Increasing Resilience of Rural Infrastructure and
Local Communities through Green Roads Concept

Updated Draft Guidelines on

Green Roads for Water in Bangladesh

18 August 2025

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Context

- This presentation / slide deck is prepared as part of the "Consultancy Services for Increasing Resilience of Rural Infrastructure and Local Communities through Green Roads Concept" and is the draft guidelines on Green Roads for Water in Bangladesh. It has been prepared for validation and feedback purposes. This version concerns the updated draft Guidelines.
- This assignment is undertaken for the Local Government Engineering Department (LGED) in Bangladesh and the World Bank under the GFDRR.
- This assignment and the guidelines aim to set the foundation for systematically integrating water management and climate resilience in road development.
- It builds on existing LGED and Forestry Department regulations
- It tailors the global guidelines on Green Roads for Water (World Bank, 2021) to the Bangladesh context.
- **Click here for web page with relevant resources and outputs on Green Roads for Water in Bangladesh.**

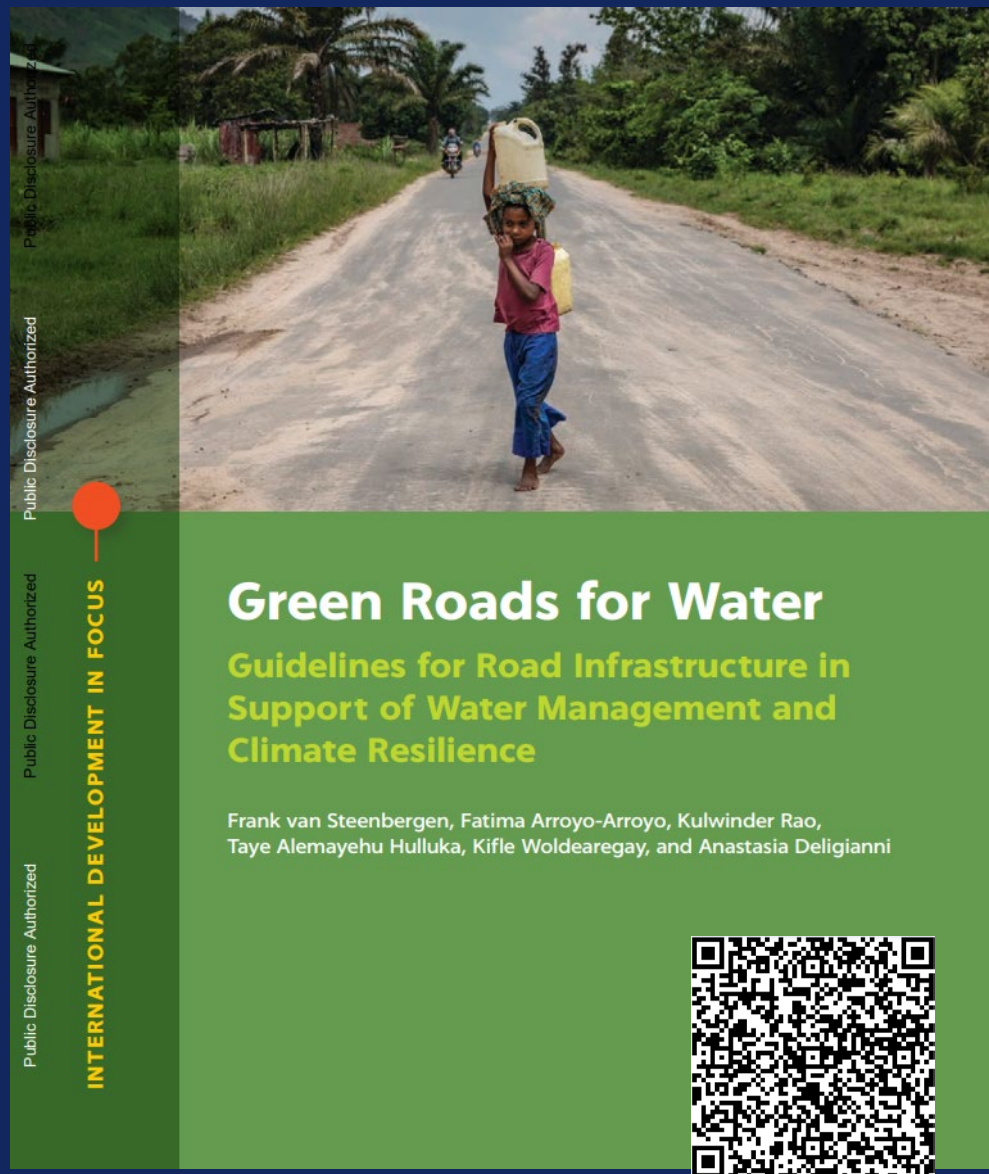

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Table of Contents

1. Introduction

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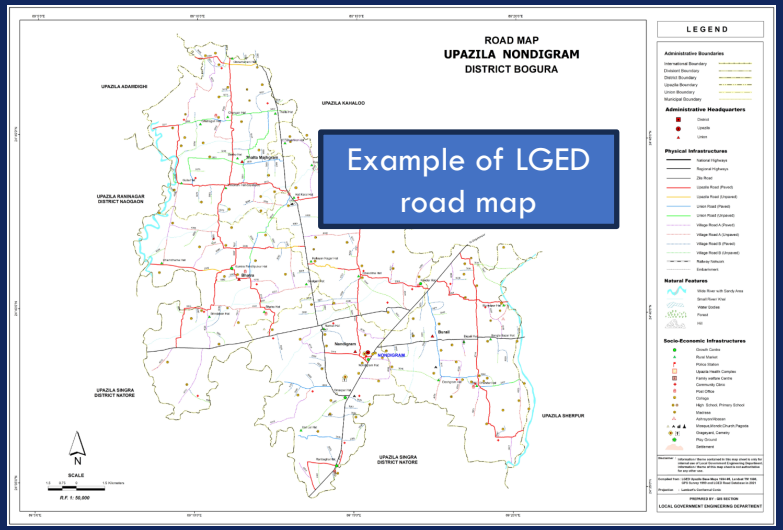
1.1 Road program of LGED

