

# Nature-based solution for the development of Laos-China high-speed railway stations surrounding Area

Giải pháp dựa trên thiên nhiên để phát triển khu vực ga đường sắt cao tốc Lào-Trung Quốc

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## ABSTRACT

Natural framework is an important factor in the sustainable development of urban spaces. High-speed railway stations are considered one of the driving forces for urban development, the spaces around the stations are important public central areas in urban development orientation. The Laos-China high-speed railway has been put into operation in 2021, however the space around high-speed railway stations has not been studied to come up with development solutions suitable to the national context and characteristics of each station. Therefore, it is necessary to provide solutions for developing space around Laos high-speed railway stations based on the natural framework. The research is based on literature review, secondary data methodologies to classify the natural characteristics of each station area, thereby providing development orientation according to the natural framework of Laos high-speed railway stations. The conclusion proposes to classify the area around HSR station into 3 types with distinct characteristics, thereby orienting the development of spaces as well as proposes future research directions.

**Key words:** Nature-based solution; natural framework; Laos-China high-speed railway; HSR station.

## TÓM TẮT

Khung thiên nhiên là yếu tố quan trọng trong phát triển bền vững các không gian đô thị. Các ga đường sắt cao tốc (ĐSCT) được coi là một trong những động lực phát triển đô thị, không gian xung quanh ga là các khu vực trung tâm công cộng quan trọng trong định hướng phát triển đô thị. ĐSCT Lào - Trung đã được đi vào vận hành năm 2021. Tuy nhiên không gian xung quanh các ga ĐSCT chưa được nghiên cứu để đưa ra giải pháp phát triển phù hợp với bối cảnh quốc gia cũng như đặc điểm từng ga. Do đó, cần thiết đưa ra các giải pháp phát triển không gian quanh ga ĐSCT Lào dựa trên khung tự nhiên từng khu vực. Bài báo dựa trên phương pháp tổng quan lý thuyết, phân tích, đánh giá dữ liệu để phân loại đặc điểm tự nhiên từng khu vực ga, từ đó đưa ra định hướng phát triển theo khung tự nhiên của các ga ĐSCT Lào. Phân kết luận đề xuất phân loại khu vực quanh ga ĐSCT thành 3 loại với các đặc điểm khác biệt, từ đó định hướng phát triển các không gian cũng như đề xuất các hướng nghiên cứu trong tương lai.

**Từ khóa:** Giải pháp dựa trên tự nhiên, khung tự nhiên, đường sắt cao tốc Lào - Trung, Ga ĐSCT.

## 1. INTRODUCTION

The concept of nature-based solutions (NBS) was first mentioned in 2008 by the World Bank [21]. The first research program on NBS was launched in 2013 [2]. The concept emerged from the search for innovative solutions to manage natural systems in a way that can balance the benefits for both nature and society. In other words, by working with nature, rather than against it, human communities can develop and implement solutions towards a resilient, resource-efficient and green economy [18]. Over the past ten years, several attempts have been made to precisely define and clarify the term 'NBS'. In 2015, NBS were for the first time officially defined by the European Commission [19] as 'actions address environmental, social and economic challenges simultaneously by maximizing the benefits provided by nature (...) inspired by, supported by, or copied from nature'. Another

commonly agreed definition was provided by the International Union for Conservation of Nature [5] as 'actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits'. The most recent EC report on NBS states that the 'concept of nature-based solutions embodies new ways to approach socio-ecological adaptation and resilience, with equal reliance upon social, environmental and economic domains' [1].

These definitions, however, are somewhat general and blurry and fail to clearly indicate which green and blue solutions should be regarded as NBS. As a result, there is a constant debate on the scope and types of interventions that can be classified as NBS [6,7]. Furthermore, the concept's ambiguity has already been stressed by many researchers ([5], [10], [16], [5], [14], [17]); United Nations Environmental

