table 5.3 below gives some characteristics of the construction environment in Yunnan, and these features are regarded as challenges that regulate the sustainable development of highway infrastructure projects.

TABLE III. CONSTRUCTION ENVIRONMENT CHARACTERISTICS OF HIGHWAY IN YUNNAN

<b>Social problems</b>	<b>Environmental problems</b>
<ul style="list-style-type: none"> <li>• Ethnic groups- based aggregation</li> <li>• Varied ethnic minority culture</li> <li>• Relatively low education level</li> </ul>	<ul style="list-style-type: none"> <li>• Complex geological and topographical condition</li> <li>• Frequent debris flow hazards</li> <li>• Biodiversity</li> </ul>
<b>Economic problems</b>	<b>Technique problems</b>
<ul style="list-style-type: none"> <li>• Unbalanced development</li> <li>• Short of funds</li> <li>• High construction and maintenance cost</li> </ul>	<ul style="list-style-type: none"> <li>• New technology and materials</li> <li>• Construction quality</li> </ul>

#### 1) Challenges of socio-economic development

According to the Yunnan Province Highway Network Plan (2005-2020), new building highway infrastructure projects are more concentrated in the less developed regions in the south and west mountainous areas of the province [5]. The main reason is to solve the unequal development problem among regions [4]. Most of the economic activities have been concentrated in the eastern region for many years. A mass of resources and investment has flowed into this region along

with a well-educated labour force, advanced technology, better medical provision and improved urban infrastructure [4]. The western region is lagging in terms of economic development and average living conditions. The eastern region of the province consists of undulating low mountains and round hills, in the west, the high mountains and valleys are closely spaced, and forms a steep, unusual, and dangerous landscape which restricts social and economic development. Highway construction inevitably needs slope excavation, embankment filling, tunnel excavating which cost 3 to 5 times than other areas. The unbalanced allocation of investment also impacts on big cities and small towns causing disparities in the level and quality of public infrastructure such as roads, water supply etc. [17].

Another important challenge is the often uncoordinated or contradictory highway infrastructure project development plans of central and local government authorities [18]. The highway development plans from central government are to consider first the cross administrative region functions, but local government is eager to achieve local development goals [19]. Therefore, local planning consideration could materially conflict with the central development plan. Additionally, many regional highway infrastructures are built blindly due to governments overstating the benefits of highway construction. The study by Ansar [20] from Oxford University disclosed that 28% of road infrastructure projects in China overrun the budget after completion, and traffic volumes did not achieve the forecast. The study cited the case of Yuanjiang-Mojiang Highway in Yunnan where the budget over-ran by 24%, and only reached half of the predicted traffic volumes 12 years after its completion. The utilisation of most of the highways built in western areas is usually low, and it is regarded as the excessive expansion problem due to inappropriate development plan.

The various agencies have started to address the unsustainability of highway infrastructure in Yunnan. To begin with, the contribution of highway infrastructure projects to the improvement of the economy and social culture is not obvious, due to the extensive countryside and dispersed population in the south and west mountainous regions [21]. As discussed by Zou [22], the highway's functions of spreading economic development benefits are not realised within the context of the weak regional economy.

Moreover, the highway construction changes local cultures to modern ways, making it difficult to maintain cultural heritage [21]. Yunnan is inhabited by many ethnic minorities, highway infrastructure projects should consider the significant threat to culture diversity, where road construction cuts populations in half and fragments it [23]. From another perspective, low educational achievement and skills is a demographic feature of minority areas. For the local population, the main source of income is agriculture, with the consequence that the public acceptance of large land occupation projects such as road building is low [24].

Finally, adequate financing is an essential factor in improving the sustainability of infrastructure [25]. A shortage of capital for infrastructure development has already become the biggest challenge in China, especially in the towns [17].

There is a significant funding gap caused by the single financing channel which is a serious problem in China, with funding provided from national finance [18]. The government-led financing model has increased government debt significantly, and is not sustainable [26].