- LGED is managing a vast rural road network. Rural roads of critical importance for the growth of the rural and national economy and for the welfare of its citizens.
- Bangladesh has one of the highest population densities + one of the highest road densities in the world – at 164 meters per square kilometer.
- Besides connecting people and places, roads also fragment the landscape and interrupt the natural flow of water – which is pivotal to consider everywhere, but especially in a riverine deltaic country such as Bangladesh, with numerous crisscrossing rivers and canals and discharging huge water and sediments.
- Currently, the impact of roads on area hydrology is an often-neglected aspect of road design in Bangladesh. But systematically combining water management functions in road development will help climate resilience, water management and prolong the life of the roads.

Road Database as on February - 2025

Road Type	Earthen Length(km)	Paved Length(km)	Total Length(km)	Bridge/Culvert Length(m)	Gap Length(m)
Upazila Road :	2,435.35	34,337.47	36,772.82	444,092.26	79,205.60
Union Road :	8,542.36	33,560.06	42,102.41	355,765.25	81,732.18
Village Road A:	94,985.04	54,921.41	182,355.34	510,231.88	192,987.76
Village Road B:	143,851.93	38,503.41	149,906.45	344,134.43	184,741.63
Total Roads:	**249,814.67**	**161,322.35**	**411,137.03**	**1,654,223.81**	**538,667.16**



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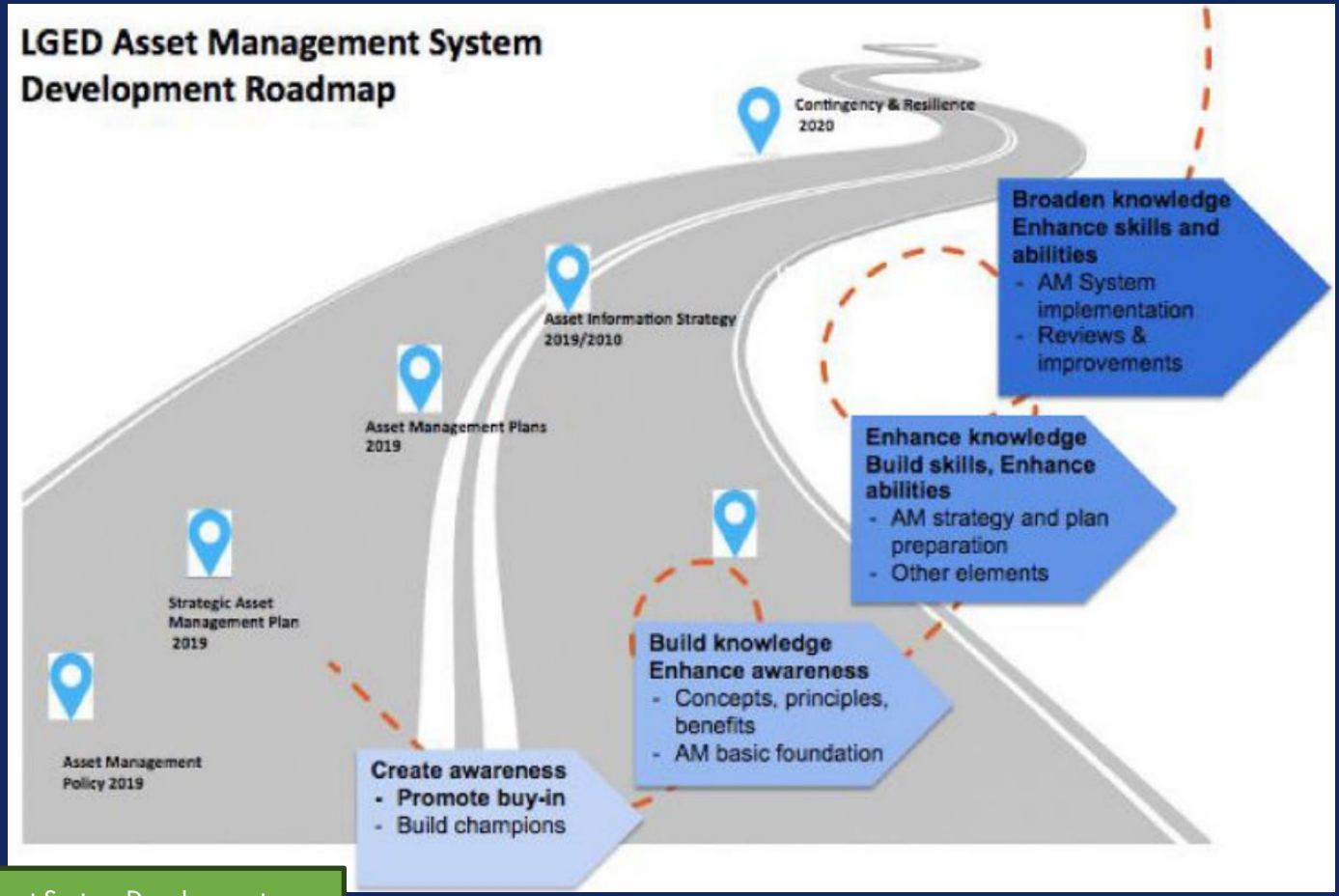
- Most roads are rural roads (94%).
- 9.5% of the rural road network comprises Upazila Roads and 11.2% comprises Union Roads.
- Most of Bangladesh's roads (63%) are unpaved, with a smaller part (37 %) paved (figures from 2017)

