ENABLING FACTORS MATURITY ASSESSMENT FOR GREEN ROADS

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Chapter 1: Introduction

This document outlines the methodology for assessing various enabling arrangements that support the transition to green roads in Asia. The road sector is vast, playing a critical role not only in connectivity and economic development but also in numerous other areas. Globally, the road network spans approximately 40 million kilometers. As of 2020, 21 million kilometers of this network were located in the Asia-Pacific region, with an additional 8 million kilometers projected to be built by 2030.

This expansion is largely driven by the region's dynamic growth but also by the still significant number of unconnected people—estimated at 1.8 billion in the Asia-Pacific. The financial scale of road development is immense: between 2020 and 2030, an estimated USD 14.5 trillion is expected to be spent to build, maintain, and rehabilitate inland transport infrastructure in Asia and the Pacific.

The case for the transition toward green roads sits with the large footprint that the road sector makes on many agendas, from decarbonization, to pollution, to the sourcing of material; from climate adaptation, to water management to biodiversity; from quality of life, to disaster risk reduction to inclusive growth. Green roads take these multiple dimension into account. A definiton is: "*Green roads will foster beneficial land and water use, reduce pollution, support restorative and regenerative ecosystems and enhance safe and affordable mobility of people to deliver inclusive low-carbon, resilient development and environmentally considerate outcomes.*"

The multiple dimension of green roads are given in figure 1. The footprint of roads on all these dimensions is now often negative: main contributor to carbon emissions, disturber of landscapes, prime biodiversity killer, bulk user of building resources. Yet we can drastically mitigate the negative impacts and even turn roads into nature-positive for example by having roads contribute to better water management, local climate and biodiversity, disaster risk reduction and inclusive growth. The measures to implement green roads measures are relatively modest financially. In fact, the cost of not doing is much higher. What is needed is a change is a change in mindsets, capacities, working practices and enabling rules. It is this what the methodology in this document addresses: how to enable the transition green roads and how to assess the current enabling frameworks in a country or a region: to what extent are they geared to facilitate the transition to green roads and where are the main bottlenecks.

Figure 1 Green Roads: Nine Dimensions

This maturity assessment of green road enabling factors complements the Green Roads Toolkit. The ADB Green Roads Toolkit is a compendium with best practices in all Green Roads dimensions, that can be accessed with a series of filters. Many of these measures can be achieved with relatively limited additional cost. Other require larger shifts. What is important however is that they are supported and facilitated with enabling frameworks: changes in the use of design standards, new financing arrangements, creative procurement systems, new ways of collaboration. It is the changes to rules and the flexibility around it that can make a large drive towards green roads possible.

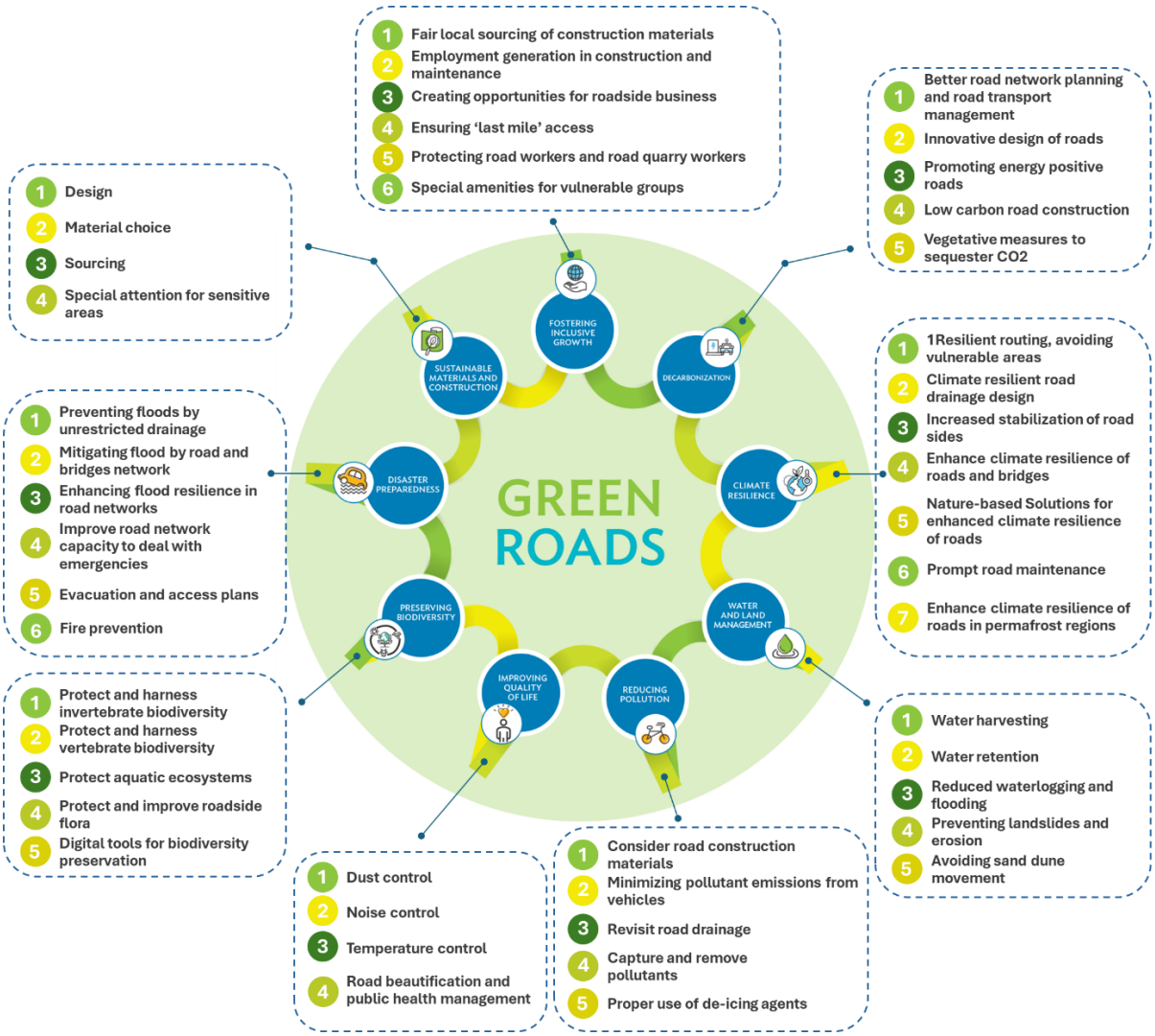
This report describes how to assess the enabling factors in place in a country or region that facilitate the transition to green roads. It will help to identify priorities in making adjustments in these enabling frameworks. This is meant to inform the loan packages that ADB is concluding but it is equally relevant for all countries that want to make the shift to green infrastructure. All projects are also seen as instrument to make changes and improvements in the way work is conducted and facilitated. Hence loans consist of financial outlays, plans and change in the institutional arrangement. This enabling framework maturity assessment provides a practical tool to assess and score and jointly identify where possible changes in enabling factors would be best placed.

This document first in section 2 describes the different dimension of green roads and discusses what are the main elements and pathways and what are highly relevant enabling factors in each of the nine green road dimensions. Chapter 3 dives deeper into the different enabling factors and their relevance to the green road sector.

Chapter 4 then introduces the assessment methodology. The methodology helps to guide the discussion on the enabling factors to be addressed so facilitate the mainstreaming of green roads measures. It is meant to start the discussion and identification of measures. In Annex 1 the methodology is presented in detail.

Chapter 2: Green Roads

Green roads move beyond the road sector's conventional focus on connectivity, affordable transport and road safety, but also address as discussed agendas in nine more dimensions: decarbonization, climate resilience, land and water management, pollution control, quality of life, disaster risk reduction, circularity and inclusive growth. Within each of these agendas there are underlying intervention areas – that describe the main categories of actions to be taken. This chapter explains the different green road dimension and the underlying intervention areas, see figure 2. We also explain how the introduction of each green road dimension is related to enabling factors. The latter is not exhaustive but gave an indication of the importance and relevance of different enabling factors to support the movement to green roads.



2.1 Dimension 1: Decarbonization

The road sector is a major contributor to global CO2 emissions (18%). In Asia CO2 emissions from transport increase faster than anywhere else, at 3.9% annually, double the rate of the global increases (1.9% in 2018)[1]. The carbon emission comes largely from road transport, and to a lesser degree from the construction of roads. Given the sheer size of these emissions, transformations in the

[1] Gota, S. and Huizenga, C. (2023) *The contours of a net zero emission transport sector in Asia*, *Asian Development Outlook Thematic Report*.

road sector are essential for countries to reach low-carbon targets set forth by the Paris Agreement among others.
To achieve decarbonization action is required in a number of interventions areas:

1. **Better road network planning and road transport management**: Improving traffic flows, reducing travel time and congestions will avoid unnecessary stationary emissions. Creating low-emission zones and facilitating the use of electric vehicles with charging stations will encourage the transitions to energy efficient transport. Energy use will be further reduced by timely asset management, avoiding slow-downs and detours.
2. **Innovative design of roads**: Friction-low asphalt may reduce fuel consumption with 1-3%. Energy use can also be reduced by energy-efficient or solar powered appliances, such as LED lightning or reflective signage.
3. **Promoting energy positive roads:** Exploring the scope for energy capture with roads. Several opportunities have been experimented. They can be game-changers but are still in proof-of-concept stage. Examples are heating water storage with black top roads and solar-paneled lanes and roads. In the meantime, the use of solar panels alongside roads has become common.
4. **Low carbon road construction**: Using recycled material in road construction and using low carbon material emission friendly 'green cement' and bio-based material reduces the carbon footprint in road construction. The effect can even be turned into a positive, when carbon-sequestering material, in particular olivine, is used in the construction of road and on road verges.
5. **Vegetative measures to sequester CO2**: Planting trees along roads will absorb carbon and proved multiple benefits to both environment and roadside communities.

These measures need to be supported by different enabling factors. Some green road construction techniques and pavement designs are novel and still under development. For such techniques to be mainstreamed additional research, piloting, testing and validation is required. Subsequently they need to be consolidated in design and material specifications. This is a time-consuming but essential process. Particularly when new material is used, it may require cooperation with different parties in the supply chain, for instance in the sourcing of bio-based material or recycled material, or the preparation of new forms of asphalt or concrete. The new techniques will need capacity building of contractors, mixing plants and construction crews.
Other measures need other enabling factors. Roadside tree planning needs to be enabled by cooperation with other departments, particularly those in charge of Forestry or Social Forestry, if the planting is done outside of the road verges owned by the Road Department. In roadside tree planting, adequate arrangements for the maintenance of the vegetation needs to be in place, preferably with profit sharing of the organization and communities that look after the vegetation and are responsible for their management.

2.2 Dimension 2: Creating Climate Resilience

Transport systems in Asia and the Pacific are vulnerable to climate-related hazards, such as floods, landslides, forest fires, heat waves, thaw – all specific-to-specific areas. This leads to direct damage to critical transport infrastructure, disruption to transport services, and wider social and economic impacts. Globally, main factors are surface, river and coastal flooding, cyclones and earthquakes.

