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Technological Challenges and Environmental Concerns in the Construction of Border Infrastructure in Tibet: A Case Study of the Lhasa-Nyingchi Railway

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Technological Challenges and Environmental Concerns in the Construction of Border Infrastructure in Tibet: A Case Study of the Lhasa-Nyingchi Railway

Japneet Kaur

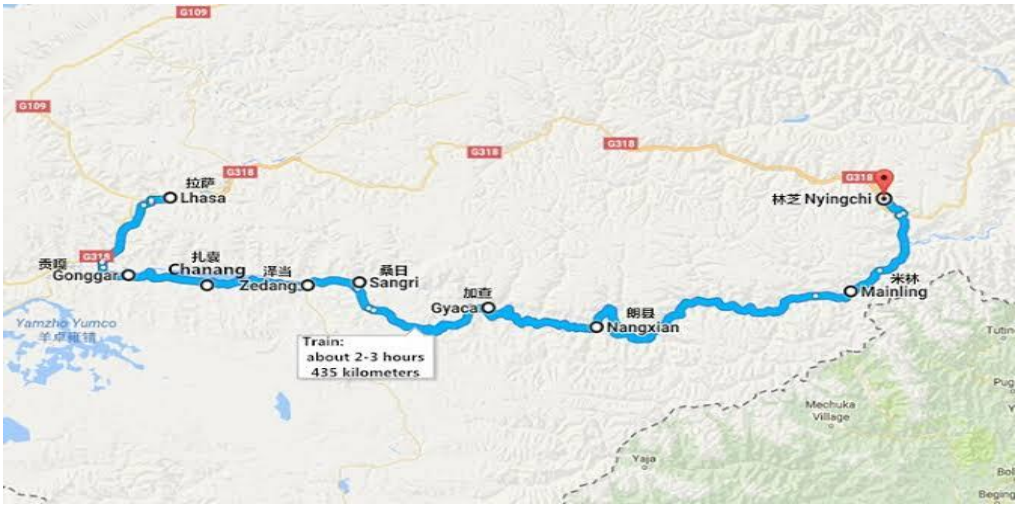
China's prowess in building infrastructure is widely recognized and evident in the massive rail, road, air, and other infrastructure built across the country and the globe. In fact, the Chinese state promotes its infrastructure building capabilities in remote areas like the border areas in Tibet as proof that the Communist Party of China-led political system is efficient in delivering on these otherwise difficult tasks. In recent years, China has also undertaken several transport infrastructure projects namely highways, expressways, rail lines, and land ports along the China-Nepal border to enhance connectivity and trade of the Tibet Autonomous Region (TAR) with Nepal (*Xizang Ribao* 2023; *Infzm.com* 2021).

However, alongside narratives of successes, there exist numerous accounts which suggest that overcoming technological, climatic, and logistics challenges in hostile terrain like in the border areas with India or in Tibet, more generally, is not easy. By taking a case study of the Lhasa-Nyingchi segment of the Sichuan-Tibet railway, the essay highlights these challenges and locates their significance for China's long-term plans for rail, road, and air infrastructure in these areas. It also highlights potential environmental and security implications.

The Lhasa-Nyingchi Railway

The 404km-long Lhasa-Nyingchi Railway section was completed in 2020 and is part of the Sichuan-Tibet Railway which runs between Chengdu and Lhasa for 1,543 kilometers. Combined with other transport infrastructure, this section is a key node in the TAR government's plan to develop Lhasa, Lhokha, and Nyingchi as part of an integrated economic zone (*China Daily 2024*). Militarily, this section is widely considered to be vital in terms of providing access to border areas (Ramachandran 2020; CSIS n.d.). Moreover, the construction of a line connecting Kangding (also called Dartsedo) in Sichuan and Nyingchi is already underway and is expected to be completed in 2030 (Ramachandran 2020).

Map 1



Source: Google Maps

The Lhasa-Nyingchi line runs along the Yarlung Zangbo and cuts through mountains – there are 47 tunnels with a total length of 216.5 kilometres and 120 bridges including the longest Yarlung Zangbo River Bridge which is 430-meter high and has a 430-meter span (Xizang Zizhiqu Renmin Zhengfu 2020). Given Tibet's geography, the construction has unsurprisingly encountered technological and logistical challenges. Moreover, its environmental impact can also be expected to be huge.