#	Type	Definition	Ownership and responsibility
1	National Highway	Highways connecting National capital with Divisional HQs or sea ports or land ports or Asian Highway	RHD (Roads and Highways Department)
2	Regional Highway	Highways connecting District HQs or main river or land ports or with each other not connected by national Highways.	RHD
3	Zila Road	Roads connecting District HQ/s with Upazila HQ/s or connecting one Upazila HQ to another Upazila HQ by a single main connection with National/Regional Highway, through shortest distance/ route.	RHD
4	Upazila Road (UZR)	Roads connecting Upazila HQ/s with Growth Center/s or one Growth Center with another Growth Center by a single main connection or connecting Growth Center to Higher Road System, through shortest distance/route. (Former Feeder Road Type-B)	LGED/LGI
5	Union Road (UNR)	Roads connecting union HQ/s with Upazila HQs, Growth Centers or local markets or with each other. (Former Rural Road Class-1 (R1)	LGED/LGI
6	Village Road (VR)	a) Roads connecting Villages with Union HQs, local markets, farms and ghats or with each other. (Former Rural Road Class-2 (R2) b) Roads within a Village. (Former Rural Road Class-3 (R3)	LGED/LGI

- Asset Management is important for the management of this extensive infrastructure.
- Well-aligned asset management is dependent on having a coherent strategy in place to link infrastructural asset planning, budgeting, (performance) delivery, operation, and monitoring with broader planning objectives.

- LGED has been working towards an Asset Management Policy (AMP), including a Strategic Asset Management Plan (SAMP), defining the key principles and mandated requirements applicable to LGED's Asset Management System (AMS). In 2019, a roadmap for the further establishment of LGED's AMS was created. In July 2020, LGED published its SAMP (LGED, 2020),.
- What is needed is to have a Building Back Better approach to Asset Management: to learn from the failures and to restore the damaged section is such a way that the same damage will not occur in the future. GR4W can also contribute to this, as much damage is water-related.



LGED Asset Management System Development Roadmap, linked to LGEDs Professional Development Strategy (blue boxes) (LGED, 2019b)

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1.2 Benefits and principles of GR4W

- Water is responsible for 80 percent of damage to unpaved roads (Chinowsky and Arndt 2012) and 30 percent of damage to paved roads.
- Water management is thus a critical area of intervention in the development of roads. Focus has so far been mainly managing water to minimize the damage to road infrastructure. The impact of roads on their surrounding landscape and surface hydrology is usually not considered.
- This lopsided focus translates into significant direct negative impacts on landscapes and natural hydrology and into missed opportunities for beneficial water management.
- Climate change compounds these challenges. Climate change is likely to exacerbate the frequency and intensity of meteorological phenomena, making it crucial to design roads that are climate resilient and do not hamper, but instead positively contribute to, water resource management.
- Green Roads for Water embodies a change in the paradigm in the way roads projects are planned and implemented.
- GR4W is about a more integrated design process with local communities and social, environmental, water, and agriculture sectors to turn around the negative impacts of roads on the surrounding landscape, and simultaneously maximize the beneficial use of roads for water management and climate resilience that can work to the advantage of local communities along the roads.

TABLE I.1 Geographies, challenges, and techniques

GEOGRAPHY OR TOPIC	PRIME CHALLENGES	TECHNIQUES
Watersheds and catchments (chapter 2)	Water harvesting Erosion control Flood control	Choice of road alignment Culvert placement and design (chapter 2) Road drainage Water-harvesting and erosion-control structures (chapters 8 through 11) Road drift and platforms (chapter 9) Warping dams
Rural water supply (chapter 3)	Source augmentation Water quality	Grass strips and ecological water control Recharge from roads (chapter 2) Surface water storage (chapters 8 and 11) Spring management (chapter 3)
Semiarid areas (chapter 4)	Water harvesting Water retention Erosion control	Floodwater spreaders Flood diversion from culverts Infiltration trenches and other recharge techniques Surface storage including borrow pits and farm ponds Raised road embankments for water retention Road drifts and sand dams (chapter 9)
Coastal areas and floodplains (chapter 5)	Water table control Drainage Water storage Flood protection Flood relief	Road alignment and heights Cross drainage and gated culverts Borrow pits (chapter 8) Fish passages Levees and flood shelters Evacuation routes Low-embankment roads (chapter 11) Submerged roads (chapter 7) Bioengineering and turfing
High- and medium-altitude areas (chapter 6)	Stabilization of mountain areas Spring and stream management	Road alignment and slope Green construction methods Bioengineering Road-water crossings Spring management Land protection measures including drifts (chapter 9) and regreening (chapter 12)
Complementary measures to protect roads from water (chapter 13)	Preventing road structures from being compromised by the proximity to water induced by the application of Green Roads for Water techniques	Impact of water Mitigation measures Roads as dams Recommended practices

Snapshot from global GR4W guidelines outlining geographies, challenges, and GR4W techniques

1.3 WHY GREEN ROADS FOR WATER?

" Water is the single largest factor in road damage; as a consequence, it is generally considered the prime enemy of road infrastructure. "

At same time roads distort hydrology, cause flooding and water logging, cause erosion and sedimentation and interrupt biodiversity

Water-related road damage

Flooding

Water logging

Erosion (gullies and landslides)

This can be

roads can become

GREEN ROADS

The GR4W approach aims to turn challenges into opportunities, achieving what we describe as a 'triple win':