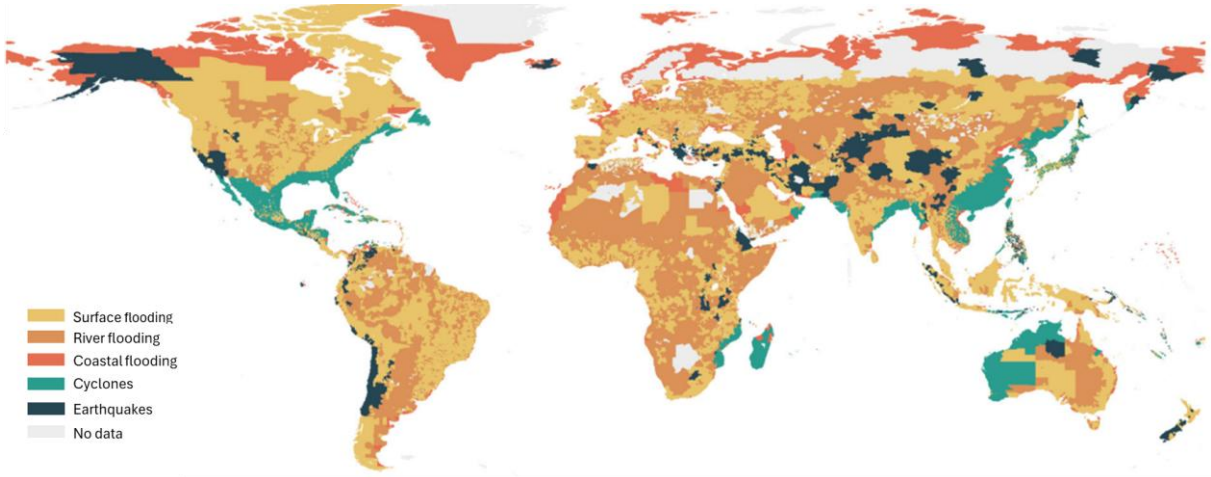


Figure 2 Risk map. It indicates that transport infrastructures are most exposed to major disasters in each region (modified from Koks et al 2019[2]).

On a global scale, the annual cost of direct damage to roads and railways due to natural hazards is estimated at around $15 billion. The Asia and the Pacific Region experiences a disproportionate share of these damages, accounting for 65% of the global annual damages to road and rail transport. Furthermore, the Asia-Pacific region is expected to bear 70% of the global annual damage to trade. ADB estimated an additional 7% (equivalent to $37 billion) would need to be added to the costs of transport infrastructure requirements in Asia and the Pacific region for adaptation and resilience of the transport infrastructure[3].

In Climate Resilience theme the interventions include:

1. **Resilient routing, avoiding vulnerable areas**: Rethinking the layout of road networks to avoid the areas, that are most vulnerable to flooding, landslides, forest fires or earthquakes
2. **Climate resilient road drainage design**: Adjusting road drainage designs to handle increased water peak flows, and avoid at the same time that drainage disposal happens at the cost of downstream erosion and landscape degradation
3. **Increased stabilization of roadsides**: Stabilizing road embankments and managing vegetation to prevent erosion due to changed and more challenging weather patterns
4. **Enhance climate resilience of roads and bridges**: Strengthening bridges and related structures to withstand severe weather, adjusting dimensions and designs
5. **Nature-based Solutions for enhanced climate resilience of roads**: Using natural methods to mitigate climate impacts – such as bio-engineering and natural slope protection. Using road-side tree planting to minimize the effect of heatwaves.
6. **Prompt road maintenance**: Implementing timely and effective maintenance to prevent small damage from becoming major service problems will increase climate resilience
7. **Enhance climate resilience of roads in permafrost regions**: As a special case, counter the thawing of permafrost areas, by using geocells for soil stabilization and using thermosyphon cooling under paved roads.

There is a variety of enabling factors, associated with each in these intervention areas. In several countries efforts are underway to climate-proof road infrastructure. This consists of revising standard designs of road pavements, drainage systems and bridges. It also consists of building the capacity in new approaches, such as the use of bioengineering for road slope management, using natural slope stabilization and vegetative measures, such a vetiver grass planting. In many countries such approaches are unknown

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[2] Koks, E. E., Rozenberg, J., Zorn, C., Tariverdi, M., Vousdoukas, M., Fraser, S. A., et al. (2019) 'A global multi-hazard risk analysis of road and railway infrastructure assets', *Nature Communications*, 10(1), p. 2677.

[3] Asian Development Bank (2017) *Meeting Asia's Infrastructure Needs*. Available at: https://dx.doi.org/10.22617/FLS168388-2 (Accessed: 27 February 2025).

It is important to distinguish between three types of climate resilience: defensive, adaptive and pro-active. Defensive resilience centers on protecting the road against from untoward weather events. The risk of this type of resilience is that the road is protected, for instance by enlarged cross drainage structures, but that this comes at the cost of the landscape around the road, that is now faced with more violent discharges. Adaptive resilience takes a broader view and identifies additional measures along the road such as flood water spreaders to protect both the road and the surrounding area from climate effects. In pro-active resilience even the design of the road is modified to deal with such effects for both the road and the area around it. The next step is to make beneficial use of the storm water around the roads, as is part of the next dimension: land and water management.

2.3 Dimension 3: Water and Land Management

Water is responsible for 80% of the damage to unpaved roads and 30% to paved roads[4]. Water around roads is also a prime cause for delays in construction. There is a saying that the main three enemies to roads are 'water, water and water'.

There is another side to the narrative. Roads have a major impact on landscape hydrology. Roads affect watersheds by concentrating and accelerating runoff. They increase hydrological connectivity. This often cause flooding, gullying, and erosion. Studies indicate that 12-40% of sediment in catchments originates from road surfaces[5]. This clogs streams and reservoirs and negatively affects soil fertility and water quality[6]. Roads may damage small mountain aquifers and disrupt subsurface flows. The construction of a road radically changes the drainage pattern, which may lead to extensive water logging.

All this can be turned around. If managed properly, roads can serve as valuable tools for water management and enhance resilience. By integrating road development with water management roads can be utilized to harvest, store, and channel water, to manage water levels, do no harm to local aquifers and - thereby contributing to beneficial water use. This Roads for Water[7] approach transforms roads from potential environmental liabilities into assets that contribute to improved land and water management. Moreover, by integrating water management and watershed conservation into road development water-related damage and disruption of roads is importantly reduced. Because roads are everywhere, the scale of positive impact on land and water management in the entire country can be high, with different best practices for different geographies.

Box 1: Transforming roads in Nepal

Mountain springs are the lifeline of Nepal's highlands, providing water for drinking, agriculture, and livestock. Yet, these essential resources are under threat from expanding road networks that disrupt the hydrogeological balance, causing springs to dry up. Unmanaged spring water also damages roads, driving up maintenance costs. The RoSPro project reimagines roads as tools for protecting water resources. By integrating road design with local hydrogeological knowledge and engaging stakeholders, RoSPro preserves springs while strengthening infrastructure. In Dhoje Dharapaani, road improvements have eliminated water-related damage, making roads safer. Jagat, who collects biophysical data from the spring, notes: "The spring discharge after interventions has doubled, increasing from 15 l/min to 29 l/min." Water availability now serves both Ward 5 and Ward 2, greatly assisting residents[8].

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[4] Chinowsky, P. and Arndt, C. (2012) 'Climate change and roads: A dynamic stressor–response model', *Review of Development Economics*, 16(3), pp. 448–462.

[5] Van Steenbergen

[6] Faisal, M., You, Z. J., Idrees, M. B., Ali, S., and Buttar, N. A. (2024) 'Exploring urban runoff complexity: road-deposited sediment wash-off mechanisms and dynamics of constraints', *Journal of Hydroinformatics*, 26(6), pp. 1396-1408.

[7] www.roadsforwater.org

[8] TheWaterChannel. (2025) 'Safeguarding roads and springs in Dhankuta, Nepal: Early findings from the ROSPRO project', The Water Blog. Available at: https://thewaterchannel.tv/thewaterblog/safeguarding-roads-and-springs-in-dhankuta-nepal-early-findings-from-the-rospro-project (Accessed: 28 March 2025).

Figure 3; Roads in Dhankuta Municipality and Chhathar Jorpati Rural Municipality in Nepal used to be muddy and prone to high erosion. Interventions contributed to safer, more durable roads and improved water access for households

Key intervention packages for beneficial water and land management in road development include:

1. **Water harvesting:** Diverting runoff guided by road drainage to storage structures, recharge areas or applied on land directly for beneficial use.
2. **Water retention:** Using road bodies and bridges to retain water, in the shape of dams, gated culverts, non-vented causeway, increased sills to retain and store water and release when needed
3. **Reduced waterlogging and flooding.** Design roads and bridges with adequate cross-drainage and passage so as not to impede free runoff and cause impoundment and/or uncontrolled overflows; also avoid concentrating run-off and create erosive floods. In addition, road networks and drainage systems, especially in flat areas, may be designed to compartmentalize flood basin and hence slow down the run-off and avoid damaging flood peaks.
4. **Preventing landslides and erosion:** Using roads to stabilize erosion prone sections, avoid land saturation and use road catchment management to stabilize hill sides.
5. **Avoiding sand dune movement:** Aligning roads away from prevailing wind directions and incorporating windbreaks and soil stabilization planting to prevent sand dune movement.

To integrate beneficial land and water use in road development will have triple wins: less damage to the road, less damage to the landscape and the beneficial use of water. What it requires is awareness, a change of perspective and capacities. It requires change in specification and design around road drainage – emphasizing beneficial reuse of drainage water rather than speedy disposal for instance. It also requires more integrated planning – between landscape managers and road agencies in particular. Several measures can be added as small cost items to road budgets or in asset management programs or can be implemented by landowners. It requires budget flexibility for the small location-specific measures, rather than large capital expenditures. Where it has been implemented, the benefits are integrated water management and road development are substantial – with returns of factor 2 to 4 within a year.

2.4 Dimension 4: Reducing Pollution

The construction and operation of roads can significantly impact both human well-being and environmental health. Vehicle emissions and dust from roadworks contribute to deteriorated air quality. This serious concern is highlighted by the Asian Transport Outlook, which estimates that 76% of global

deaths related to breathing particulate matter happen in Asia and the Pacific[9]. In fact, data by IQAir, which operates the world's largest free real-time air quality monitoring platform, show that 18 of the 20 most air-polluted cities globally are in Asia[10]. Smog, triggered by winter weather and air pollution, has led to temporary closure of schools in many parts of Asia in recent years.
Furthermore, roads can be a conduit for pollutants to enter soil and water systems; contaminants such as gasoline, oil from vehicles, heavy metals, rubber particles, trash, and microplastics are often carried by rainwater runoff from roads. Additionally, in colder climates, the use of deicing salts and sand on roads presents further environmental challenges, as these substances can leach into the soil and potentially contaminate groundwater and surface water. Perera et al. (2013) for instance found that about 40% of the chloride from road salt enters shallow aquifers[11].
Key areas for reducing pollution through road development include:

1. **Consider road construction materials**: Using materials with fewer fine particles and avoid additives that act as pollutants.
2. **Minimizing pollutant emissions from vehicles**: Setting minimum standards for vehicle emissions and fuel composition, enforcing anti-idling regulations, removing traffic bottlenecks and use non-abrasive road pavements.
3. **Revisit road drainage**: Avoiding untreated runoff near sensitive areas, using porous asphalt for better water quality, treating effluent through systems like detention ponds and sand filters, and implementing frequent drainage measures.
4. **Capture and remove pollutants**: Planting grass buffer strips and vegetation to absorb and intercept pollutants and using accumulator plants for soil bioremediation.
5. **Proper use of de-icing agents**: Using de-icing and traction agents in environmentally considerate ways.

These different areas are very much helped by environmental standards that define acceptable limits for air, soil and water quality. In some countries regular monitoring stations are in use, for air quality. These help enforcement of the environmental standards, but also to signal problem areas and the need to intervene. It is also important to integrate road planning and regreening with larger planning, especially in urban areas to make sure residential development and road construction are synchronized to reduce exposure to emissions.