Problems during Construction

Since the Lhasa-Nyingchi line runs through high-relief mountains and active faults, there are ultra-long and deep tunnels which are consequently prone to tectonic stress and high ground temperatures (Cui et al. 2022). As a result, water inrush, large deformations, rock bursts, and landslides are some of the common problems faced during construction and during operations and maintenance. Rock bursts, in particular, were identified as one of the most recurring problems in high-stress areas during the construction of the Lhasa-Nyingchi line (Lan et al 2021).

Other studies have identified rock deformation as a problem as these areas fall in the zone of collision between the Eurasian and Indian tectonic plates. The complex tectonic movement has led to the development of a large number of active faults with potential to cause earthquakes threatening the maintenance of the line (Chinese Academy of Sciences 2022).

The Sangzhuling Tunnel（*Sangzhuling suidao*桑珠岭隧道）was constructed by the China Railway No. 5 Engineering Group Co., Ltd. Official accounts state that in order to solve the problem of high rock temperature due to depth of the tunnel, Zhu Xuren, the project leader, introduced such construction measures as setting up relay fans to enhance ventilation, installing automatic sprinkler systems, and placing ice cubes in the tunnel (Zhongguo Zhengfu 2018).

Expansion shell anchors – a kind of bolt extensively used in mining – were used to lock the rock mass, and early warning sensors and high-pressure water spraying to reduce the temperature of the rock surface, release stress, and ensure construction safety (Guowuyuan Guoyou Zichan Jiandu Guanli Weiyuanhui (SASAC) 2019; *Sina.com* 2018). While there are no reports available on potential casualties and accidents, media reports quoting engineers suggest that 'emergency rescue stations' (*yingji jiuyuan zhan/zu* 应急救援站/组), were also established at the entry and exit of the tunnel.

Given that the Sangzhuling tunnel is quite long and crosses many fault zones, the railway line is not straight but meandering, which makes it prone to rock bursts. In fact, Chinese studies suggest that the Sangzhuling Tunnel and the Bayu Tunnel (*Bayu suidao* 巴玉隧道) experienced rock bursts during construction leading to injuries to workers (Xie et al. 2022).

In fact, in the Bayu Tunnel it was assessed that the incidence of rock bursts was even higher during the construction (Tian et al. 2022). Moreover, it also had higher ground stress (Zhongguo Zhongtie Gufen Youxian Gongse 2022). The Bayu Tunnel is 13,073 meters long and goes up to a depth of 2,080 meters. The rock burst sections account for 94% of the total length of the tunnel and builders call it 'a tunnel where stones fly like cannonballs' (*shitou xiang paodan yiyang fei de suidao*石头像炮弹一样飞的隧道). During the construction and excavation process, the tunnel rock

mass had to be first stress-released to reduce the frequency of rock bursts. However, even so, rock bursts continued during the construction process, generally lasting three to six hours, with the longest exceeding a week (Mark 2019; Xizang Zizhiqu Jiuye Fuwu Zhongxin 2019).

Due to the fact that the tunnels in the Lhasa-Nyingchi railway are longer with narrow valleys and wider mountains, there cannot be auxiliary tunnels which can be used for safety as in other parts of China. Thus, 'weak blasting' was used so as to make sure that rock bursts could be minimised, and their impact lessened.

Picture 1
Rock Burst in Bayu Tunnel

Source: Chinese Academy of Sciences 2022

Other studies had identified similar challenges of rock bursts in the Yufengsi tunnel in Lijiang City of the Yunnan-Tibet Railway due to the same geological conditions (Liu et al 2007). These challenges delayed the construction of the tunnel for eight long years (CGTN, 2022). While scientists have identified the challenges, overcoming them remains a difficult task to achieve.

