GREEN ROADS TOOLKIT

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Download the **Green Roads Toolkit**

SCAN ME

The Green Roads Toolkit is an extensive collection of best practices designed to guide government officials, project teams, and road sector practitioners in selecting interventions that support alignment of road investments, with the goals of the Paris Agreement on Climate Change, the Sustainable Development Goals, and other sustainability agendas. The toolkit includes around 150 best practices in 9 key areas: decarbonization, climate resilience, pollution reduction, water and land management, improved quality of life, preservation of biodiversity, disaster preparedness, sustainable materials and construction, and inclusive growth.

This booklet outlines selected intervention areas for each of the dimensions.

DECARBONIZATION

In 2020, the transport sector was responsible for over a quarter of global energy-related emissions, as reported by the International Energy Agency. The rate of emission growth in this sector outpaces all other major economic sectors, with the most significant increase occurring in Asia. This rise is primarily driven by the growing demand for road passenger and freight transport.

Given that the majority of transport sector emissions originates from the road subsector, it is crucial to implement effective measures to decarbonize roads. Such actions are essential for countries to fulfill their low-carbon aspirations set forth by the Paris Agreement and the 2030 Agenda for Sustainable Development.

Key Intervention and Solution Areas for Decarbonization

No.	Key Intervention Areas	Solution Areas
1.1	Material production and transportation	See table under "Sustainable Material Sourcing and Construction Practices"
1.2	Design of roads and ancillary road assets	1.2.1. Low-carbon road specifications
		1.2.2. Using carbon sequestering road material (olivine)
		1.2.3. Reducing road friction - Smoother asphalt reducing fuel consumption with factor 3%–5%
		1.2.4. Energy generation with roads (solar panels)
		1.2.5. Use of energy-efficient light-emitting diode lighting along roads and in tunnels
		1.2.6. Avoiding roads in peatlands to minimize methane and carbon dioxide (CO_2) emissions
1.3	Road construction	1.3.1. Emerging asphalt mixture and other emerging technologies
		1.3.2. Recycling in road construction
		1.3.3. Using energy-friendly "green cement"
1.4	Road transport management	1.4.1. Encourage use of fuel-efficient vehicles
		1.4.2. Traffic management to limit peak hour congestion
		1.4.3. Optimize traffic signal timing
		1.4.4. Encourage mass transit (buses and trains)
		1.4.5. Implement anti-idling ordinances
		1.4.6. Introduce electric vehicles
		1.4.7. Low-emission zones
1.5	Vegetative measures to sequester CO_2	1.5.1. Roadside tree planting for sequestering CO_2

CLIMATE RESILIENCE

Transport systems in Asia and the Pacific are vulnerable to climate-change-related hazards, the consequences of which include direct damage to critical transport infrastructure, disruption to transport services, and wider social and economic impacts. 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, however, experiences a disproportionate share of these damages, accounting for 65% of the global annual damages to road and rail transport. Furthermore, this region is expected to bear 70% of the global annual damage to trade.[1]

The Asian Development Bank (ADB) estimated the costs of transport infrastructure requirements in Asia and the Pacific region to be about $520 billion a year, with an additional $37 billion per year, required for adaptation of transport infrastructure. This adaptation is crucial for improving the resilience of transport systems in the face of increasing climate and disaster risks.[2]

[1] Koks, Elco E. et al. A Global Multi-hazard Risk Analysis of Road and Railway Infrastructure Assets. Nature communications 10.1 (2019): 1–11. Jasper, Verschuur, et al. Multi-hazard risk to global port infrastructure and resulting trade and logistic losses. https://doi.org/10.1038/s43247-022-00656-7

[2] Asian Development Bank. Meeting Asia's Infrastructure Needs. https://dx.doi.org/10.22617/FLS168388-2