2.5 Dimension 5: Quality of Life

Roads can significantly shape the quality of life for roadside communities. There are four critical factors: road dust, traffic noise, temperature, and beauty or road appeal.
Road dust, composed of coarse (PM10) and fine (PM2.5) particles, includes harmful substances from vehicle emissions, brake and tire wear. , and contains toxins like heavy metals – besides the dust particles from the road itself. Effective dust control on unpaved roads is essential for reducing the incidence of respiratory diseases, particularly in densely populated areas. The presence of vegetation along roadsides can mitigate the adverse effects of road dust as well as reducing noise pollution, and heat island effects.
Next, traffic noise is an often-forgotten health factor, causing the loss of healthy live years, particularly in cities. In Gwangju Metropolitan City, Republic of Korea, approximately 10% and 5% of the total

[9] Anyala, M., Stapleton, R., Keller, G., and van Steenbergen, F. (2023) 'Six Steps Toward Greener Climate-Resilient Roads in Asia and the Pacific', *Asian Development Blog*, 12 December. Available at: https://blogs.adb.org/blog/six-steps-toward-greener-climate-resilient-roads-asia-and-pacific (Accessed: 27 February 2025)
[10] https://www.iqair.com/world-air-quality-ranking. These 18 cities most polluted cities were in order of pollution: Beijing, Hanoi, Mumbai, Dhaka, Shanghai, Kathmandu, Kolkata, Chengdu, Wuhan, Bishek, Tashkent, Chongging, Phnom Penh, Kaohsing, Delhi, Almaty, Lahore and Ulan Bator. This is as of 27 February 2025. The ranking is changing daily.
[11] Perera, N., Gharabaghi, B., & Howard, K. (2013). Groundwater chloride response in the Highland Creek watershed due to road salt application: A re-assessment after 20 years. *Journal of Hydrology*, *479*, 159-168.

population (n = 1,471,944) experienced high-level annoyance and sleep disturbance, respectively[12], because of noise.

Furthermore, the issue of high temperatures and heat waves has attracted much attention in recent years. Urban Heat Islands occur when cities experience significantly higher temperatures than the surrounding rural areas due to human activities and urban development. The daytime effect can easily reach 1-3°C, but the difference is very much marked at night: 5-7°C or even higher. There are also considerably more heat wave days in cities. A main cause is the absorption of **heat by buildings and pavements – next to changes in air circulation and reduced vegetation and water bodies.**

A final quality of life factor is beautification. Beautification is not a luxury. Greenery along roadsides improves the appearance of roads and is associated with reduced mortality and longer life expectancy for nearby residents[13]. The impact of beautification goes further. It is estimated that people globally spent 10% of their time outdoors, and most of this is on roads and streets. The perception of the outer world is hence to an important degree shaped by what roads and streets look like: organized, clean, inviting and open or grim, neglected and dirty. Roads are an important factor in environmental psychology.
Key intervention areas to promote quality of life are:

1. **Dust control**: Using road stabilization through towns or rural areas, applying binding agents and dust palliatives on unpaved roads, use well-planned vegetation to capture dust.
2. **Noise control**: Use silent pavement such as porous asphalt and rubberized asphalt, create distances, use sound barriers and apply anti-honking regulations
3. **Temperature control**: Utilizing cool (white) pavements, planning the effect of roads on open space and air circulation, regreening of roadsides, managing shadow effects.
4. **Road beautification and public health management**: designing scenic roads and roadside facilities, managing public health of roads and sales of street food vendors, avoiding waste-fringes areas around roads.

Policies and regulations are important enabling factors in improving the quality of life. Preferably these are linked with systematic and accessible monitoring, for instance with dust levels. This creates awareness on the importance of managing these different elements. It is also important to have a strong connection with urban planning, as the quality of life in city environments is importantly affected by roads but also by many several other factors.

2.6 Dimension 6: Preserving Biodiversity

Road development can pose a significant threat to biodiversity, potentially leading to habitat fragmentation, impeding wildlife movement, disrupting plant and animal populations and material flows within landscapes[14]. On the other hand, if the road ecology is well managed, it can also provide a safe harbour for animal and plant species, particular in areas where widespread commercial farming or industries dominates. Roadside tree corridors, moreover, can be the connecting lines and passageways for biodiversity linking together different habitats.
In alignment with the global commitments under the Convention on Biological Diversity, it is imperative to maintain ecological connectivity and minimize habitat division during infrastructure development to help preserve biodiversity. To adhere to these international commitments, measures to prevent road kills are essential, especially for larger mammals. This is important not only for wildlife protection but also for road safety. Mitigation strategies include the creation of appropriate wildlife crossings,

[12] Park, T., Kim, M., Jang, C., Choung, T., Sim, K. A., Seo, D., & Chang, S. I. (2018). The public health impact of road-traffic noise in a highly populated city, Republic of Korea: Annoyance and sleep disturbance. *Sustainability*, *10*(8), 2947.
[13] ///
[14] Goldfarb, Ben (2023), Crossings: How Road Ecology Is Shaping the Future of Our Planet. New York: W.W. Norton.

installation of fences or wild-life detection system with high-frequency noise emitters, and regulation of vehicle speeds in areas frequented by wildlife. All this can avoid tragic and costly vehicle-wildlife collusions.
Key intervention areas for Preserving Biodiversity are:

1. **Protect and Harness Invertebrate Biodiversity:** Managing habitats to support invertebrate populations, create specially designed crossings for amphibians, and creating water points away from roads to support species diversity.

2. **Protect and Harness Vertebrate Biodiversity:** Installing (electronic) fencing and wild-life sound emitters in sensitive areas and providing safe passages like wildlife overpasses and underpasses (including flat culverts), creating roadside oases and mini-wetlands fed by road water harvesting or nesting boxes under bridges to support vertebrate species.

3. **Protect Aquatic Ecosystems:** Designing culverts to facilitate fish passage and prevent alterations or sedimentation of streams that affect aquatic habitats.

4. **Protect and Improve Roadside Flora:** Fostering roadside flora through appropriate mowing practices and hydroseeding to maintain healthy plant communities.

5. **Digital Tools for Biodiversity Preservation:** Utilizing digital tools to identify and monitor animal-vehicle collision hotspots, enhancing efforts to prevent wildlife fatalities.

These measures need to be supported by different enabling factors. An important precondition are the mechanisms to finance biodiversity measures. Whereas many measures require mainly small well-considered but inexpensive adjustments for instance in modified culverts, other measures are more costly such as special wild-life overpasses or regular mowing of roadside grasses. In several cases there is a cost saving even in costly measures, such as the reduced cost of traffic disruption or the reuse of cut vegetation.

2.7 Dimension 7: Disaster Preparedness

Disasters, exacerbated by climate change, significantly threaten economic and social progress in Asia and the Pacific. From 2015 to 2022, a total of 814.8 million people in ADB's developing member countries were impacted by disasters. During the same period, total losses amounting to $418.5 billion were recorded in ADB's developing member countries[15].
Roads are a fundamental component of disaster preparedness and response. They serve as critical lifelines, providing safe passage during emergency and enabling the delivery of relief. During the 2022 mega-flood in Pakistan, which covered 30% of the country, roads served as evacuation routes to relief camps for more than 800,000 people. They also served to evacuate livestock, a critical economic asset for rural families. Over 70% of livestock was successfully moved in regions with functional road networks. In general, affected people close to roads can salvage a much larger portion of their assets during disaster and businesses close to roads are much quicker to restart.

The strategic planning and construction of road infrastructure can significantly enhance disaster resilience, particularly in areas prone to floods. Moreover, proper drainage can mitigate water-related hazards. In coastal regions, roads can double as protective embankments, when carefully managed. Additionally, roads can aid in forest fire prevention by allowing access for firefighting equipment. However, this access must be balanced with the potential risk of exacerbating fires.
Key Intervention Areas for Improving Disaster Preparedness through Road Development are:

[15] Centre for Research on the Epidemiology of Disasters (CRED) (2008) *EM-DAT: The International Disaster Database*. Available at: http://www.emdat.be/Database/Trends/trends.html (Accessed: 27 February 2025)

1. **Preventing floods and water logging by unrestricted drainage:** Floods in many areas are not so much result from heavy rainfall but are caused by obstructions to the natural drainage pattern. Road development with inadequate cross drainage or too narrow bridges is a major factor here, impeding run-off and causing water to accumulate and flood to rise. Where this happens the road drainage systems needs to be adjusted, and bridges need to be reengineered. Another area of attention is to ensure that the road drainage system does not overly concentrate run-off and thus generate floods during heavy rainfall. Also, roads should not divert streams at road-stream crossings.

Figure 4: Bridge on Indus River acting as chokepoint

2. **Mitigating floods by road and bridges network:** The road and bridges network also be used to mitigate flood risks. Particularly in flat flood-prone areas the road network can be designed so to create flood compartments, slowing down the accumulation of floods. A related strategy is to have overflow section in roa er during floods and to route this to recharge areas c

3. **Enhancing flood resilience in road networks:** Elevating roads and bridges to appropriate flood levels to prevent water damage and ensure functionality during high stress. In Bangladesh submersible roads have been developed in the hoar areas that are flooded annually. The roads are constructed to withstand the period of inundation and not obstruct the rising floods. It is explored that what extent these submersible roads can be used to retain some of the receding floods and hence secure soil moisture in the dry period.

4. **Improve Road Network Capacity to Deal with Emergencies:** Increasing road network capacity for emergency response and integrating early warning systems enhances disaster preparedness and effective response. Flood shelters may be added to enhance the lifeline capacity for people and livestock in search for safe shelters during flood emergencies

5. **Evacuation and Access Plans:** Developing clear emergency communication strategies with appropriate signage and messaging, managing emergency traffic efficiently, and planning detailed disaster preparedness procedures are critical for effective evacuation and access.

6. **Fire Prevention:** Using roads to provide access for fire and emergency equipment, incorporating fire breaks along their routes, and using fire-resistant materials to prevent and manage fires.

An important enabling factor is proper road planning and design, especially of road drainage structures. Design standards need to be adjusted. It has been observed that a common response to concern of climate change and higher risk of heavy rainfall has been to resize cross drainage structures. This has often been a disaster in the making, because it comes down to exporting the problems to the roadside environment. Instead, there many other options – improved lead in and lead out of the culvert, reconsidering where the road drainage water is led to and having a more distributed drainage pattern. It also uses a careful choice of the road crown – to understand where the run-off is distributed to – making sure it does not harm but instead can serve beneficial use even.

2.8 Dimension 8: Sustainable Materials Sourcing and Construction Practices

The construction and rehabilitation of roads require a substantial amount of construction materials, representing 30%-40% of all materials used in construction projects [16]. The rapid growth in demand for these materials, particularly in Asia and the Pacific, poses a challenge to the sustainability of natural resources and the management of waste and pollution. In the last decade, Asia's demand for construction materials has surged by 64%, compared to a global increase of only 17%[17]. This disparity highlights the urgent need for implementing good practices toward sustainable material sourcing, promoting circularity and well-planned extraction.

To effectively implement sustainable sourcing and construction practices, interventions must be tailored to the specific context of each country or region. This could involve selecting lower carbon construction materials, reusing and recycling waste, and a shift toward construction methods that extend the lifecycle of the materials used. This approach not only preserves natural resources but also aligns with the global pursuit of net-zero emissions and sustainable development. The reuse of material is also major opportunity to dispose of non-biodegradable material.

Key Areas for Sustainable Materials Sourcing and Construction Practices:

1. **Design:** Implementing economical designs and specifying sustainable construction materials and techniques, such as cold mix asphalt and polymer-modified bitumen (PMB), helps reduce environmental impacts and resource consumption.

2. **Material Choice:** Opting for materials with efficient life-cycle use, ensuring the safe use of recycled and bio-based materials, and incorporating geo-textile fibres and marginal materials contribute to sustainability and reduce reliance on raw resources.

3. **Sourcing:** Reducing the environmental costs of material extraction by avoiding sensitive areas, bringing down haulage distances, and ensuring sustainable extraction practices are essential. A promising practice is the repurposing of extraction sites, such as borrow pits and quarries.

4. **Special attention for sensitive areas.** An example are small islands, which have extremely limited access to construction material. These need utmost care by way of environmental analyses and end-of-life strategies, as well as special techniques such as stabilizing coral rock and sands.

Several enabling factors are important in the transition to circularity and safe sourcing. One is the regulation of extraction sites. All over the world for instance the mining of sand and gravel from riverbeds is problematic. Removing the sand and gravel load of the rivers affect the capacity to store floods and recharge the aquifers adjacent to rivers. Also, if sand and gravel is extracted haphazardly, the composition of the bed material may be spoiled. Hence it is necessary to regulate how building material is sourced, banning or strictly regulating the use of rivers for instance or preferably identifying other extraction sites that can be repurposed.