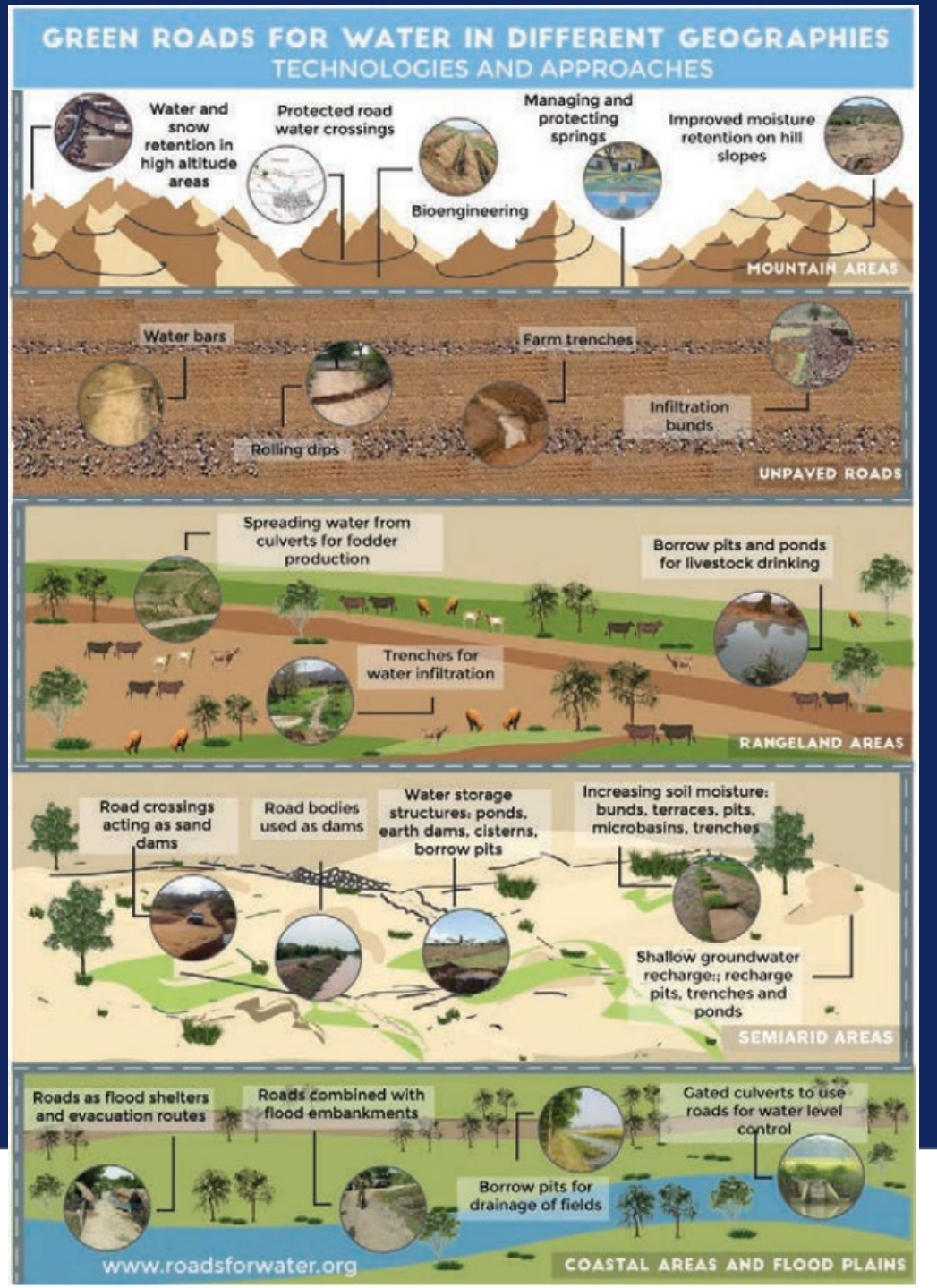
1. Reduced road downtime and maintenance costs
2. Reduced degradation of the landscape around roads and
3. Enhancing water availability by using roads as instruments for water harvesting and water management

GREEN ROADS FOR WATER

BASIC RESILIENCE: PROTECTIVE KEY OBJECTIVE: PROTECTING ROAD INFRASTRUCTURE	RESILIENCE PLUS 1: ADAPTIVE KEY OBJECTIVE: MAKING THE BEST USE OF, AND ADAPTING TO, HYDROLOGICAL CHANGES INTRODUCED BY THE ROAD	RESILIENCE PLUS 2: PROACTIVE KEY OBJECTIVE: REDESIGNING ROAD INFRASTRUCTURE TO OPTIMIZE THE AREA'S WATER MANAGEMENT AND CLIMATE RESILIENCE, OFTEN TO BENEFIT LIVELIHOODS

Three levels of resilience are addressed with GR4W

Different applications in different geographies



10 Reasons for GR4W in LGED's road network

1. As water is a major cause for road failure and maintenance costs, **Green Road for Water reduce the spending requirements in road maintenance** – starting with improving road maintenance problem spots rather than just restoring these. This will help reduce the funding gap in maintenance.

2. **Disaster risk reduction is greatly enhanced** by systematically mainstreaming this in road design and asset management – by raising roads and create safe shelters and by flood protection: this is important as roads are lifelines during disaster.

3. By responsible sourcing, excess sediment in low lying areas can be put to good use for local road building – giving **a boost to desilting.**

4. By bio-engineering and spring shed protection around roads**, erosion can be controlled and the decline in spring discharges can be reversed in the Chittagong Hill Tracts**.

Road developed with excavated silt

Roadside spring captured and developed

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5. By systematically removing the blockage of natural drainage by roads and bridge sills in Riverine Areas and Coastal Zone, **water logging can be greatly reduced – bringing a large boost in production and a reduction of diseases**.

6. By retrofitting too narrow 'choking' bridges in SW**, tidal rivers can be salvaged.**

7. By systematically introducing gated culverts in rice growing areas **water control can be enhanced for HYV Amon Paddy,** which can double yields and shorten growing season, freeing land up for an additional crop.

8. By tailoring culverts and other cross drainage structure to accommodate fish passage, **fish capture can be enhanced** importantly.

9. By systematically using the extensive road infrastructure for water harvesting and supporting groundwater recharge the drought crisis in the Barind can be addressed.