Programme, [20]). Such ambiguity results first from the fact that any definition of NBS involves integrating multiple scientific fields and experts with different backgrounds think about NBS from the point of view of their own base discipline [8]. For example, Dorst et al. [9] claim that NBS should mostly address the sustainability challenges caused by processes of urbanization and climate change. On the other side, Kabisch et al. [16] emphasize the positive contribution of NBS to biodiversity restoration. By contrast, Frantzeskaki et al. [15] view NBS in a solely socio-ecological context. There are however studies that emphasize the multi-functionality of NBS and their capacity to simultaneously address multiple societal challenges (e.g. [1,6]). Second, there is a noticeable tendency to mix existing related actions with the NBS concept, such as the management of green-blue infrastructure (GBI), conservation approaches, the implementation of ecological/environmental engineering projects and ecosystem-based management. Third, there has been a delay in establishing clear standards for NBS (e.g. the IUCN published its standards in 2020) as well as practical guidelines for their implementation (e.g. Dumitru and Wendling eds. in 2021). Consequently, prior to 2020 there was a noteworthy lack of specific, detailed criteria for NBS and, as a result, a number of actions that today would be regarded as measures complementary or related to NBS but that do not fulfil all the requisite criteria to truly be NBS, were branded as such.

To clarify the NBS concept, the IUCN Global Standard [11] includes eight criteria by which to frame green/blue interventions as NBS actions. These criteria are built upon the concept's principles as well as feedback from consultations with stakeholders and refer to the following aspects: (1) address societal challenges; (2) landscape scale of intervention; (3) biodiversity gain; (4) economic viability; (5) governance capability; (6) equitably balance trade-offs; (7) adaptive management; (8) mainstreamed within an appropriate jurisdictional context. Furthermore, the latest EC document on NBS [18] proposes five questions to define whether an action can or cannot be framed as NBS: (1) Does the NBS use nature/natural processes? (2) Does it provide/improve social benefits? (3) Does it provide/improve economic benefits? (4) Does it provide/improve environmental benefits? (5) Does it have a net benefit for biodiversity? Clear examples of actions that fulfil these requirements are flowering plants planted on green vertical walls in urban settings, which help significantly increase biodiversity and are also highly appreciated by people for aesthetic value. Such formulated questions pay central attention to the notion of 'benefits' and highlight environmental benefits in particular. The importance of biodiversity is also accentuated by the EC [19] and the IUCN Global Standard [11].

However, NBS should not only simultaneously provide multiple benefits. To effectively tackle urgent (and usually global) social and ecological challenges, they should also be economically efficient and be based on transparent models of governance [7,11,2]. Therefore, the list of questions could be enlarged to: (6) Is the solution cost- and resource-efficient or economically viable? ([11,4]); (7) What societal challenges can the NBS address? [6,5]; and (8) Is the NBS based on inclusive, transparent and empowering governance processes [11,3]? Such a practical perspective has already been presented by Albert et al. (2020), who lists three NBS criteria: challenge-orientation, ecosystem process utilization and practical viability. Sowińska-Świerkosz et al. [19] add further possible criteria: management capabilities and superposing of grey solutions.

The Laos-China high-speed railway (HSR) is a strategic cooperation project between Lao PDR and China (also known as the Boten-Vientiane railway) is a new railway that connects Kunming in China to Vientiane capital in Lao PDR. The railway is 422.4 km long electrified high-speed railway that runs between the capital Vientiane and the town of Boten on the Laos-China border. Apart from the border shuttle operated by the

State Railway of Thailand, this is the first railway in the landlocked nation of Laos. This HSR project was built in December 2016 and completed at the end of 2021. There are 10 passenger stations, includes 5 main stations and 5 sub stations in small towns. In general, HSR stations in Laos are located in areas that are still largely natural areas, without many constructions, have rich fauna and flora.

Taking into account the growing demand to implement NBS actions, within the limits of the paper, mainly focuses on ecosystem process utilization according to NBS criteria of Albert et al. (2020). The natural structure around the stations is researched, synthesized and classified to come up with a design plan in harmony with natural conditions. The application of NBS in developing the space around the stations contributes to balancing three pillars: ecology - economy - society, creating the identity of the area, attracting tourists, from there, the city's economy develops.