2.9 Dimension 9: Fostering Inclusive Growth

Green roads play a crucial role in fostering **inclusive growth** by creating employment, enhancing connectivity, and stimulating economic opportunities along transport corridors. Globally, road construction and maintenance account for **USD 1-1.5 trillion annually**, making the sector a major economic driver and one of the top employers in many countries. The road sector contributes **5-10% of national economies** and generates large-scale employment. Road infrastructure projects can kickstart

[16] Anyala, M., Stapleton, R., Keller, G., and van Steenbergen, F. (2023) 'Six Steps Toward Greener Climate-Resilient Roads in Asia and the Pacific', *Asian Development Blog*, 12 December. Available at: https://blogs.adb.org/blog/six-steps-toward-greener-climate-resilient-roads-asia-and-pacific (Accessed: 27 February 2025)

[17] Anyala, M., Stapleton, R., Keller, G., and van Steenbergen, F. (2023) 'Six Steps Toward Greener Climate-Resilient Roads in Asia and the Pacific', *Asian Development Blog*, 12 December. Available at: https://blogs.adb.org/blog/six-steps-toward-greener-climate-resilient-roads-asia-and-pacific (Accessed: 27 February 2025)

economic development, both by the money they bring in the economy and the economic opportunities the create. Key intervention areas for **inclusive development** include:

1. **Fair local sourcing of construction materials.** Supporting local economies by creating business opportunities around road construction, such as local fair sourcing of building materials
2. **Employment generation in construction and maintenance.** Providing rewarding local jobs in road development and maintenance, providing capacity building and other support, creating opportunities for young contractors, adjusting designs so that more local opportunities are created, for instance in stone bridges or in asphalt roads as against concrete roads.
3. **Creating opportunities for roadside business. Creating special spaces for roadside business with good access and appeal, protecting and managing conditions for existing roadside vendors.**
4. **Ensuring 'last mile' access. Prioritizing access to isolated and small settlements, deploying special elements to overcome difficult terrain, such as trail bridges in mountainous terrain or improved motorbike trails.**
5. **Protecting road workers and road quarry workers. Programs to ensure safe and decent working conditions for these labour groups and special measures to provide basic social protection such minimum wage, pension and insurance and avoid child labour. Ensuring salary payment in safe accounts to avoid abuse. Special measures to avoid exploitation and hazards around labour camps, such as prostitution and substance abuse.**
6. **Special amenities for vulnerable groups. Special consideration for people with disability such as guideways for the blinds, special ramps or safe traffic lights.**

While road construction employs millions, workers—often **low-educated, migrant, and poor**—face **exploitation and hazardous conditions**. Road quarry workers are a specially exposed group. Effective labour regulations can protect workers through **minimum wage laws, insurance, and pensions.** Strong **safety regulations, inspections, and enforcement mechanisms** are necessary to protect workers. Road quarry workers are especially vulnerable, exposed to **silica dust and silicosis**, a severe but sometimes underreported public health issue.

Furthermore, road networks wire economies, linking remote areas to key markets. **Strategic network design** influences regional economic models, balancing the need to connect major growth centres with ensuring **'last mile access'** for isolated populations. Globally, a significant share of people remains disconnected, including large number of people **in Asia** who live more than 2 km from an all-weather road. Innovative techniques – not common in many countries - such as **trail bridges and improved motorcycle paths** can bridge these gaps. Beyond connectivity, roadsides present **economic opportunities**, ranging from urban roadside vendors to business parks along highways. Inclusive roadside development should be **regulated and designed to benefit vulnerable groups**. To ensure green roads support inclusive growth, examples of enabling factors are:

- **Strategic road network planning** to improve access for vulnerable populations.
- **Road designs** that promote **local labour and material sourcing**
- **Capacity building and enforcement** of labour protections and last-mile measures.
- **Occupational safety programs** with strict compliance and monitoring.
- **Special uplift measures** for vulnerable groups in construction and quarry sites.

Embedding these measures into **road construction standards and worker protection programs** will ensure that green roads **not only enhance mobility but also drive social and economic inclusion**.

Chapter 3: Enabling Factors for Green Road implementation

Enabling factors are the driving forces behind the successful rollout and integration of green roads. They provide the essential support systems that pave the way for environmentally and socially responsible road development. To make green roads a reality, these enablers must be firmly rooted at the national or regional level - with governments taking charge to create a policy and planning environment where sustainable road practices can thrive and sound partnerships with private sector, research agencies and diverse interest groups develop. There are several categories of enabling factors. They are outlined in **Error! Reference source not found.**, with detailed descriptions provided below.

Table 1: Enabling factors required for the majnstreaming of green roads

Nr.	Enabling factors
1	Policy Development
2	Roadmaps for Green Roads
3	Application of New Technologies
4	Improved Design Standards
5	Environmental Standards
6	Regulatory Frameworks
7	Improved Planning Systems
8	Capacity Building and Awareness
9	Sustainable Procurement
10	Financial Mechanisms
11	Supply Systems: Available Resources and Materials
12	Collaborative Partnerships and Connection with Other Programs

3.1 Policy Development

Green Roads Visioning or Policy Development is crucial for mainstreaming green roads. It provides the starting point and foundation for the uptake of green roads approaches and practices. Policy development brings together current practice, new insights, and on-the-ground experience. It helps to align with national and international commitments pertaining to crucial themes such as inclusive growth, climate mitigation, adaptation, and biodiversity conservation. It helps to visualize what a green roads future would like – this visualization being an important driver for change in itself. Policy development also helps to think through what it takes to introduce the new practice.

It is said that the policy process is as important as the end product. The formulation of the policies is an opportunity for different stakeholders to interact, to hold discussion, formulate common viewpoints and have public statements made. In case of green roads, it can help set the basis for cooperation with organizations with different mandates at different levels. It may enable a broad collective rethink of the direction one moves toward and sets the basis for follow up: with targets, a road map, implementation guidelines and new financing.

Policies can be made at different levels and have different scopes. The policy may cover the entire country or concern a region. One may formulate policies along all green roads dimensions or focus on one or more themes. In Bangladesh the Local Government Engineering Department, that is in charge for 420,000 km of rural roads, developed a policy guideline on systematically integrating water management in the rural roads network it is managing – both to use roads as instrument for water management and to better cope with water-related events, such as flooding or water logging or incessant rainfall. What is important for policies is to have a strong owner – ideally a finance and planning department or the main road authority. Policies should also a 'bite' – to make a binding

connection with financial systems and regulations for instance and to be connected to programming and implementation.

In short, policy is where change begins. It is where vision becomes actionable, where collaboration becomes institutionalized, and where green roads become not just possible, but inevitable.

3.2 Roadmaps for Green Roads:

From the policy development and visioning, green road roadmaps may follow. They are strategic plans that provide a clear path for implementing sustainable road development practices. These roadmaps outline the steps and milestones required to transition from traditional road construction to green road development. They should include a timeline for incorporating various green road elements and objectives, ensuring a systematic and structured approach to sustainable infrastructure development and asset management. Road maps cover a medium-term period and can consist of different stages. They are ideally actively managed by a unit mandated to oversee the change. The road maps contain changes in regulation, the building up of experience and planning and programming. Roadmaps may cover the entire green road sector or they may focus on certain elements, such as making the road network climate resilient and disaster-prepared or to optimize the inclusive growth opportunities in road investments. Table 3.2 below gives possible phases within a green roads roadmap.

Table 2: Example of a road map: different phases

Phase 1: Planning (0-1 Year)	1. **Assess Current Infrastructure** - Conduct studies and assessment. - Prioritize areas and themes where green roads can be implemented. 2. **Set Goals and Targets** - Define targets for different themes (e.g., integrating hydrology, emissions reduction, recycled materials use). - Align with other programs and policies 3. **Stakeholder Engagement** - Involve government bodies, environmental groups, and construction companies – create a platform. - Sensitization campaigns on the benefits of green roads 4. **Secure Funding and Partnerships** - Seek government grants at different levels, private investments, and green finance. - Partner with resource institutions.
Phase 2: Eerly Implementation (1-3 Years)	1. **Select Early Intervention Areas** - Choose low-risk areas to introduce green road technologies. - Measure costing, durability, efficiency, and sustainability metrics and take lessons 2. **Set programs in motion work out details** 3. **Discussion changes in laws and regulatory enablers**
Phase 3: Policy & Standardization (3-5 Years)	1. **Develop Green Road Standards & Regulations** - Establish guidelines for green road construction and asset management. - Introduce incentives for different organizations adopting green practices. 2. **Expand Capacity Building of Main Actors Training Programs** - Educate engineers, contractors, workers, local government and communities on green construction. - Collaborate with learning institutes for skill development
Phase 4:	1. **Roll Out Nationwide Green Road Projects** - Integrate green roads into regional and urban planning.

Large-Scale Implementation (5-10 Years)	- Scale up funding for widespread adoption. **2. Set up supporting supply chains.** - **New materials**
Phase 5: Continuous Improvement (Ongoing)	1. **Regular Maintenance & Upgrades** - Implement eco-friendly maintenance strategies. - Real-time monitoring. 2. **Research and Development** - Create forum for change - Innovate new materials and techniques

3.3 Application of New Technologies

The technologies used in green road development are often different from the ones used in conventional road development,. A change in practice is required. This may concern proven yet underutilized technologies or novel techniques and approaches. What is important is that green road technologies are as robust as conventional technologies, ultimately captured in precise specifications and operating procedures – to do justice to the large economical and financial responsibilities in infrastructure development.

Breakthroughs in areas such as self-healing concrete, graphene-enhanced asphalt, digital twins, energy-harvesting pavements, water storage with roads, machine learning, and AI-driven asset management are redefining what is possible. Meanwhile, sustainable practices like using recycled materials and optimizing resource use continue to deliver significant benefits. It is however not only cutting edge new technology that matters, but also good practice that is used in some place but not yet mainstreamed. Together, these advancements not only reduce emissions and environmental footprints but also improve public well-being and resilience.

However, new technology alone does not suffice. The real challenge for application lies in validating, testing, and integrating these technologies into real-world implementation. construction. To accelerate progress, a dynamic ecosystem of improvement across the road sector should be developed:

- **Attract the best and brightest minds** to the field of green infrastructure.
- **Forge strong partnerships** between universities, research institutions, and industry to co-develop transformative solutions.
- **Promote innovation-friendly procurement**, using open or performance-based contracts that provide flexibility and incentive (see also section 3.9).
- **Launch pilot projects** and experimental road initiatives to test new techniques in real-world settings.
- **Foster a culture of learning**, where practical innovations from across the sector are captured, shared, and scaled through open collaboration, knowledge exchange, and competitions.

3.4 Improved Design Standards

Improved design standards consolidate the new ways of working. They ensure uniformity and they control quality. Given the enormous length of roads already constructed and the large task load ahead the importance of well-described practice cannot be overemphasized. Design standards dive deep into the specifications – material composition, construction techniques, the quality control, deviation procedures. They guide engineers and planners in designing roads that align with green road objectives, promoting features like wildlife crossings, efficient drainage systems and road water harvesting, or the use low-impact materials and more. These standards help ensure that the design of roads is optimized for broad functionality, sustainability and long-term climate resilience.
Roads are typically classified in different categories and design standards differ per category and sometimes per geography as well. The design standards may not be limited to the road body and the bridges but also to many other appurtenant structures. In case of green roads, it is particularly

important to consider the drainage pattern, the material specification, the landscaping, but also to revisit mundane elements such as the road cross sections and culvert designs.
Design standards in Green Roads may also define practices that consider factors such as optimizing the positive impact of roads on landscape and hydrology, pollution, biodiversity loss, reducing carbon emissions, and enhancing safety and functionality for disaster risk reduction for instance.