Key Intervention and Solution Areas for Climate Resilience

No.	Key Intervention Areas	Solution Areas
2.1	Climate-resilient road drainage design	2.1.1. Preventing stream diversion at road-stream crossings
		2.1.2. Avoid using multiple small culverts
		2.1.3. Climate resilient culvert design
		2.1.4. Road surface drainage to prevent water concentration
2.2	Increased stabilization of road sides	2.2.1. Complete ground cover in disturbed areas
		2.2.2. Deep-rooted vegetation for slope stabilization
		2.2.3. Hardening road embankments
		2.2.4. Preventing road surface water concentration
		2.2.5. Armoring the roadway driving surface
		2.2.6. Stabilization of unstable cut and fill slopes
2.3	Resilient routing and/or vulnerable areas	2.3.1. Moving roads out of channel migration zones
		2.3.2. Avoid unstable and wet areas
2.4	Resilient road maintenance	2.4.1. Staying current on road maintenance
2.5	Enhance climate resilience of roads and bridges	2.5.1. Need for best engineering practices for climate resilience
		2.5.2. Climate adaptation measures for bridges
		2.5.3. Artificial Intelligence use in climate resilience
		2.5.4. Asphalt pavement in high temperatures
		2.5.5. Vulnerability assessment for infrastructure
2.6	Enhance climate resilience of roads in permafrost regions	2.6.1 Using geocell for soil stabilization
		2.6.2. Thermosyphon cooling under paved road
2.7	Nature-based solutions for enhanced climate resilience of roads	2.7.1. Nature-based solutions for enhanced climate resilience of roads

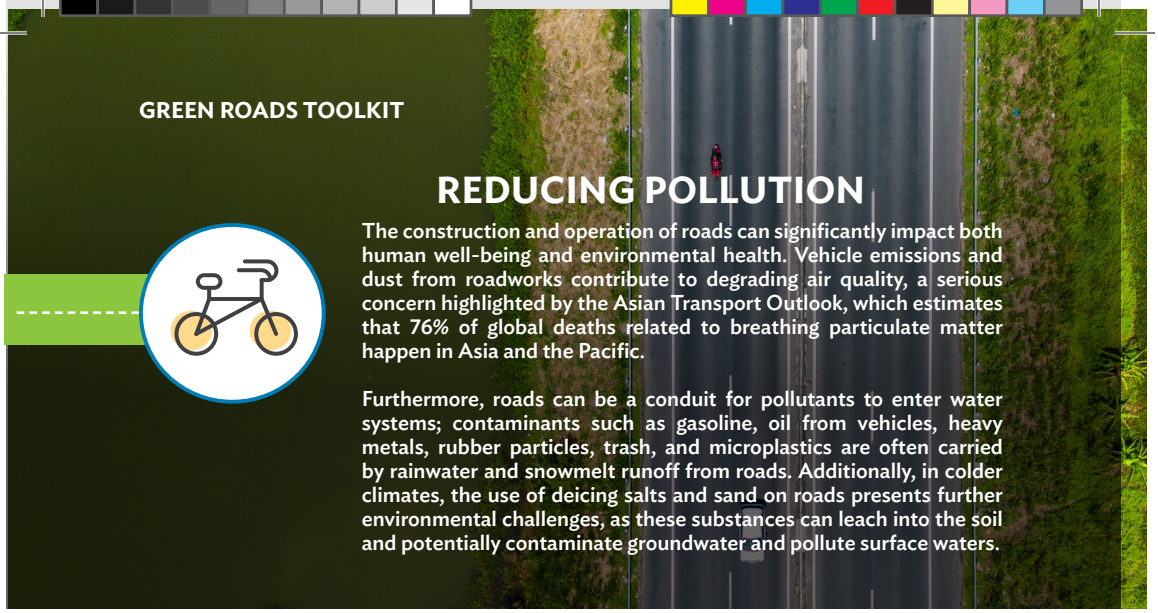
WATER AND LAND MANAGEMENT

The construction of roads can have a profound impact on the natural water balance of landscapes. In mountainous regions, road development may lead to the depletion of springs, while in coastal areas, it could cause an increase in waterlogging. Furthermore, roads can interfere with natural drainage systems, potentially exacerbating flood conditions. The erosion rate in watersheds is also likely to rise by 12%-40% due to road construction, which can negatively affect both soil fertility and water quality.