## 2. OVERVIEW OF NATURAL CONDITIONS IN LAOS

The Lao People's Democratic Republic, a landlocked nation, lies in the center of the Southeast Asian Peninsula and borders on five countries. The country is landlocked and heavily forested, with 80% of land cover featuring hilly or mountainous terrain, and the remaining 20% comprising plateaus and lowland valleys along the Mekong floodplain. Mountainous topography is characteristic of all of Laos outside the Mekong River Basin. Phu Bia, in Xieng Khouang Province, the highest point in the country, rises 9,249 feet above sea level.

The Mekong River, with its headwaters in Tibet, flows over 2,600 miles to its mouth in the south of Vietnam. One of the world's great rivers, it forms the country's western boundary for the greater part of its length and is the cradle of Lao culture. Most major Lao towns are on its banks. The largest population center in Laos removed from the Mekong River is Phonsavan in Xieng Khouang Province. Lately, the Lao Government has encouraged the establishment of new towns and villages in the country's interior. The Mekong River is vital as a transportation route for cargo and passengers, a source of electricity at dams, a water supply for crops, and a home to fish which are an important food in the diet of Laotian people. There are three plateaus the mountains and the Mekong River-the Xiangkhiang, the Khammouan, and the Bolovens Plateaus.

The Xiangkhiang is the largest, while the Bolovens Plateau near Cambodia provides more fertile farmland where coffee, tea, rice, strawberries, and pineapples are grown. The lowland region is the most vital to the Lao. There the Mekong River floods the soil providing rich nutrients to grow enough rice and other crops to feed the whole country for one year.

Most of the country's population lives along the river, which winds more than 2,600 miles (4,180 kilometers) from China through Laos to the ocean in south Vietnam. Only 10 percent of the country is below 600 feet, and the highest peak, Phu Bia is 9,242 feet (2,817 meters).

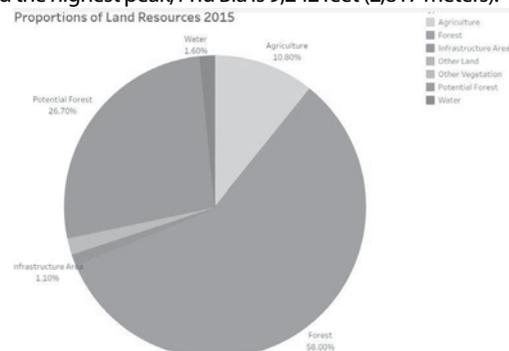
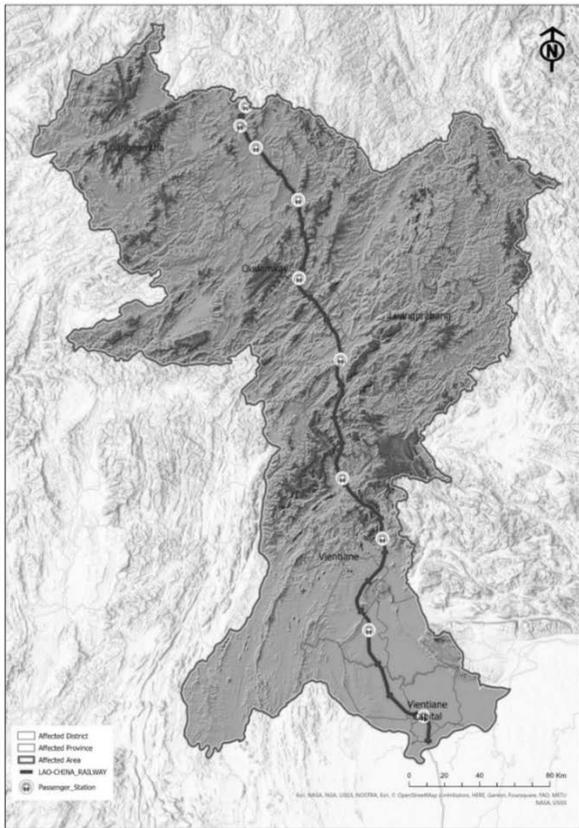


Figure 1. Proportions of Land Resources 2015 [13]

With regard to geographical topography, most of the country is mountainous and thickly forested; the Mekong River forms a large part of the western boundary with Thailand. Forest (including primary and potential forests) covers the majority of land area in the country (>80%). 10% of total land is used for agriculture, while arable soil for cultivation is responsible for less than 7% of total area.