Box 3.1 Malaysia: Intermediate Guidelines to Road Reserve Landscaping
To set standards for the regreening of road reserves in Malaysia, guidelines were developed for landscaping of road reserve lands in Malaysia. They were developed based on previous guidelines to address safety concerns with planting trees along roads. The objectives are to formulate guidelines for planting roadside trees/shrubs considering road safety, establish a landscape corridor and buffer zone, and provide a guide to suitable plant types. Functions of roadside trees discussed include screening for glare/noise, undesirable views, providing direction/safety, and diverse environmental benefits. Planting setback distances and considerations for sight lines and vehicle recovery zones are also outlined

Design standards are always specific and detailed: this is what should be. At the same time this should no stifle innovation and improvement. There is much value in using design standards responsibly and flexibly and create space for introducing new approaches and techniques. This should be encouraged and enabled, also by the body that is responsible for issuing the standards. Ideally there are three stages in introducing new green road approaches:

- Allowing existing standards to be used flexibly or create the space for experimental approaches
- Adjusting existing design standards
- Designing new design standards.

3.5. Environmental Standards:

Environmental standards set the boundary conditions for road development – both during construction and in the subsequent operations. Establishing and implementing clear environmental standards are a driver for introducing green road practice, as it makes it possible to combine infrastructure development with observing agreed environmental quality standards. The standards are generic and concern general norms for air quality, water quality, noise, soil quality and biodiversity: examples are given in table 3.3.
The generic environmental standards can be tailored to different areas and applications, for instance having stricter standards close to densely populated areas. Sometimes environmental standards are made specific to road conditions.
What is important is that environmental standard are matched with monitoring and reporting arrangements, including giving space for citizen science. The environmental standards usually apply at two different domains – for for the design of the road and the construction process.

Table 3: Main environmental standards

Air Quality Standards	**Ambient air quality standards, setting** levels of NO_2, PM2.5, PM 10, CO, O_3, others
	Vehicle emission standards
	Area specific low emission zones
Noise Pollution Standards	**Environmental noise standards**
	Road traffic noise limits
	Area specific noise standards
Water Pollution Standards	Water quality standards for water bodies, setting levels for hydrocarbons, heavy metals, TDS, oil pollutants
	Water quality standards specific to for road-related water bodies: hydrocarbons, heavy metals, TDS, oil pollutants
	Storm water run-off discharge quality standards
	Groundwater quality standards, related tprrp

	Salt and deicing regulations
Soil and land pollution Standards	**Soil screening levels** for heavy metals and hydrocarbons.
	Compulsory erosion and sediment control practices
	Hazardous material spill regulations
Biodiversity standards	Habitat regulations
	Red lists for endangered species.

3.6. Regulatory Framework

Effective regulations play a crucial role in shaping the development of green roads. They give instruction on how to safely handle the different steps and who is responsible for assessing, preparing, implementing, supervising, validation and more.
Governments and regulatory bodies need to establish a clear framework that mandates the integration of green road principles into project planning and implementation. These regulations can include requirements for data collection, compulsory assessment and studies, communication, engagement with other parties, discussion with communities, complaint handling, but also storm water management, material use and reuse, or waste handling. A robust regulatory framework ensures that green road practices are enforced and adhered to throughout the project lifecycle.

3.7 Improved Planning Systems

Improved planning systems are essential for the effective integration of green road practices. This enabling factor involves enhancing planning processes to systematically incorporate environmental and social considerations from the project's inception. It includes the development of comprehensive planning frameworks that address factors such as climate resilience, water and land management, disaster preparedness and inclusive growth among other aspects. Improved planning systems ensure that green road objectives are seamlessly integrated into project plans, contributing to the creation of environmentally sustainable and socially responsible road infrastructure.
A main is a using an integrated approach – combining different interests, aligning road development in larger area-based plans and the understanding and managing the different sides of road development – so not only connectivity but also the footprint in other sectors (chapter 2).

This requires effective relations with various other organizations (see also 3.12), capacity to align road development to different development scenarios, flexibility and openness. What makes this possible is clear frameworks and support from the leadership. Another important factor is staffing. There is a personal dimension to having improved planning systems. It is not uncommon for good intentions to become lost because of inadequate staffing, vacancies, the unavailability of in-house experts or lack of access to high level consultancy. In other cases, responsibilities for planning are transferred to organizations with limited capacity or high exposure to political influence. The latter is always a risk because road development is often a vote-catcher. Roads are **tangible and highly visible** infrastructure projects. Voters can physically see and use them, unlike some policy changes or more integrated green approaches that are abstract or harder to measure. Completed or ongoing roadworks give the impression that the government or candidate is **"getting things done."**

3.8 Sustainable Procurement:

Sustainable procurement shapes the relationships between government clients, contractors, and stakeholders, influencing the market for materials and services. In the emerging field of green roads, sustainable procurement facilitates innovation and enhances performance in road construction, management, and maintenance. With over USD 13 trillion spent annually on procurement globally, and ADB alone disbursing more than USD 9 billion, sustainable procurement is a crucial driver of change toward green roads.

Modified tendering procedures are essential for integrating environmental and social considerations into contractor selection for green road projects. There are three broad categories of **Sustainable Procurement Systems**

1. **Conventional Procurement Systems, using Improved Specifications**
    - Follows a detailed-design approach where green road elements (e.g., drainage networks, animal crossings, recycled materials) are pre-defined in engineering designs.
    - Contracts are awarded to the lowest evaluated compliant bid following the FIDIC Red Book, often with an adversarial client-contractor relationship.
    - Suitable for mainstream green road practices that can be incorporated into detailed designs.
2. **Merit Point Systems**
    - Evaluates contractors based on technical proposals and past experience, ensuring quality and impact are prioritized over low-cost bids.
    - Considers factors like local sourcing, pollution control, and biodiversity practices.
    - Requires contractors to achieve a minimum technical score or the highest combined technical and price score.
    - Includes performance-based contracts where bonuses/malus systems are applied for under or overperformance (e.g., roadside tree planting).
3. **Early Contractor Engagement**
    - Encourages innovation by involving contractors early in project planning to develop creative solutions for green roads.
    - Multiple service providers are invited to propose solutions aligned with the client's objectives.
    - Frequent client-contractor interactions foster innovation, with expert panels assessing proposals and implementation feasibility.

Sustainable procurement is a vital tool in promoting green road practices. Whether through improved specifications, merit-based selection, or early engagement, modified tendering procedures help integrate sustainability into infrastructure development, fostering environmental responsibility and innovation in road construction.

3.9. Capacity Building and Public Awareness

Public awareness and education campaigns are essential for garnering support and understanding of green road initiatives, and so is capacity building. These campaigns inform the public about the benefits of sustainable road development often in combination with road safety. It helps getting attention for another approach to roads and visualize a road as a multi-purpose work – to which many interests can relate. Awareness creation is also a good way of finding champions that take the discussion to new domains and decision-making levels. Educated and engaged communities can advocate for green road projects, contribute to their success, and hold stakeholders accountable for their environmental and social responsibilities.

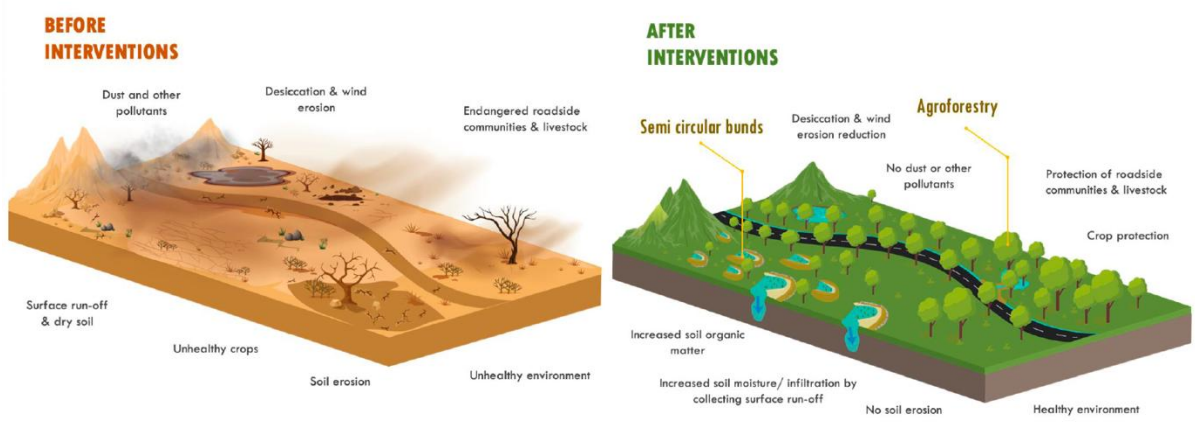
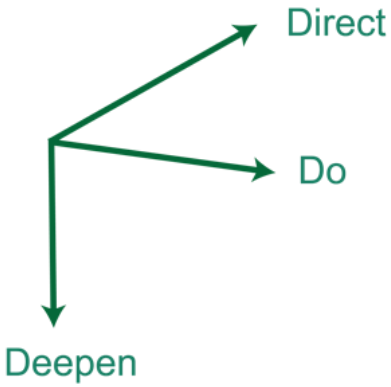


Figure 5 Awareness material contrasting a road before and after green road measures

Capacity building is an equally important enabling factor. Green roads need the active appreciation of new disciplines, such as water management or biodiversity. It also needs a broader more landscape-oriented approach in addition to excellent engineering skills. A change in mindset may be embedded in the new orientations.
At present professional education in most countries has a relatively narrow focus. This would need to be opened up and also skills like community discussion and multidisciplinary team work may be useful. Change can come from courses and academic education, but also very important in-house training may be adjusted toward new green roads approaches.

3.10 Financial Mechanisms



In understanding the financial mechanisms and how they enable the transition to Green Roads, there are three import dimensions to understand: Direct, Do and Deepen.
Direct means the overall direction of financing in the road sector – what is made possible, what is prioritized and made possible. What is the type of roads that are being financed and under what conditions, how are non-road measures included? Direct also relates how other programs take on board financing of green road measures – how climate funds or biodiversity funds can be mobilized to support green roads.
For a long time, the road sector was anathema to climate financing. Organizations such as the **Climate Bonds Initiative (CBI)** provide certification for green bonds, ensuring that the projects meet sustainability criteria. Climate bunds however have a taxonomy that excludes road investment in toto, the reasoning being essentially that more roads means increased carbon dioxide emission. The opposite reasoning should be that given the large inevitable size of the road sector, much is to be gained by better alignment between climate and road agendas, recognizing the opportunities in green roads and the nature-positive effects they may have. The Green Climate Fund has been – but a breakthrough has been the funding of Green Roads Component in DEFIS-+ in Madagascar.
Do is the second are the actual financing mechanisms: the existence of a Road Fund, the way that multiyear investments are financed, the manner on how road asset management is organized. In these basic mechanism green road measures should be facilitated. The Do means the practicality of financing green roads – for instance flexibility to adjust NRM measures within ongoing programs, set-asides for NBS measures or special grants,

1. **Green Bonds for Road Projects**
    - Governments or private entities issue green bonds to fund sustainable road construction, such as low-carbon asphalt roads, electric vehicle (EV) charging infrastructure, or roads with solar panels.
    - Example: France issued green bonds to support sustainable transport infrastructure, including eco-friendly roadways.
2. **Public-Private Partnerships (PPPs) with Green Criteria**
    - Private investors finance and operate road projects with sustainable requirements, such as using recycled materials, permeable pavements, or noise-reducing surfaces.
    - Example: The UK's A6-M1 Link Road used PPP financing with sustainability goals.
3. **Climate Funds and Multilateral Bank Loans**
    - Institutions like the World Bank, Asian Development Bank (ADB), or Green Climate Fund provide loans for low-carbon and climate-resilient road projects.
    - Example: The ADB financed climate-resilient roads in the Philippines to withstand extreme weather conditions.
4. **Toll Revenue-Based Green Investments**
    - Revenue from toll roads is reinvested into green infrastructure, such as bike lanes, pedestrian-friendly roads, or electric bus lanes.
    - Example: Norway uses toll revenues to fund sustainable transport projects, including green road upgrades.
5. **Sustainable Infrastructure Investment Funds**

- Institutional investors (pension funds, sovereign wealth funds) allocate funds toward road projects that meet environmental, social, and governance (ESG) criteria.
- Example: The European Investment Bank (EIB) supports green infrastructure, including road projects that reduce carbon footprints.