### *2) Challenges of ecological environmental*

The natural geographical conditions of Yunnan pose a major obstacle to sustainable highway infrastructure projects. As already discussed, Yunnan has diverse geographical features, the terrain slopes sharp down from the northwest to the southwest with the highest point of the province reaching 6,740 metres and the lowest point 76.4 metres. The major landforms in Yunnan are mountains and highlands (94%). The major new highways will be built through high altitudes of mountainous ranges. The southern part of the province is covered with mountains, remote cultivated valleys, and forested ridges. This part has adequate rainfall throughout the year, but it can lead to floods and landslides. Northern Yunnan lies at the threshold of the Himalayas with high mountains, roadways get blocked due to landslide during each summertime monsoon and heavy snowfall in wintertime [27]. Constructing and maintaining highways in these areas have been a challenge for engineers [28]. Additionally, the province is an earthquake zone, this is another challenge facing highways construction.

The geography has encouraged species diversification within the province. Yunnan provides half of China's total number of animal and plants species, and it possesses rich mineral resources and freshwater [29]. However, the biodiversity is faced with damage as the result of excessive exploitation of resources and environmental impacts caused by construction activities [30]. First, it results in habitat fragmentation and can be a source of pollution [31]. Second, as a mountainous province, the land resources are generally more valuable in Yunnan [32], the arable land represents 15.9% of the total area [33]. Highway infrastructure projects occupy a large area of land due to their scale [34], they will permanently occupy agricultural land, green space, forest, wetlands and other land resources [31]. Finally, the construction of subgrade, bridges, culverts and tunnels can alter the original topography, damage vegetation, and cause soil erosion [35]. The highway construction with great quantity excavations and backfill volume of soil which can cause geological disasters as landslide, debris flow, collapse and etc. [36].

The most serious existing problem of infrastructure construction in respect of sustainable development in China is the high resources use and waste [37]. Data from the Centre for Energy and Development of China shows in 2013, the construction energy consumption accounts for 20-40% of total energy consumption, and the energy consumption per unit area is 2-3 times that of developed countries [38].

### *3) Challenges of technological*

The extensive mountainous areas and complicated geological formations require long tunnels, bridges, and high embankments during highway infrastructure projects. The construction is difficult and can take a long time. According to Yunnan Highway Development & Investment Co. Ltd [39],

the cost of each kilometre of highway construction in Yunnan is two-to-three times that of the central and east areas of China, also the highway maintenance cost is higher than other areas. New technologies and materials have become important for developing highway infrastructure project in Yunnan.

#### Challenges of sustainable awareness

The more recent advances in economic theory suggested that the quick development of highway infrastructure projects will drive economic growth. Economic growth therefore is a higher priority to developers than other objectives, at the same time builders are more focussed on project schedule in order to complete the construction quickly while ignoring environmental issues [22]. A series of environmental protection regulations and building standards have been enacted, but some of them have not been implemented due to environmental issues being a low priority for local authorities, and local people failing to realise the importance of sustainable development [11]. The obvious contribution to economic growth and social benefit can mean that the negative impacts are tolerated in some places [40].

Lacking awareness of sustainable development has raised questions of unsuitable planning and design, and unsustainable construction and operation activities [41]. Liang [42] argued that pollutants comprising of solid waste, waste water, waste emissions and smoke from construction have not been effectively controlled because there is no significant awareness of environmental pollution and sustainable construction. Zuo [26] studied the top 50 international construction companies in China, only a few of whom expressed any concern for sustainability issues, thus, sustainability awareness in construction needs to be improved in China [43].

#### 4) Challenges on construction quality

Construction quality is regarded as an integral part of sustainability [44], in China the construction quality problems as foundation settlement, pavement cracks, leakage, seepage, jerry-building, plumbing leaks, poor materials, etc. Zhao [45] have long been commented on by researchers [45-47]. The Global Competitiveness Report 2014 by the World Economic Forum disclosed the overall quality of infrastructure in China is ranked 64, and the quality of road construction is ranked 49 in the world [48].

Some builders considered that quality just needs to be ensured on the construction phase but the quality of site selection and building environment are seldom considered in the design and planning phase [46]. Likewise, when the projects are subcontracted, it is hard to control the quality of highway infrastructure projects [47].

### III. 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 examined the conditions in Yunnan including geographical location, topography, cultural traits, etc. With the local factors considered within the context of current highway construction in Yunnan, the challenges faced by sustainable

highway construction were analysed and assessed. The findings indicated that with rapid economic growth, the demands on highway infrastructure are continuously increasing in Yunnan, as a landlocked, mountainous and less developed province in China, it has its own emphases for sustainable development.

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