China's Long-term Objectives in Border Areas and Environmental Concerns

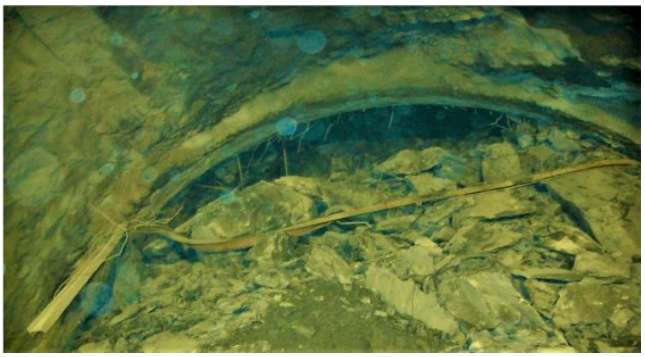
As China plans to expand its infrastructure development in TAR, the potential environmental concerns have become increasingly significant while the geological challenges to construction of big infrastructure remain hurdles and impose limitations on the extent to which China can pursue and rely on such initiatives in critical situations. For example, according to the TAR's 14th Five-Year Plan and medium- and long-term railway network planning, by 2035, the total scale of Tibet's railway network will reach more than 5,000 kilometres, aiming to conveniently connect neighboring provinces and regions such as Xinjiang, Qinghai, Sichuan, Yunnan and major land ports along the border. The objective is to build a Himalayan economic cooperation belt with South Asian countries, and integrate also with the Bangladesh-China-India-Myanmar Economic Corridor. China is accelerating the construction of railways connecting Tibet's major land ports along the border with the aim of opening up international railway channels between China and South Asian countries (Zhonghua Renmin Gongheguo Guojia Fazhan he Gaige Weiyuanhui (NDRC) 2021: 17-19, 27-29).

The completion of the Lhasa-Nyingchi line itself is part of broader economic plans in the region in terms of economic integration of south-eastern parts of the TAR with the

Sichuan-Chengdu economic belt and creating a sub-regional economic integration zone covering Lhasa, Nyingchi, Chamdo and Lhokha (*Xinhua* 2021).

However, geological conditions pose significant challenges to such big infrastructure projects and connectivity ambitions. In June 2023, for instance, it was reported that the Lhasa-Nyingchi line was closed for a few days due to land sinking during the construction of the Gangmula Mountain Tunnel (*Gangmula shan suidao*岗木拉山隧道）in the Jiazhu-Kangsa section（*Jiazhu zhi Kangsa qu* 甲竹至康萨区） (Shannan Shi Youyong Fazhan Ju 2023). There are also significant maintenance and human resources costs to deal with such problems (Tielu.cn 2020). The need for altogether closing off routes through difficult terrain also cannot be discounted

Picture 2
Landslide inside Bayu Tunnel



Source: Chinese Academy of Sciences 2022.

All of this is in addition to the dangers and costs to the environment itself. Drilling in mountains, in general, destroys the ecosystem in surrounding areas not just making the mountains more fragile but also due to contamination of soil by hazardous metals. For example, Chinese studies have noted that the construction of the Qinghai-Tibet railway has led to an increase in the quantity of lead and zinc, among other such metals, in the soil, threatening the health of the soil and potentially agriculture in the region (Zhang et al. 2012; Zhang et al. 2023). Moreover, although the tunnels are underground, construction activities such as transport of materials and building of bridges involve and have an impact on the land surface as well.

Therefore, two related challenges come with the Chinese prowess in building mega infrastructure projects – the geological conditions that they face and the environmental dangers they pose to a fragile Himalayan ecosystem.

A larger question surrounding such infrastructure projects is of their sustainability in ecologically sensitive areas. China has committed to protecting ecological balance through large-scale conservation projects such as the 'four-two rivers project' ('*liang jiang sihe' zaolin luhua gongcheng* '两江四河' 造林绿化工程) covering 40 counties of the TAR (Zhongguo Zhengfu 2014). China has also expressed its commitment to achieving the Sustainable Development Goals (SDGs) related to climate change. While it has made progress on several SDGs overall (Zhonguo Zhengfu 2021), China still lags behind on environment-related goals particularly relevant here such as affordable and clean energy (Goal No. 7), sustainable cities

and communities (Goal No. 11), climate action (Goal No. 13), and life on land (Goal No. 15).

At the same time, China already has massive plans to expand urbanization and transport infrastructure in the border areas in the TAR (Zhongguo Zhengfu 2022). Thus, China's policies to strengthen infrastructure, both large- and small-scale, and its expressed commitment to climate change are conflicting and often contradictory. For example, longer-term plans for infrastructure in Tibet comes amidst the Tibetan Plateau's changing climate. The Plateau is widely believed to be negatively affected by climate change with rising average temperature and changing patterns of precipitation with serious implications for its ecology (Kuang and Jia 2016).

Clearly, China's goals of construction of infrastructure projects and ecological conservation are in conflict with each other in TAR.

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