6. **Green Grants and Subsidies**
   - Governments provide grants for sustainable road-building materials, LED road lighting, or smart traffic management systems to reduce emissions.

Finally, **Deepen** – the last of the 3Ds - concerns the way the funds are spent – whether for instance they are procured locally or internationally, whether small and medium enterprises are given a chance to access contracts, whether spending is used not just to complete the work but also to build up lasting capacity. The dimension is particular import for Inclusive Growth – are measures are taken to make sure that the spending in the sector benefits the larger picture, creating more local jobs and capacities for q

These financial mechanism may have in-built obstacles to stand in the way of a greener road future. It needs in several cases path-breaking discussion and even lobbying to reassess and recalibrate road financing mechanism along all three d's.

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3.11 Supply System: Organizing Available Resources and Materials

Access to appropriate resources and materials is a crucial factor for implementing green road practices. It ensures the availability of sustainable construction materials, workforce, and equipment necessary for environmentally responsible and cost-effective green road development. Resetting the supply system is particularly important in introducing new road construction techniques where new materials are used. The road sector is a major consumer of construction material. Utilizing reused material, eco-friendly materials, or local resources in road construction can support broad societal sustainability goals. These new materials however need to be sourced and stocked, and quality controlled and processed. To make investment in these supply systems viable, an assured intake is needed. This requires on the one hand a secured demand. The reuse of material in road construction and elsewhere is however an important strategy to address pollution and contamination of material that otherwise would have no value, such as discarded plastic. It gives a value to these inputs and create the incentive for the collection of the waste material and investment in waste processing. The benefit is hence on both sides. Policies and incentives on circular development may create the overall environment to make these things happen. In some cases, price incentives and purchase guarantees may encourage investment in the supply systems. Import and export of waste material may be used as instruments. Also work with concrete mixing plants and asphalt processing facilities.

A related practice is avoiding the use of construction material resource from sensitive areas, such as the mining of sand and gravel from active riverbeds or beaches for road construction, that can have a detrimental effect on river hydrology and coastal protection.

Box 3: Sourcing plastic for reuse in roads in Papua New Guinea

Climate change, causing fluctuating and extreme weather, has considerable impacts on road performance. For example, floods and wildfires result in destroying road surfaces and road melting. To address this, Papua New Guinea (PNG) is participating in an ADB project that uses recycled plastic materials in road construction to combat climate change. This approach not only enhances road resilience during extreme weather but also significantly improves PNG's recycling industries by establishing a new supply line for road paving. Previously, the recycling rate of plastic in this country was zero. Plastic products were part of a linear economy where they were produced, consumed, and consequently disposed of in landfills. To recycle plastic waste and return it to production, the waste is collected and sorted into various types of plastics. It then undergoes shredding and extrusion to become recycled polymers that are ready for use in road construction. PNG has used 7500 kg of recycled plastic per km for asphalt road pavements in main cities. Meanwhile, the country has selected Ensisi and Boroko in Port Moresby to pilot the development of recycling lines for plastic waste. Collaborating with local councils, special recycling bins are placed in communities with clear instructional flyers to help residents dispose of plastic waste properly. This waste will be compacted and delivered to recyclers in Australia to undergo recycling processes and produce recycled polymers,

demonstrating the feasibility of the technologies. The polymers will then be sent back to PNG for road paving. In the future, the government will deploy the technologies and build recycling facilities to further develop the recycling industry that supports PNG roads.

An example is the reuse of processed waste plastic, as has done introduced in PNG (see box) This concerns the sourcing of the material, their processing so as to make them use-ready and their processing in special mixing asphalt plants.

Table 4: Contribution of Reused Materials to Road Infrastructure and Environmental Goals

Reused material	Purpose	Value for roads	Value for environment
Slag		Prevents road from breaking or deformation, avoid corrosion	
Rubber tires	Waste tires are shredded into small granules (crumb rubber) and mixed with bitumen to create rubberized asphalt **Concrete roads:** ground rubber replaceing a portion of the fine aggregate (sand) or coarse aggregate in concrete. Shredded tires (1-12 inches) are used as a lightweight fill material under roads Whole or shredded tires are used in retaining walls, embankments, and erosion control structures	Adapt to changing temperatures without cracking Improves road flexibility and resistance to cracking. Reduces road noise. Increases durability and skid resistance. Enhances impact resistance. Reduces density, making it suitable for lightweight construction. Increases shock absorption and durability Prevents soil erosion in road embankments. Acts as a sustainable alternative to traditional fill materials	Avoid filing of landfills Pollution Reduces noise pollution
Construction debris	Used as aggregrate (Recycled Concrete Aggregate) Used as fill material or in sub-base layers.	Cost saving, improve flexibility, and ensure longevity of roads Provides good drainage, reduces landfill waste, and stabilizes road foundations.	Avoid filling of landfills Reduces demand for virgin building material

Reclaimed asphalt pavement	Reused on site with Full Depth Reclaimation techniwes Can be mixed with fresh hot mix bitumen, after crushing and milling Can be used in cold mix asphalt, after crushing and milling Blended with new aggregates to strengthen new asphalt mixes. Applied in base and sub-base layers	Lowers construction costs, , and enhances pavement quality. reduces costs and transportation	reduces bitumen demand and demand for bitumen avoid persistence of non-biodegradeable material
Plastic	Can be mixed with hot mix bitumen Can be used in cold mix asphalt Partial replacement for conventional aggregates in road sub-base layers Create durable plastic paving blocks or tiles, used for pathways, parking lots, and low-traffic roads	Enhances binding properties: Increases stability with fluctuating temperatures Increases water resistance Improves road longeitivity	Incentives the removal of non-biodegradeable material from environment Reducing space in landfills
Glass	Mixed with asphalt (after crushing) replacing some natural aggregates Ground galls used as a replacement for sand or as a partial cement substitute in concrete mix ed in concrete roads Base or subbase material Used as drainage material instead of sand	Can be used up to 15% in relatively dry climates Improves skid resistance Esthetic appeal In case of base or drainage material - improved drainage	Incentives the removal of non-biodegradeable material from environment Reduces demand for virgin construction material
Shingles		Can be used as recycled into asphalt cement Can be used as binder	Save space in landfills
Ashes: Fly ash Boiler slag (bottom ash) Pond ash		Can be used as a filler Enhance the surface, can improve moisture resistance, skidding resistance, and strength of the roadways.	Avoids contamination

3.12 Collaborative partnerships and connection with other programs

Collaborative partnerships involve cooperation between various stakeholders, including government agencies, private sector companies, non-governmental organizations, and local communities. These partnerships facilitate the sharing of resources, knowledge, and expertise and also the exchanges to plan, fund, and implement green road projects. The intensity of collaboration differs – from being a network where contacts are made easily to program specific joint operations.
Collaborative efforts create a network of support and expertise that can address the multifaceted challenges of sustainable road development. There may be existing forums that can provide this function: national road councils or federations or within given area general development councils. The partnerships may
Establishing connections with other programs is a strategic enabling factor that amplifies the impact of green road initiatives. By aligning with existing environmental, social, or community development programs, green road projects can leverage resources, expertise, and collaborative efforts. This connection enhances the project's reach and effectiveness, creating synergies between green road objectives and broader sustainability goals. It fosters an integrated approach to road development, ensuring that green road practices contribute to holistic and multifaceted benefits for the environment and society.
The development of roads in many countries presents a fragmented landscape. Within the road sectors there is often an institutional divide between national highways and district roads for instance. Then there are urban roads by municipalities or roads by special estates. There may also be unlisted roads, motorcycle tracks and footpaths, that are sometimes served by employment guarantee programs or special initiatives. Such roads are very important for the last mile access. What is important that there is exchange and communication – and that good practices are mainstreamed across the board and that the initiatives are carried throughout the road sector. Learning and coordination.
There is also a need for collaborative partnerships with other programs, by other parties. A various important connection is with the organizations that deal with the landscape immediately surrounding the roads – doing landscape improvement and slope stabilization – this needs to be closely coordinated. Also, these programs have merit in their own, which needs to be synchronized. Same with organizations responsible for disaster risk reduction – need to be more pro-active, avoid flooding in integrated flood management – evacuation, improved drainage, but also water harvesting – move beyond relief.

At basic level stakeholder engagement should be strengthened, Involve government agencies, contractors, engineers, and local communities in coordinated planning and decision-making. Regular meetings, workshops, and public consultations should be organized to ensure that all voices are heard. Getting to know and open up the sector.

At a next level joint programming between road sector and other make take shapes, developing joint conventions and guidelines for instance on disaster risk reduction or water management, integrating road planning in urban management. What is important is that joint programming may develop.

Chapter 4: The Maturity Assessment Tool

The Enabling Factors Maturity Assessment Tool is designed to assist governments in evaluating the current status regarding essential enabling factors for Green Road implementation. The primary aim is to promote environmentally and socially sustainable road development practices by providing a structured framework for assessing and enhancing these factors at the relevant level. This assessment tool helps countries and regions identify gaps, prioritize areas for improvement, and facilitate broader adoption of green road practices.

The Green Roads Toolkit identifies 12 crucial enabling factors required for the successful implementation of green roads, described in section 3. These factors include: 1) Improved Design Standards, 2) Sustainable Procurement, 3) Policy Development, 4) Environmental Standards, 5) Regulatory Frameworks, 6) Improved Planning Systems, 7) Capacity Building and Awareness, 8) Financial Mechanisms, 9) Roadmaps for Green Roads, 10) Supply Systems: Available Resources and Materials, 11) Application of New Technologies, and 12) Connection with Other Programs/Collaborative Partnerships. Each of these elements plays a vital role in fostering an environment conducive to green road development.

The assessment framework involves a three-step methodology to evaluate the maturity of each enabling factor. The first step is data collection through a questionnaire, where c teams rate each enabling factor based on the status, ranging from 1 to 5, indicating Not initiated, Developing, Moderately established, Well established, and Mature and sustainable.

In the second step, the maturity level of each enabling factor is assessed based on the responses from the questionnaire. This involves analysing the questionnaire responses to categorize the readiness of each factor and identify gaps or areas for improvement. The maturity levels categorize as Absent, In development, In place, and Mature and Sustainable, offering a clear framework to evaluate progress and integration of each enabling factor into national practices.

The final step involves prioritizing enabling factors that require immediate enhancement. Utilizing the findings from the assessment and the Green Roads Excel toolkit, country teams can prioritize the enabling factors that need urgent attention. This step ensures that the assessment results translate into actionable priorities for addressing a particular Green Road theme in road development practices.

The maturity assessment is meant as a tool to initiate discussion on steps to support the introduction of green roads systematically, beyond the scope of a single project or pilot. In most cases several enabling factors are already in place. They may be or not be used or applied and can be triggered.

ANNEX 1

Green Road Theme 1: Decarbonization

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at reducing CO_2 emissions across all stages of road development and comply with national standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of decarbonization practices in road development.
Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr.	Enabling factor	Questions	Rating Least Positive			Most Positive	
			1	2	3	4	5
1	**Policy Development**	Are there policies promoting low-carbon approaches in road projects?					
		Do these policies align with national and international commitments on reducing CO2 emissions (e.g., Paris Agreement)?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Has a strategic roadmap been developed for transitioning to low-carbon road development?					
		Does the roadmap include specific milestones and a timeline for incorporating low-carbon elements?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access and expertise in technologies aimed at reducing CO2 emissions of road projects?					
		Is there support for innovation in low-carbon road practices, including practices such as energy generation from roads, improved construction techniques, and roadside tree planting?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Have the road design standards been updated in the last 5 years to incorporate measures for CO_2 emission reduction?					
		Are there guidelines for incorporating CO2 reduction in road design, construction, and maintenance?					