The sustainable use of natural resources has been referred to as “advancing human well-being without undermining ecological integrity”. In Laos, natural resources are valued for their direct contribution to the national GDP through export-driven growth in the agricultural, forestry, mining, and hydropower industries. They are also valued by the predominantly rural, highly diverse population of Laos, who use these resources to support their livelihoods. Natural resources also provide a broad range indirect ecosystem services that benefit Laos and other downstream countries.

**3. NATURAL FRAME OF STATION AREA**



**Figure 2.** Digital elevation model of Laos

The high-speed railway passes through the area with relatively rugged terrain, the average altitude at the station locations is about 700m. However, some stations are located in areas with difficult terrain, causing many challenges for future development directions (Luang Prabang, Kasi), a few stations are located in areas with relatively flat terrain. flat and convenient for construction activities such as Vientiane and Phon Hong.

The natural framework of the area is studied based on 3 groups of criteria:

- Natural topography,
- Natural structures
- Construction structures

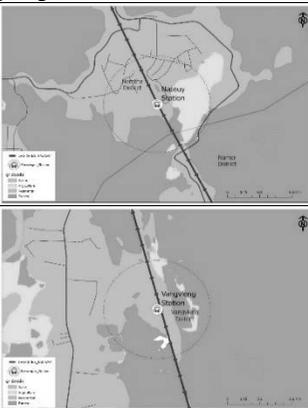
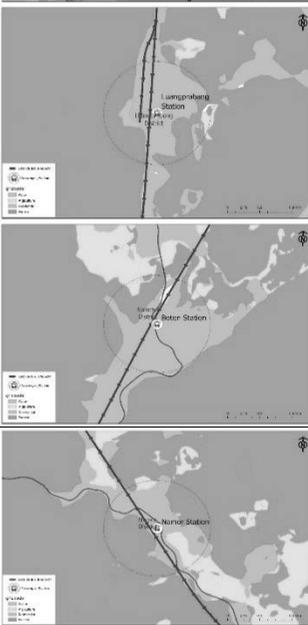
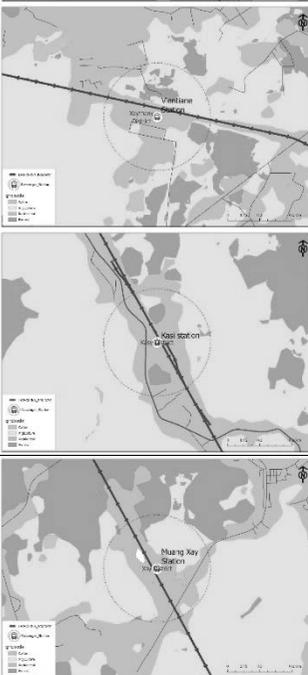
**\* Natural topography**

**Table 1. Terrain conditions of HSR station areas**

<p>Vientiane Station and Phon Hong Station are located in a relatively flat terrain area in Laos. with nearly 90% of the area located within a 5km radius circle with a slope of &lt;15%. This is a favorable topographic condition for construction activities and has the potential to form an area for the development of socio-economic activities. At the same time, construction activities in this area also cause little change to the natural flows in the area or geological risks.</p>	
<p>MuangXay station, Namor station and Van vieng station are located in areas with valley-like terrain, surrounded by mountains. About 60% of the area within a 5km radius around the station has a slope of &lt;15%. This is quite convenient for construction activities due to the low cost of leveling the terrain. However, with the valley terrain, future development activities need to take into account the risks of floods and landslides caused by Water in mountainous areas will flow here, and construction activities in this area may affect natural flows in the area.</p>	
<p>Boten station, Mueang Nga station, NaTeuy station and Luangpra Bang station are built in areas with complex terrain, within a radius of 5km around the station, most of the land has steep slopes. These are areas that are not favorable for large-scale construction activities. At the same time, construction in this area needs to carefully consider impacts on natural flows in the area and geological conditions to limit negative impacts such as floods, landslides...</p>	