10. By designing roads and overflows in the Haor, so that they help retain the reclining flood, the **period of available soil moisture can be extended.**

Production losses due to raised bridge sill and blocked drainage

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1.4. Why this is so important

- The transport sector contributes around 11% to Bangladesh's GDP, with roads accounting for the majority of passenger and freight transport.
- By 2050, coastal flooding event is likely to cause €7.4 billion of direct economic damage to the road network
- By 2050, riverine flooding is likely to cause €5.4 billion of direct economic damage to the road network.
- Without climate adaptation, an impact equivalent to 2% of the GDP by 2050 and 9% by 2100.
- According to the GCA's national infrastructure stress test of Bangladesh, 95% of the road network is exposed to at least one type of climate hazard.

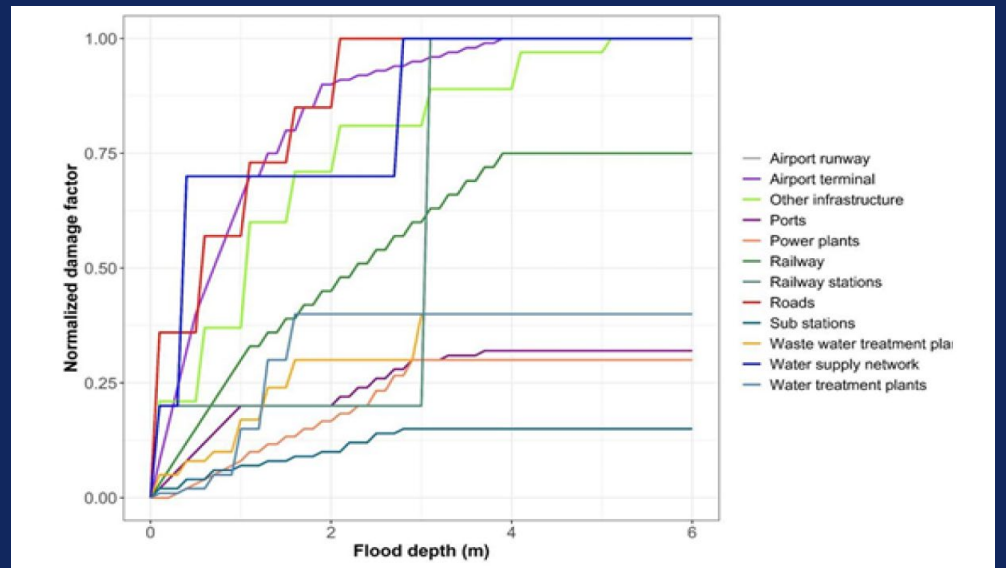
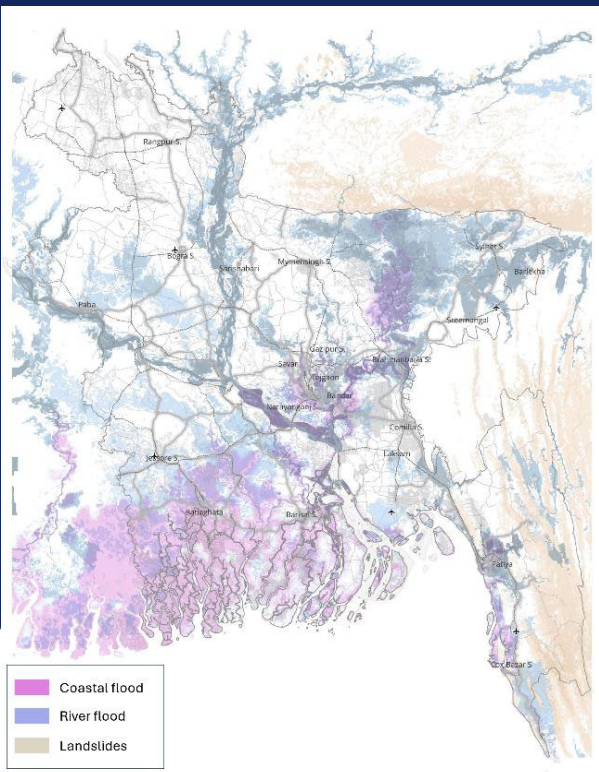


Figure: Flood damage curves (Sources: Huizinga, et al., 2017; Miyamoto Interna 2019; FEMA, 2011; Kok et al., 2005; Snuverink et al., 1998)

Flood damage curves of critical infrastructure in Bangladesh, showing road infrastructure as most vulnerable to flooding events of all critical infrastructure in Bangladesh.