		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Are there established environmental standards for road projects that specifically target CO2 emission reductions?					
		Is there a mechanism in place for monitoring and enforcing CO2 emission reduction in road projects?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Is there a regulatory framework mandating CO2 reduction in road planning and implementation?					
		Are carbon footprint assessments required for road projects?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Are CO2 emissions considered in road planning from inception?					
		Is there a comprehensive planning framework for road projects that includes CO2 emissions analysis and management strategies?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there ongoing awareness and education campaigns about the benefits of low-carbon road development?					
		Is community engagement encouraged in CO2 reduction road projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Does the tendering process for road projects include criteria for minimizing CO2 emissions?					
		Are contractors evaluated on their experience with and commitment to reducing CO2 emissions in road projects?					
		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through climate finance mechanisms such as green bonds, carbon credits, or international climate funds?					

		Are there financial incentives or policies in place to promote the use of low-carbon materials and sustainable road construction practices?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Is there access to low-carbon construction materials, workforce, and equipment for road development?					
		Are eco-friendly materials and technologies prioritized in road construction projects to reduce CO2 emissions?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are low-carbon road initiatives aligned with existing environmental, social, or community development programs?					
		Is there a strategy in place for leveraging resources and collaborative efforts with other programs to enhance the impact of low-carbon road projects?					
		Special considerations/ Comments affecting the score					

Green Road Theme 2: Climate resilience

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at enhancing climate resilience and implementing climate adaptations at all stages of road development and comply with national standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of climate-resilient practices in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Are climate resilience strategies integrated into transport development policies?					
		Are there incentive policies for climate resilience established in the road sector?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Has a strategic roadmap been developed for transitioning to climate-resilient roads?					
		Does the roadmap include specific milestones and a timeline for implementing resilience of road projects?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access and expertise in technologies aimed at improving climate resilience of road projects?					
		Are there policies or measures to establish pilots in road projects to test the effectiveness of new technologies or practices addressing climate resilience?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Are there guidelines for road designs that account for extreme natural hazards (e.g., flooding, high temperatures)?					
		Are climate risk assessments required for road projects?					
		Special considerations/ Comments affecting the score					

5	**Environmental Standards**	Are there policies or measures requiring road projects to conduct climate impact assessments?					
		Is the use of eco-friendly materials and construction practices promoted to strengthen resilience to climate impacts in transport projects?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are climate resilience requirements incorporated into existing regulatory frameworks to ensure road projects comply with these standards?					
		Are the regulatory frameworks updated regularly to incorporate new technologies and practices in climate resilience?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Are guidelines of climate adaptation developed and incorporated into urban or regional planning for transport networks?					
		Are climate scenarios incorporated into the planning processes for road projects?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any campaigns or platforms to educate communities and provide information on climate impacts and adaptation strategies during road projects?					
		Do road project provide opportunities for dialogue to involve local communities in climate resilience measures?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Does the tendering process for road projects include criteria for climate resilience and evaluation to ensure that contractors incorporate these considerations into road designs and constructions?					
		Is quality assurance established to ensure the implementation of climate-resilient measures is effective in road projects?					
		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through mechanisms that specifically support climate resilience, such as climate adaptation funds, resilience bonds, or concessional loans for resilient infrastructure?					

		Are there financial incentives or policies in place to encourage climate-resilient road designs, materials, and maintenance practices?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Is there access to construction materials, workforce, and equipment for climate-resilient road development?					
		Are eco-friendly materials and technologies prioritized in road construction projects to enhance climate resilience?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are climate-resilient road projects aligned with existing environmental, social, or community development programs, such as disaster risk management or urban planning?					
		Are there funding mechanisms in place to leverage resources and collaborate with other programs to enhance resilience measures?					
		Special considerations/ Comments affecting the score					

Green Road Theme 3: Water and Land Management

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at enhancing water management and land resilience at all stages of road development and comply with national standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of practices related to water and land management in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Is any framework established to ensure integrated water resources management is applied to road developments?					
		Are there policies to manage land use changes and protect environmental resources during road development?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there strategic documents including goals, actions, and benchmarks for implementing water and land management?					
		Does the roadmap include specific steps and timelines for addressing water and land management of road projects?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access and expertise in technologies aimed at promoting water and land management in road projects?					
		Are there policies or measures to establish pilots in road projects to test the effectiveness of new technologies or practices addressing water and land management?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Does any hydrological guideline suggest methods for assessing and incorporating water flow patterns into road design to prevent flooding and erosion?					
		Are there any standards to ensure that road design considers potential impacts on surrounding water bodies and land within road projects?					

		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Are there any standards to prevent soil erosion and water bodies pollution, and manage sedimentation during road construction and operation?					
		Do the standards relevant to biodiversity conservations effectively protect local flora and fauna from the impacts of road development?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any laws regulating the use, protection and management of water resources?					
		Is regulatory required road projects to obtain permits related to land and water use?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Are there any strategic documents that guide long-term investments in infrastructure (e.g., infrastructure master plan), with considerations for sustainable water and land management?					
		Do any framework provide a systematic approach for evaluating the environmental effects of proposed plans and programs, including road development?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any training programs or resources to educate communities and provide information on sustainable water and lands practices in road development, and water conservation?					
		Are any capacity building programs established that include modules on water and land management, focusing on the impacts of infrastructure projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Does the procurement process for road projects include requirements of environmental and social impact assessment?					
		Are there criteria of water and land management practices included in the evaluation of bids?					

		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through mechanisms that support sustainable water and land management, such as watershed protection funds, land restoration grants, or nature-based solutions funding?					
		Are there financial incentives or policies in place to promote water-sensitive road design, erosion control, and sustainable land use practices?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using materials that minimize environmental impact and promote effective water and land management?					
		Are eco-friendly materials and technologies prioritized in road construction projects to implement water and land management practices?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects related to water management and land use with existing environmental, social, or community development programs?					
		Are there funding mechanisms in place to leverage resources and collaborate with other programs to enhance water and land management?					
		Special considerations/ Comments affecting the score					

Green Road Theme 4: Reducing Pollution

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at minimizing environmental impacts of traffic pollutants at all stages of road development and comply with national or/and international standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of the practices to reduce traffic pollution in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Do any national transport policies have quantitative visions or targets addressing traffic pollutants?					
		Do transport policies align with global goals (e.g., the Paris Agreement)?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing technologies and practices that minimize traffic pollutants?					
		Does the roadmap include specific steps and timelines for addressing traffic pollutants?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at reducing pollutants from roads during operations?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices for addressing traffic pollutants?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Do road design standards set requirements to minimize disturbance of natural water resources (e.g., a minimum buffer zone between the edge of pavement and a natural watercourse)?					
		Do any frameworks provide a systematic approach to removing traffic pollutants from road runoff, such as through stormwater management practices?					

		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Do environmental policies include requirements for reducing impacts on water bodies during road construction?					
		Do environmental standards suggest any international standards for controlling pollution from road construction or vehicles?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any laws regulating water quality control in road projects?					
		Are road projects required to obtain permits in certain situations (e.g., environmentally sensitive areas)?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Are environmental assessments required in road projects to reduce impacts on surrounding water bodies during construction?					
		Does the planning process introduce technologies or practices to predict road intensity and climate conditions in road projects to minimize traffic pollution during operation?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any measures suggesting workshops or school training in road projects to educate the public and government about the environmental impacts of roads and current practices to address these issues?					
		Do existing measures engage communities in road projects to support the reduction of traffic pollutants?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Does the procurement process for road projects include procurement policies that prioritize technologies and practices minimizing pollutants during road construction and operations?					
		Are there any contractor requirements for water quality control during road construction and operations?					
		Special considerations/ Comments affecting the score					

10	**Financial Mechanisms**	Is the project financed through mechanisms that support reducing traffic-related pollution, such as sustainable transport funds, low-emission infrastructure grants, or carbon pricing revenues?					
		Are there financial incentives or policies in place to promote cleaner transportation options, such as non-motorized transport, electric vehicle infrastructure, or traffic management strategies?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using materials that minimize the leakage of pollutants from roads?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects related to the reduction of traffic pollution with existing environmental, social, or community development programs (e.g., stormwater management development plans)?					
		Is there a formal partnership or collaboration in place with local governments, private sector companies, and environmental organizations to address traffic-related pollution in the green road development project?					
		Special considerations/ Comments affecting the score					

Green Road Theme 5: Quality of Life and Health

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at dust control, temperature control, noise control, beautification, and public health management in road development at all stages of the process, ensuring compliance with national and/or international standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of practices that address environmental and public health issues in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive → Most Positive 1	2	3	4	5
1	**Policy Development**	Do any national transport policies have quantitative visions or targets addressing road dust, noise pollution, and road temperature?					
		Do transport policies align with global goals (e.g., the Paris Agreement)?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing technologies and practices that reduce dust, noise, and temperature impacts and enhance public health and beautification efforts?					
		Does the roadmap include specific steps and timelines for addressing environmental and public health issues?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at addressing environmental and public health issues?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Are there any road design guidelines on dust control, temperature regulation, noise reduction, and/or beautification?					

		Do the guidelines adopt vegetation principles for urban and rural roads?					
		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Do environmental policies include requirements for air quality, noise level, and thermal comfort in road projects?					
		Do environmental standards suggest environmental management or best practices in road construction?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any regulations on the environmental and public health impacts of road projects?					
		Do frameworks require regular audits and inspections to ensure compliance?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Do planning systems integrate land use and transportation planning that includes environmental and public health considerations?					
		Does the planning process introduce technologies or practices for environmental and public health considerations in road projects?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any measures suggesting campaigns, workshops, or school training in road projects to educate the public and government about the importance of dust control, noise reduction, temperature control, and beautification in road projects?					
		Do existing measures provide platforms for public feedback and suggestions regarding ongoing and planned road projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Do the procurement documents include criteria for environmental and public health considerations?					
		Are there evaluation criteria that prioritize environmentally friendly and health-conscious bids?					

		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through mechanisms that support improving quality of life and health, such as public health grants, urban development funds, or community well-being initiatives?					
		Are there financial incentives or policies in place to promote road designs that enhance public health, such as improved air quality, access to green spaces, or safer pedestrian and cycling infrastructure?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using materials that can reduce dust, noise, and heat and enhance road aesthetics and public health?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects addressing environmental and public health issues with existing environmental, social, or community development programs (e.g., urban greening, urban development, health, and environment)?					
		Are there collaborative partnerships with health organizations or programs to assess and improve the quality of life and public health outcomes as part of the green road development project?					
		Special considerations/ Comments affecting the score					

Green Road Theme 6: Preserving Biodiversity

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at minimizing disruption and preserving biodiversityin road development at all stages of the process, ensuring compliance with national and/or international standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of biodiversity protection practices in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Do any national transport policies integrate biodiversity to ensure road transport policies explicitly include provisions for preserving biodiversity?					
		Do national strategies and action plans prioritize biodiversity conservation in infrastructure development?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing technologies and practices that preserve biodiversity in road projects?					
		Does the roadmap include specific steps and timelines for implementing practices that minimize the impacts of road projects on biodiversity?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at addressing biodiversity protection?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Do road design standards require mandatory environmental impact assessments to evaluate the potential effects on biodiversity before approving road designs?					

		Are there any road design guidelines that incorporate wildlife crossings, underpasses, overpasses, and corridors to maintain habitat connectivity?					
		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Are there laws or regulations that mandate biodiversity conservation in all stages of road development?					
		Do environmental standards suggest technologies or best practices in road construction?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any regulations that prevent road construction in critical habitats and biodiversity hotspots?					
		Is there legal protection for designated protected areas to ensure roads do not fragment these areas?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Are there environmental assessments at the planning stage to assess the cumulative impacts of road networks on biodiversity?					
		Does the planning process introduce technologies or practices for preserving biodiversity in road projects?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any measures suggesting campaigns, workshops, or training in road projects to educate the public and government about the importance of biodiversity and the impacts of road projects?					
		Do existing measures provide platforms for public feedback and suggestions regarding ongoing and planned road projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Do the procurement documents require bidders to demonstrate their capacity to minimize biodiversity impacts and implement mitigation measures?					
		Are there any requirements for bidders to show experience and success in implementing biodiversity conservation measures in similar road projects?					