Conversely, if managed properly, roads can serve as valuable tools for water management and enhance land resilience. By integrating road design with water conservation strategies, roads can be utilized to harvest, store, and channel water, thereby supporting irrigation and other water-related requirements. This approach transforms roads from potential environmental liabilities into assets that contribute to improved land and water management.

Key Intervention and Solution Areas for Water and Land Management

No.	Key Intervention Areas	Solutions Areas	
3.1	Water harvesting and runoff storage	3.1.a. Diverting runoff to storage structures	3.1.1. Floodwater spreaders along road surfaces
			3.1.2. Directing water to retain ponds and/or ditches at the roadside
			3.1.3. Flow diversion from culverts and road drainage
		3.1.b. Storing runoff	3.1.4. Infiltration structures fed from road drainage
			3.1.5. Surface storage fed from road drainage (repurposed borrow pits, ponds, and cisterns)
			3.1.6. Using roads as reservoir embankments
3.2	Agricultural water management	3.2.1. Cascading irrigation fed from road drainage	
		3.2.2. Connecting road drainage cuts to farm trenches	
		3.2.3. Controlled (gated) culverts	
		3.2.4. Fodder plantations along culvers in arid areas	
		3.2.5. Reuse of urban stormwater along roadsides in cities	
3.3	Groundwater management	3.3.1. Use of infiltration bunds for groundwater recharge along roadsides	
		3.3.2. Roadside spring protection and management	
		3.3.3. Non-vented road drifts as sand dams	
		3.3.4. Use of water-harvesting measures upstream and downstream of the road	
3.4	Reduced waterlogging and protecting natural channels	3.4.1. Adequate cross drainage to prevent water concentration and adjusted bridge sills	
3.5	Preventing landslides	3.5.1. Catchment management in sensitive and unstable areas	
		3.5.2. Soil bioengineering for Green Roads	
3.6	Erosion and gully control	3.6.1. Gully control and stabilization	
		3.6.2. Erosion control options for soil and water protection	
3.7	Avoiding sand dune movement	3.7.1. Disconnecting road alignment from prevailing wind direction	
		3.7.2. Windbreak and soil stabilization planting	
3.8	Green routing	3.8.1. See 2.3 in Climate Resilience table	



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 degrading air quality, a serious concern highlighted by the Asian Transport Outlook, which estimates that 76% of global deaths related to breathing particulate matter happen in Asia and the Pacific.

Furthermore, roads can be a conduit for pollutants to enter water systems; contaminants such as gasoline, oil from vehicles, heavy metals, rubber particles, trash, and microplastics are often carried by rainwater and snowmelt 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 pollute surface waters.

Key Intervention and Solution Areas for Reducing Pollution

No.	Key Intervention Areas	Solutions Areas
4.1	Consider road construction materials	4.1.1. Reduce to use the materials with high content of fine particles
		4.1.2. Additives used in road materials as pollutants
4.2	Source control: minimize pollutants from vehicles and road material	4.2.1. Set minimum standards for vehicles and essential spare parts, fuel and oil composition, and tires
		4.2.2. Implement anti-idling ordinances
		4.2.3. Enabling framework
4.3	Road maintenance	4.3.1. Maintaining abrasion and erosion resistance in roads and roadside structures
4.4	Prioritize road drainage	4.4.1. Avoid disposal of untreated road runoff near sensitive areas to prevent potential contamination
		4.4.2. Porous pavements: use porous asphalt to treat water quality
		4.4.3. Treat road effluent from controlled concentrated disposal systems through detention ponds, wet ponds, infiltration trenches, sand filters, grassed swales or constructed wetlands
		4.4.4. Incorporate frequent road surface drainage measures to prevent accumulation of water
4.5	Proper use of deicing agents/ traction agents	4.5.1. Proper use of deicing agents/traction agents
4.6	Capture and remove pollutants	4.6.1. Planting roadside grass buffer filter strips to absorb dispersed road runoff pollutants
		4.6.2. Planting roadside vegetation to intercept road dust and ambient pollutants, taking into account distance from the road and aerodynamics
		4.6.3. Using special accumulator plants for bioremediation of soils along roads

QUALITY OF LIFE

Roads can significantly shape the quality of life for communities. Well-planned and well-designed roads contribute to safety, economic growth, and social well-being. Conversely, poor road conditions can limit economic opportunities, hinder access to education, and delay critical medical care.