Key climate hazards in Bangladesh

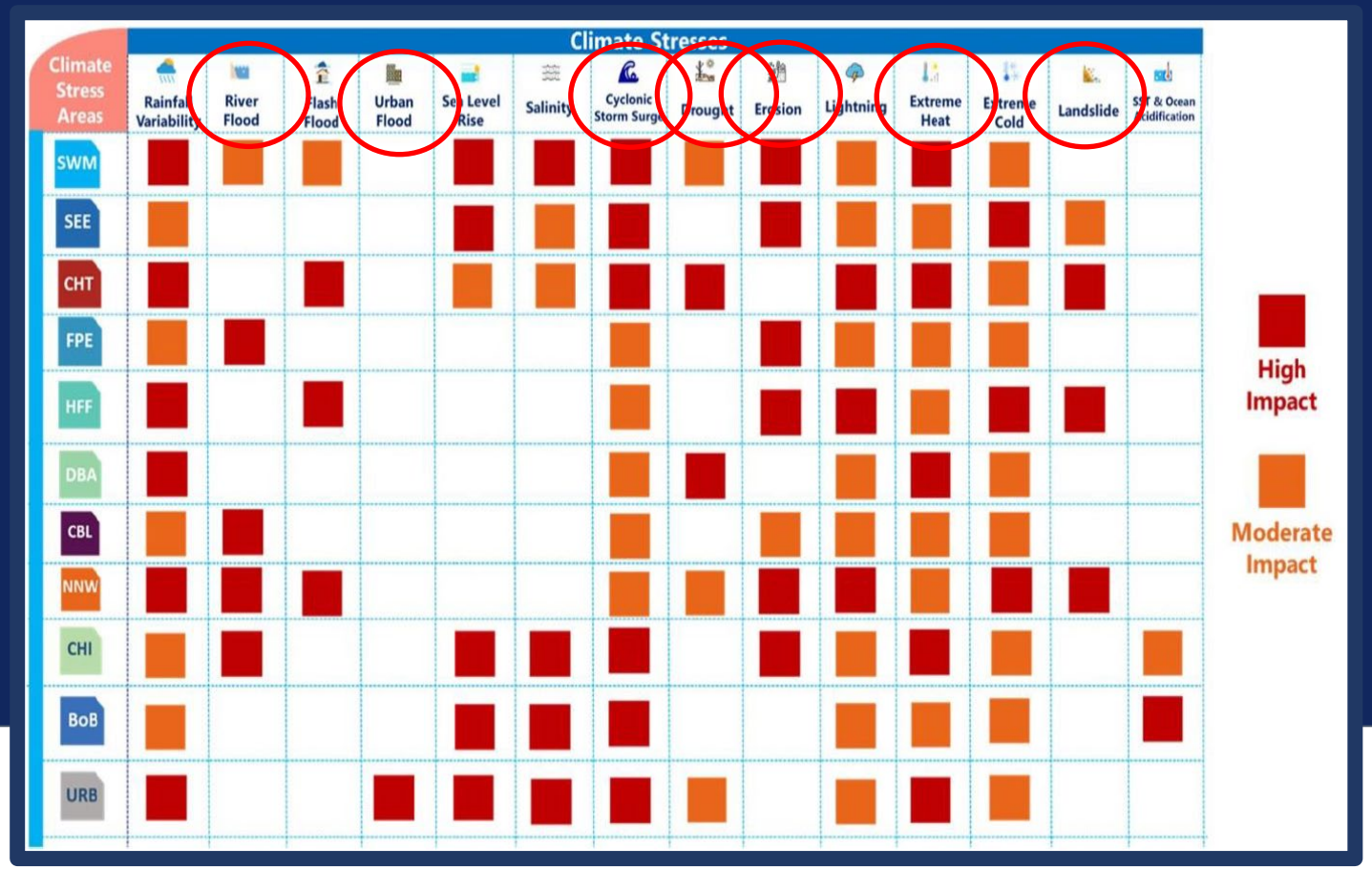
Summary of the transport sector's exposure and estimated economic damage as a result of climate hazards

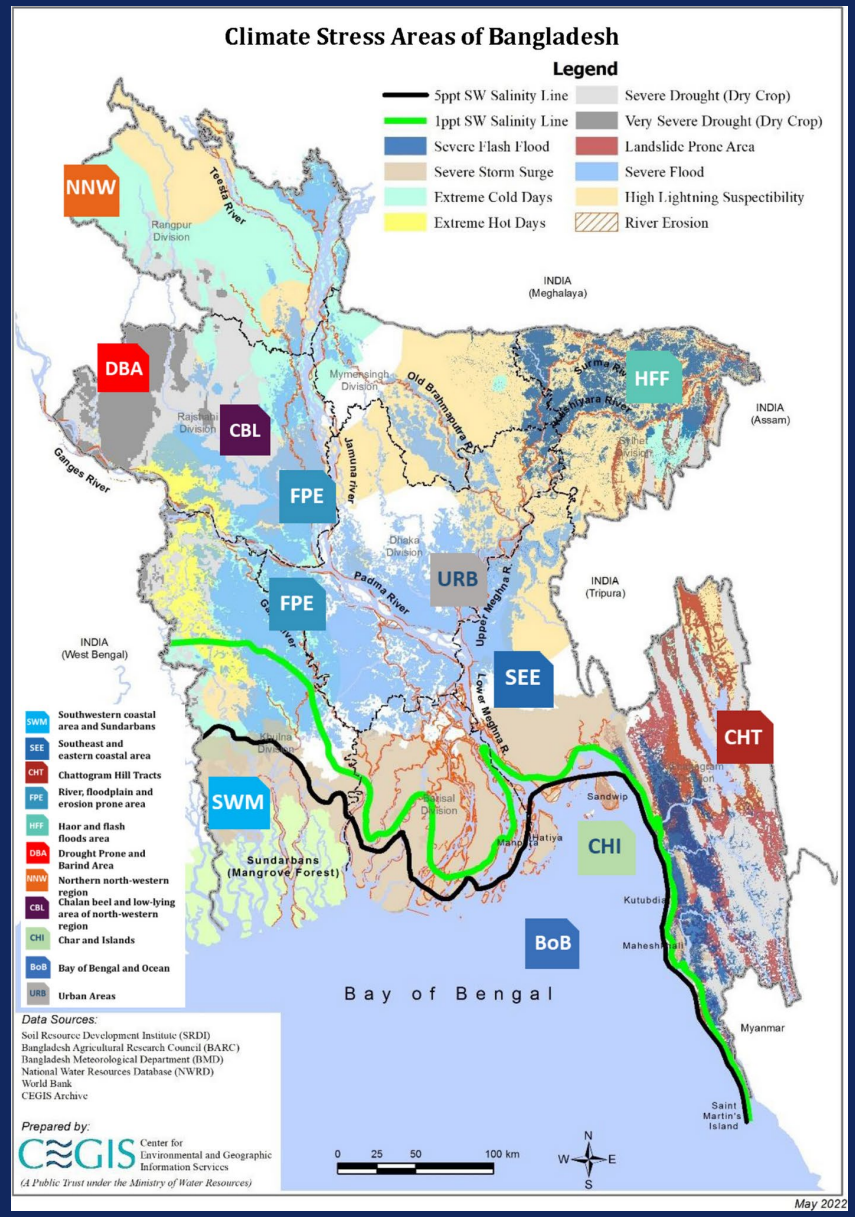
Hazard		Transport Infrastructure											
		Roads		Railway lines		Railway stations		Airports		Ports		Inland water terminals	
		% assets exposed	Damage (million €)	% assets exposed	Damage (million €)	% assets exposed	Damage (million €)	% assets exposed	Damage (million €)	% assets exposed	Damage (million €)	% assets exposed	Damage (million €)
Coastal	Present day	15.71	6259.80	4.55	2.80	4.05	0.11	15.38	0.16	46.88	0.19	61.25	2.03
	2050*	18.59	7362.46	5.35	3.68	4.43	0.18	15.38	0.16	50.00	0.21	62.50	2.18
Riverine	Present day	22.03	6016.12	19.26	6.69	20.23	0.55	15.38	0.05	43.75	0.16	32.50	0.85
	2050*	24.32	5352.26	26.47	5.42	25.24	0.46	15.38	0.04	53.13	0.14	40.00	0.70
Cyclones**	Present day	86.13	NA	84.38	NA	82.27	NA	76.92	NA	100.00	1.83	95.00	NA
Erosion***	Present day	39.71	NA	39.71	NA	56.26	NA	61.54	NA	31.25	NA	40.00	NA