		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through mechanisms that support biodiversity preservation, such as biodiversity conservation funds, ecosystem restoration grants, or nature-based solutions financing?					
		Are there financial incentives or policies in place to promote road designs that minimize environmental impact and protect local ecosystems, such as wildlife corridors or habitat restoration initiatives?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using resources that minimize disturbance to biodiversity?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects addressing biodiversity with existing environmental, social, or community development programs?					
		Are there partnerships with environmental or conservation organizations to ensure the preservation of biodiversity in the green road development project?					
		Special considerations/ Comments affecting the score					

Green Road Theme 7: Disaster Preparedness

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at integrating disaster preparedness in road development at all stages of the process, ensuring compliance with national and/or international standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of disaster-resilient practices in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Do any national transport policies integrate with disaster risk reduction policies?					
		Do emergency preparedness policies include road developments as part of the emergency plans?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing technologies and practices that enhance disaster resilience in road projects?					
		Does the roadmap include specific steps and timelines for implementing disaster-resilient practices?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at enhancing disaster preparedness?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Do road design standards include elements that address the risks of extreme weather?					
		Do road design standards incorporate disaster resilience guidelines to integrate disaster resilience into road designs for extreme weather?					

		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Do environmental impact assessments involve disaster risks to ensure the assessments account for vulnerability to natural hazards?					
		Do environmental standards suggest technologies or best practices in road construction?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any regulations that mandate the incorporation of disaster resilience measures in road development?					
		Are there coordination mechanisms between different regulatory bodies and agencies involved in disaster management and road development?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Do road planning processes integrate land use and disaster management in road projects?					
		Does the planning process use any tools for mapping hazards in road projects to avoid disaster-prone areas?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any measures suggesting campaigns, workshops, or training in road projects to educate the public and government about the importance of disaster preparedness?					
		Do any policies or measures suggest involving local communities in the planning of road projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Do the procurement documents require contractors to have experience in road designs and construction methods related to disaster preparedness?					
		Are there any procedures for non-compliance with disaster preparedness implementations?					
		Special considerations/ Comments affecting the score					

10	**Financial Mechanisms**	Is the project financed through mechanisms that support disaster preparedness, such as disaster risk reduction funds, climate resilience financing, or emergency response grants?					
		Are there financial incentives or policies in place to promote road designs that enhance disaster preparedness, such as flood-resistant infrastructure or early warning systems?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using local resources?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects addressing disaster preparedness with existing environmental, social, or community development programs?					
		Are there collaborations with disaster preparedness programs or agencies to integrate resilience measures into the road project?					
		Special considerations/ Comments affecting the score					

Green Road Theme 8: Sustainable Materials Sourcing and Construction Practices

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at enhancing the use of recycled and bio-based materials and optimizing road designs in road development at all stages of the process, ensuring compliance with national and/or international standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of sustainable practices in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr.	Enabling factor	Questions	Rating Least Positive				Most Positive
			1	2	3	4	5
1	**Policy Development**	Do any policies promoting the use of sustainable materials and practices in road construction?					
		Are there financial incentives or subsidies for adopting sustainable materials and technologies?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing sustainable technologies and practices in road projects?					
		Does the roadmap include specific steps and timelines for integrating sustainable practices into road projects?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at enhancing sustainable materials?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Do road design standards incorporate sustainability aspects on reducing environmental impacts and optimizing resource use?					
		Are there material specification documents for road designs to provide the specifications for the use of sustainable materials, including criteria for recycled					

		content, local sourcing, and environmental impact?					
		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Do any certification systems for sustainable materials, ensuring they meet specific environmental criteria?					
		Are there waste management standards for recycling and reusing materials in road construction?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any regulations on the use of sustainable and locally sourced materials?					
		Do the frameworks strengthen institutions responsible for implementing, monitoring, and enforcing sustainability regulations in the road sector?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Do road planning processes integrate sustainable resources and designs in road projects?					
		Does the planning process use any tools for mapping road routes in road projects to optimize the use of resources?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Are there any measures suggesting campaigns, workshops, or training in road projects to educate the public and government about the importance of sustainable materials and practices?					
		Do any policies or measures suggest involving local communities in the planning of road projects?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Do procurement documents include requirements for sustainable materials, energy-efficient construction methods and/or lifecycle assessments?					
		Do the tender documents require contractors to have experience in road designs and construction methods related to sustainable practices and materials?					

		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Is the project financed through mechanisms that support the use of sustainable materials and construction practices, such as green procurement funds, sustainable infrastructure grants, or low-carbon technology financing?					
		Are there financial incentives or policies in place to encourage the use of sustainable materials and construction methods, such as recycled materials, energy-efficient technologies, or eco-friendly construction techniques?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using local resources?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects using sustainable practices with existing environmental, social, or community development programs?					
		Are there partnerships with suppliers or organizations focused on sustainable materials sourcing and eco-friendly construction practices for the road project?					
		Special considerations/ Comments affecting the score					

Green Road Theme 9: Fostering Inclusive Growth

Objective: This framework assists governments in evaluating their readiness to implement measures aimed at enhancing opportunities for inclusive growth, entrepreneurial capacity and local economic circulation in road development at all stages of the process, ensuring compliance with national standards. The evaluation will guide the identification and prioritization of actions necessary to facilitate the adoption of inclusive growth practices in road development.

Step 1: Data collection through questionnaire

Mark an 'x' in the box on the rating scale that best applies to your country. Add any comments you wish to make. A questionnaire rating guide is provided below with a detailed explanation of the rating scale.

Nr	Enabling factor	Questions	Rating Least Positive → Most Positive				
			1	2	3	4	5
1	**Policy Development**	Do any transport policies integrate into the policies or measures that prioritize inclusive growth and equitable distribution of resources in road development?					
		Are there policies for engaging diverse stakeholders in road projects?					
		Special considerations/ Comments affecting the score					
2	**Roadmaps for Green Roads**	Are there long-term strategic documents including goals, actions, and benchmarks for implementing sustainable technologies and practices in road projects?					
		Does the roadmap include specific steps and timelines for integrating inclusive growth practices in road projects?					
		Special considerations/ Comments affecting the score					
3	**Application of New Technologies**	Do you have access to and expertise in technologies aimed at enhancing sustainable materials?					
		Are there policies or measures to establish pilot projects in road construction to test the effectiveness of new technologies or practices?					
		Special considerations/ Comments affecting the score					
4	**Improved Design Standards**	Do road design standards incorporate inclusive aspects including pedestrians, cyclists, people with disabilities and other marginalized groups?					
		Do road designs incorporate universal design principles that ensure accessibility in road infrastructure?					

		Special considerations/ Comments affecting the score					
5	**Environmental Standards**	Do the environmental standards involve local, marginalized or vulnerable communities in road to ensure their considerations are addressed?					
		Do the mitigation plans to address environmental impacts involve local communities in monitoring these plans?					
		Special considerations/ Comments affecting the score					
6	**Regulatory Framework**	Are there any regulations on the use of sustainable and locally sourced materials?					
		Do the frameworks strengthen institutions responsible for implementing, monitoring, and enforcing sustainability regulations in the road sector?					
		Special considerations/ Comments affecting the score					
7	**Improved Planning Systems**	Do road planning processes integrate sustainable resources and designs in road projects?					
		Does the planning process use any tools for mapping road routes in road projects to optimize the use of resources?					
		Special considerations/ Comments affecting the score					
8	**Capacity Building and Awareness**	Is the project financed through mechanisms that support fostering inclusive growth, such as funds for gender equality, community development, or inclusive economic development?					
		Are there financial incentives or policies in place to promote inclusive growth, such as job creation for marginalized communities, skills training, or support for local entrepreneurs?					
		Special considerations/ Comments affecting the score					
9	**Sustainable Procurement**	Do tender documents include the policies that encourage the participation of local businesses, including small and medium-sized enterprises and disadvantaged groups?					
		Do the tender documents develop procedures to promote transparency, fairness, and competitiveness in road construction tenders?					

		Special considerations/ Comments affecting the score					
10	**Financial Mechanisms**	Are there communication platforms, such as forums or dialogues, between government agencies, NGOs, the private sector, and communities to coordinate efforts and share knowledge?					
		Are there any frameworks relevant to joint research focusing on best practices and innovative sustainable solutions?					
		Special considerations/ Comments affecting the score					
11	**Supply systems: available Resources and Materials**	Are there any specifications for selecting and using local resources?					
		Are eco-friendly materials and technologies prioritized with sufficient application information in road construction projects for implementation?					
		Special considerations/ Comments affecting the score					
12	**Connection with other programs/ collaborative partnership**	Are there any development plans that align road projects considering inclusive growth with existing environmental, social, or community development programs?					
		Are there collaborations with local communities or organizations to ensure the road project fosters inclusive economic growth and benefits all socio-economic groups?					
		Special considerations/ Comments affecting the score					

Examples of implementing the maturity assessment tool

To understand the assessment process, several examples as hypothetical scenarios are provided to illustrate how a country might use the Green Roads Toolkit to conduct a maturity assessment.

Example 1:

The maturity assessment tool evaluates the current situation in Bangladesh to identify the extent of competency in implementing the Dig Once Approach, which aims to address decarbonization. In the first step, country teams, such as the Roads and Highways Department (RHD) or the Ministry of Road Transport and Bridges (MRTB), participate by answering questionnaires for data collection.

The questionnaire regarding decarbonization covers various aspects, including road design standards and guidelines, green procurements, policies on low-carbon approaches, and more. For instance, one question might be, "Are there guidelines for incorporating CO2 reduction in road design, construction, and maintenance?" Possible responses to this question are based on a 5-rating scale and may include:

1. The mentioned guidelines are lacking.
2. Relevant research and consultations are ongoing to develop the guidelines.
3. The guidelines have been finalized and published.
4. The guidelines have been implemented in pilot or small-scale projects in the country.
5. The guidelines have been efficiently implemented for a while in large projects.

RHD or MRTB can rate how closely the current situation reflects these scenarios.

In the second step, after completing the questionnaire, the average scores for each enabling factor are calculated to categorize them into the corresponding maturity level. This process provides the country team with a clear picture of which factors have gaps that need development and which are mature enough to implement to address decarbonization. According to the Green Roads Toolkit, the practice of the Dig Once Approach requires enabling factors such as Improved Design Standards, Sustainable Procurement, Policy Development, Regulatory Framework, Improved Planning Systems, Roadmaps for Green Roads, and Connection with Other Programs/Collaborative Partnerships. Based on the assessment results, RHD or MRTB should prioritize these factors, deciding which ones need to be considered first to successfully implement the practice.

Example 2:

Nepal is dedicated to implementing the practice of roadside spring protections as an intervention under the Green Road theme of Water and Land Management to prevent road damage and slope erosion in Dhankuta and Chhathar Jorpati. The Department of Local Infrastructure, Dhankuta Municipality, and Chhathar Jorpati Rural Municipality can form a country team responsible for this assessment.

By conducting the assessment for Water and Land Management, significant gaps in the enabling factors are identified, including Improved Design Standards, Capacity Building and Awareness, and Connection with Other Programs/Collaborative Partnerships. These gaps are due to the absence of roadside spring designs, implementation of roadside spring measures, and expert knowledge and experience.

To address these gaps, the government can collaborate with external organizations as partners to develop roadside spring designs with local governments, build capacity at the national level, implement roadside spring measures, and facilitate knowledge sharing.

Example 3:

Another example in Nepal focuses on the health and safety of site workers, which is related to the Green Road theme of Inclusive Growth. The Department of Roads officials and the Occupational Health and Safety (OHS) Consultant Team can form a team to conduct the maturity assessment.

During the evaluation, several gaps may be identified. For instance, Nepal has mature developments in national policies regulating health and safety and working hours for labor and employment. However, the implementation of occupational health and safety measures is absent.

By conducting the assessment, the Nepal government gains insights into how to address these challenges and better consider the health and safety of workers. Consequently, it develops safety measures in the local road network construction manual that require providing Personal Protective Equipment to site workers, training first aid officers at designated sites, assigning site supervisors to oversee the safety of on-site workers, and more.