Road dust, composed of coarse (PM10) and fine (PM2.5) particles, often includes harmful substances from vehicle emissions, brake, and tire wear, and contains toxins like heavy metals. 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 the urban heat island phenomenon. Greenery along roadsides also beautifies the environment and correlates with longer life expectancy for nearby residents.

Poorly designed roads can increase crash fatalities and serious injuries with high economic and social costs and serious repercussions for quality of life. About 60% of global road crash fatalities occur in Asia and the Pacific. Vulnerable road users, including pedestrians, bicyclists, and motorized two-wheelers, account for approximately 54% of global road traffic deaths. Designing and constructing roads that ensure their safety is paramount to improving overall quality of life.

Key Intervention and Solution Areas for Quality of Life

No.	Key Intervention Areas	Solutions Areas
5.1	Dust control	5.1.1. Road stabilization through towns or rural areas
		5.1.2. Binding agents and dust palliatives on unpaved roads
5.2	Beautification and public health management	5.2.1. Scenic roads and roadside facilities
		5.2.2. Managing public health of roads and sales of street food
5.3	Noise control	5.3.1. Reducing noise from roads
5.4	Temperature control	5.4.1. Urban heat islands – cool pavements and other solutions
		5.4.2. Separating nonmotorized bicycle and pedestrian lanes from vehicles
		5.4.3. Personalizing public road spaces

PRESERVING BIODIVERSITY

Road development can pose a significant threat to biodiversity, potentially leading to habitat fragmentation and impeding wildlife movement. 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 roadkill 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, installation of fences, and regulation of vehicle speeds in areas frequented by wildlife.

Key Intervention and Solution Areas for Preserving Biodoversity

No.	Key Intervention Areas	Solution Areas
6.1	Protect and harness invertebrate biodiversity	6.1.1. Habitat management
		6.1.2. Developing water points (with road water harvesting) away from roads
		6.1.3. Controlling of invasive plant species
		6.1.4. Native plant selection (habitat alteration)
		6.1.5. Ecologically safe road routing
		6.1.6. Butterfly nets
		6.1.7. Safe passages (culverts, climate tunnels)
		6.1.8. Reduce light pollution
		6.1.9. Creating biodiversity corridors by linking road side tree planting with perpendicular hedges
6.2	Protect and harness vertebrate biodiversity	6.2.1. Fencing of sensitive areas
		6.2.2. Safe passages (culverts, ecoducts, wildlife overpasses and underpasses)
		6.2.3. Roadside oases and mini wetlands (fed by road water harvesting)
		6.2.4. Protecting wildlife species on bridges
		6.2.5. Aerial bridges (canopy crossings) for wildlife connectivity
		6.2.6. Broken roadside vegetation to foster species diversity
		6.2.7. Viaducts for avoiding or crossing sensitive areas
		6.2.8. Defragmentation - re-establishing wildlife migration corridors
6.3	Protect aquatic ecosystems	6.3.1. Culvert design for fish passage/aquatic organism passage/stream stimulation
		6.3.2. Avoid alteration and sedimentation of streams that affect fishing grounds
6.4	Protect improved roadside flora	6.4.1. Fostering roadside flora: mowing practice
		6.4.2. Fostering roadside flora: hydroseeding
	Digital tools for biodiversity preservation	6.4.3. Animal–vehicles collision hotspots

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.[3]

Roads are a fundamental component of disaster preparedness and response. They serve as critical lifelines, providing safe passage during evacuations and enabling the delivery of emergency services and relief aid. The strategic planning and construction of road infrastructure can significantly enhance disaster resilience, particularly in areas prone to floods, where proper drainage can mitigate water-related hazards. In coastal regions, roads can double as protective embankments, though this requires careful management to ensure their effectiveness. 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.