* Scenario shown here is for RCP 4.5, and a return period of 1 in 50 years.
** Exposed to more than 30m/s of max wind gust
*** Exposed to erosion more than once per year

Effective response to many hazards

A multi-hazards risk map presented in the National Adaptation Plan of Bangladesh (2023-2050) illustrates the spatial distribution across the country. The risk map includes all described hazards and segregates the country into 11 climate stress areas. GR4W can address several of the hazards

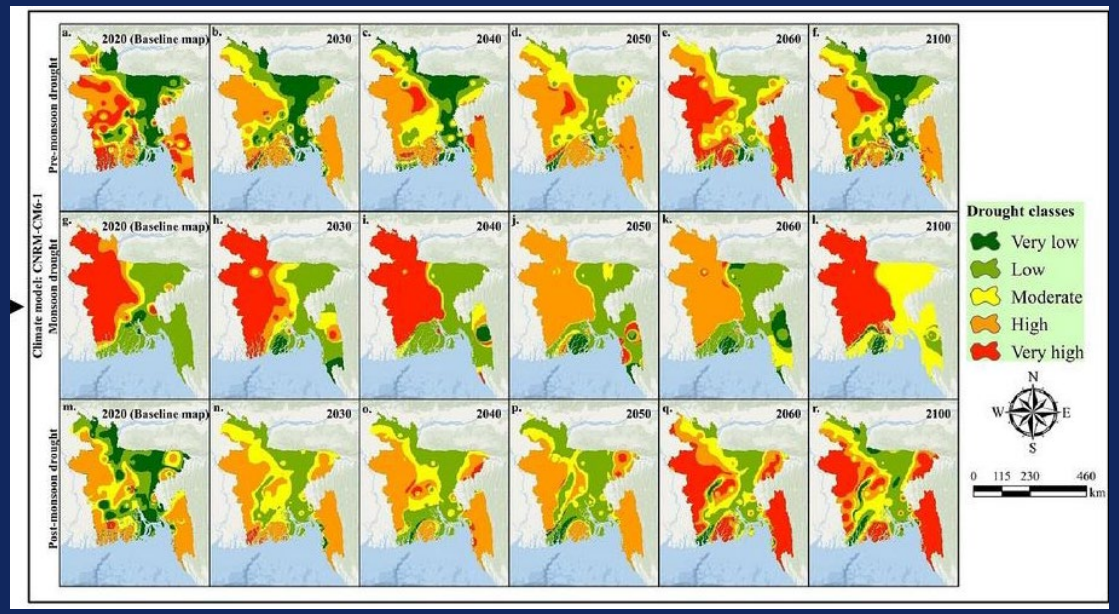


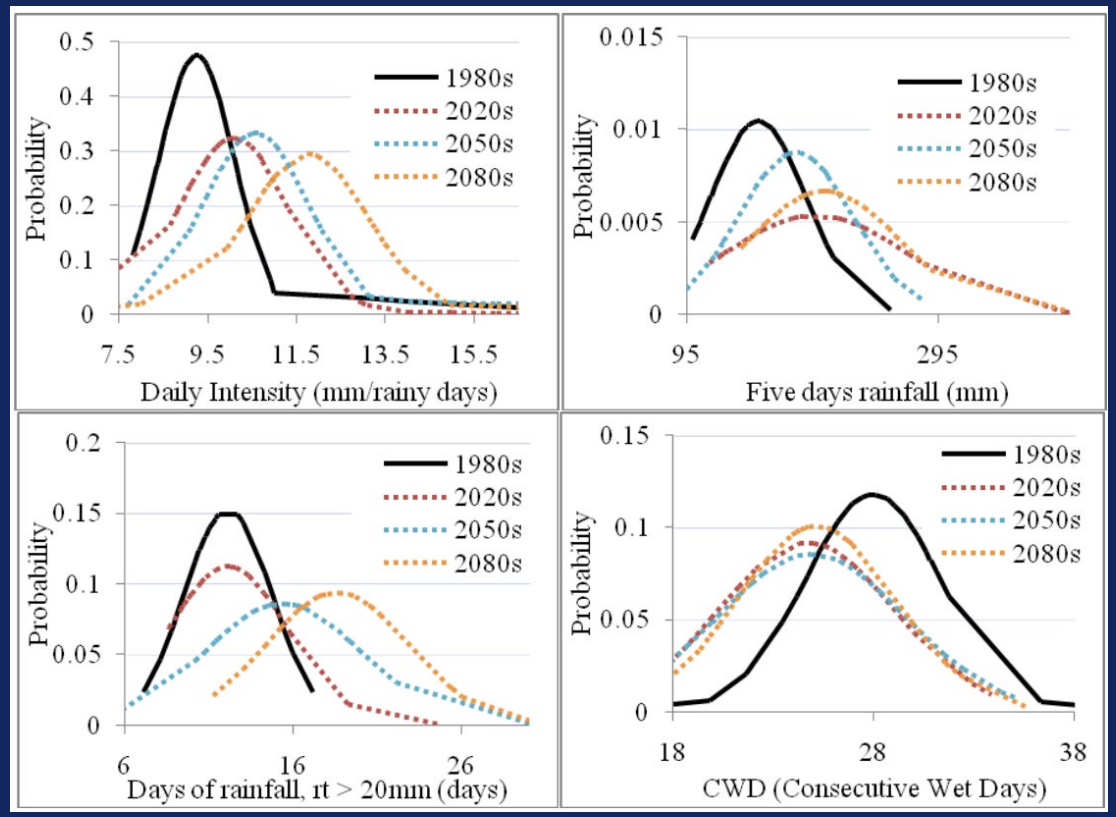


The Future will be different

- Climate change is having a major impact and bringing an unpredictable future for Bangladeshi
- **With more than 400,000 km of roads throughout the country under LGED, Green Roads for Water will be a gamechanger in addressing climate impact**

Current and future drought susceptibility in Bangladesh using historical climate data (1991–2020) and coupled model intercomparison project 6 data for three seasons: pre-monsoon, monsoon, and post-monsoon.