**\* Natural structures**

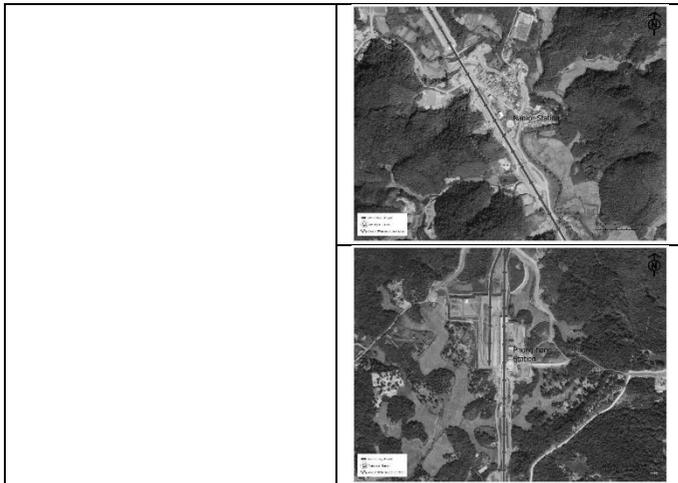
*Table 2. Natural structures surrounding the stations*

<p>Nateuy station and Vanvieng station are built in a naturally structured area surrounded on one side by existing residential areas that have had a long development process and on the other side are natural forest areas with ecosystems, diverse and rich. This natural structure has moderate room for future development of the area due to the limited land fund, as well as the limited infrastructure capacity of the area.</p>	
<p>Luangpra Bang station, Namor station and Boten station are built in an area surrounded by natural forests, with only a small area of construction areas around the station - which are infrastructure works serving operations. of the station, not the local residential areas. This natural structure has little room for future development due to the risks of disrupting the landscape and natural ecosystem of the area. Therefore, it is necessary to choose a development model that limits loading on this area.</p>	
<p>Vientiane station, Muang Xay station and Kasi station are built in areas with long-term residential areas on one side and agricultural production areas on the other - capable of being easily converted into urban functions. town. This is an area with a favorable structure for development due to the low risk of disrupting natural structures in the area and the ability to easily expand land and upgrade infrastructure.</p>	

**\* Construction structure**

*Table 3. Construction structure around the station*

<p>Nateuy, Kasi, Muang Nga station are located near residentially developed areas. This helps the development areas around the station to take advantage of the existing infrastructure in the area, but also poses challenges in choosing a development model suitable for small residential areas, have an average standard of living.</p>	
<p>Vientiane and Vanvieng stations are built in areas with relatively large traffic density and construction activities. This allows the development of large-scale construction activities without worrying about overloading the infrastructure system. In addition, around the station are medium and high density residential areas, so it will meet the human resource needs as well as market size for future development plans of this area.</p>	
<p>Meanwhile, Boten station, Luangpra Bang station, Namor station and Phonhong station are built in areas with low construction density and poor connection infrastructure - there is only one road connecting from the station to surrounding residential areas. around. Therefore, the development of areas around the station will face major challenges in meeting infrastructure needs as well as labor shortages for economic activities to develop.</p>	



#### 4. DISCUSSION AND CONCLUSION

HSR is considered one of the driving forces for urban development. In developed countries, most HSR stations are located in existing urban centers, where is high construction density to facilitate urban development. However, HSR stations in Laos are located in areas with low construction density, large natural land areas with natural conditions of terrain, ecosystem, and rich flora and fauna. Aiming at the goal of sustainable development in the areas around HSR stations, researching and providing solutions in harmony with inherent nature is necessary. Through researching on the natural framework of the area around the Lao HSR stations it is possible to classify solutions for developing areas around the stations: (1) The station is located in a relatively flat area, the surrounding construction density is quite high, it is possible to develop a regional center with the station in the middle (Vientiane station); (2) The station is located next to a high mountainous area, on the other side is a plain area, surrounded by mostly bare land or partly forested land, it is possible to develop the flat area around the station into a service center model with one side leaning against the mountain (Vang Vieng station, Namor); (3) Both sides of the station area are high mountains, the station is located in a valley, surrounded by forests, developing the station into a transfer point with services serving the station itself (Luang Prabang station). In the further study, it is necessary to conduct research on: land use structure around the station and Design solutions for the space around the station to be input for Lao's city master plan.

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