[3] Based data from Center for Research and Epidemiology of Disasters

Key Intervention and Solution Areas for Disaster Preparedness

No.	Key Intervention Areas	Solution Areas
7.1	Flood mitigation by road network	7.1.1. Flood compartmentalization by roads
		7.1.2. Roads-cum-flood embankments
		7.1.3. Permeable pavements in urban areas
		7.1.4. Prevent stream diversion at road-stream crossings
7.2	Flood resilience by road network	7.2.1. Elevated roads and bridges (adjusted to flood levels)
		7.2.2. Overflow roads
7.3	Road network capacity to deal with emergencies	7.3.1. Road network capacity to deal with emergencies
		7.3.2. Information technology (IT) use in disaster management
7.4	Evacuation and access plans	7.4.1. Emergency communications (signage and messaging)
		7.4.2. Traffic management
		7.4.3. Emergency disaster procedures and preparedness planning
7.5	Fire prevention	7.5.1. Access for fire and emergency equipment and fire break
		7.5.2. Fire break along roads
		7.5.3. Use of fire-resistance material

SUSTAINABLE MATERIALS AND CONSTRUCTION

The construction and rehabilitation of roads require a substantial amount of construction materials, representing 30%-40% of all materials used in construction projects. 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%. This disparity highlights the urgent need for implementing good practices toward sustainable material sourcing and construction.

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, extending the lifespan of roads, and a shift toward innovative construction methods that consider the entire 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.

Key Intervention and Solution Areas for Sustainable Materials and Construction

No.	Key Intervention Areas	Solution Areas
8.1	Design	8.1.1. Economical design
		8.1.2. Specifications for construction material and technique
		8.1.3. Technology choice: alternative to hot-mix asphalt and warm-mix asphalt (and half warm and cool mix asphalts)
		8.1.4. Polymer modified bitumen
8.2	Material choice	8.2.1. Efficient life-cycle use of material
		8.2.2. Safe use of recycled material
		8.2.3. Use of bio-based material
		8.2.4. Use of geo-textile fiber material
		8.2.5. Use of marginal material
8.3	Sourcing	8.3.1. Reduce environmental costs of extraction and production: avoid sensitive areas
		8.3.2. Reduce haulage costs
		8.3.3. Sustainable extraction of road building material
		8.3.4. Repurposing of extraction sites (borrow pits, stone/clay removal) flat land-play fields,
		8.3.5. Reuse of excavation material
8.4	Operation and maintenance – tailored to small island material options	8.4.1. End-of-life strategy for roads
		8.4.2. Environmental analysis and reclamation plan for pits/quarries
		8.4.3 Stabilization of coral rock and sands

FOSTERING INCLUSIVE GROWTH

Enhancing rural access is an important element in aligning road investments with inclusive growth. The Asian Transport Outlook estimates that over 400 million people across Asia and the Pacific lack access to all-weather roads. To bridge this gap, the Asian Transport Outlook estimates that by 2030, there will be a need to construct 8 million kilometers of new roads in the region.

Notably, the costs associated with maintaining and operating the current road networks are projected to surpass the expenses of new road construction within the same period. This underscores the need for significant investments in both road infrastructure and its maintenance, which can be leveraged to foster inclusive economic development.

Key Intervention and Solution Areas for Fostering Inclusive Growth

No.	Key Intervention Areas	Solution Areas
9.1	Local sourcing	9.1.1. Local fair sourcing of material (sand, gravel, bricks)
		9.1.2. Repurposing material excavated from water ways (drains, canals, rivers) for road construction
9.2	Employment generation and local capacity building	9.2.1. Safety net programs and employment guarantee programs connected to road building
		9.2.2. Local and community maintenance programs
		9.2.3. Local community involvements in road rehabilitation - example of Makueni in Kenya
		9.2.4. Community engagement for planting/maintaining roadside trees
9.3	Promoting roadside business	9.3.1. Assign roadside land for business and industrial parks
		9.3.2. Regulating roadside vendors
9.4	Ensuring last-mile access	9.4.1. Motorcycle paths
		9.4.2. Trail bridges
9.5	Gender and indigenous population considerations	9.5.1. Promoting gender equality and indigenous populations in road projects
		9.5.2. Making special provisions for people with disabilities and elderly people