Probability distribution functions (PDFs) of daily intensity (mm/rainy days), Five days rainfall (mm), number of days when rainfall > 20mm, and consecutive wet days over Bangladesh.

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2. Opportunities in Five Hotspot Areas

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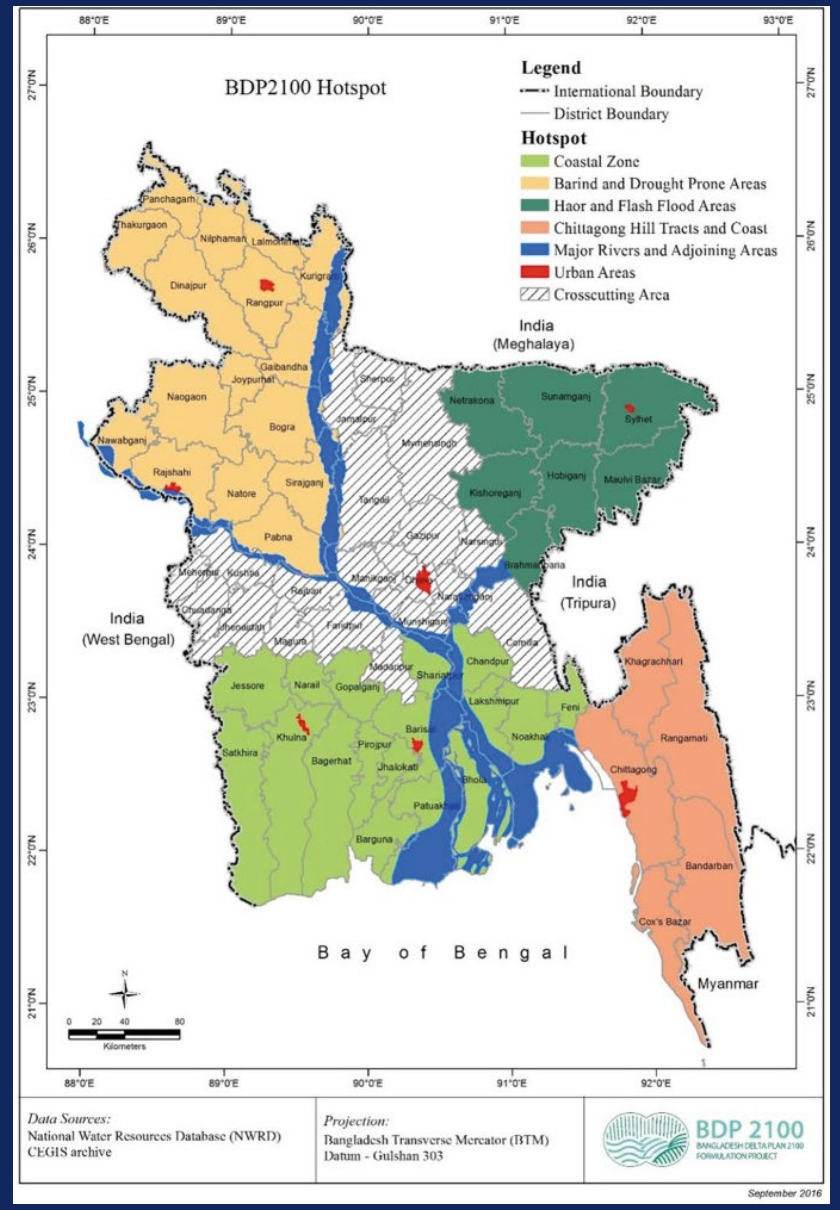
- The impact of the road network on surface hydrology differs with the geography (regional hotspots) of the country
- The Green Roads for Water Guidelines follow the BDP2100 hotspots (excluding urban):
  - Coastal Zone
  - Barind and Drought Prone Areas
  - Haor and Flash Flood Areas
  - Chattogram Hill Tracts
  - River Systems and Estuaries
- Gains result of adjustments in design, retrofitting on existing roads, and revitalization of roadside vegetation programs, and modifications in the way road programs are implemented and managed.



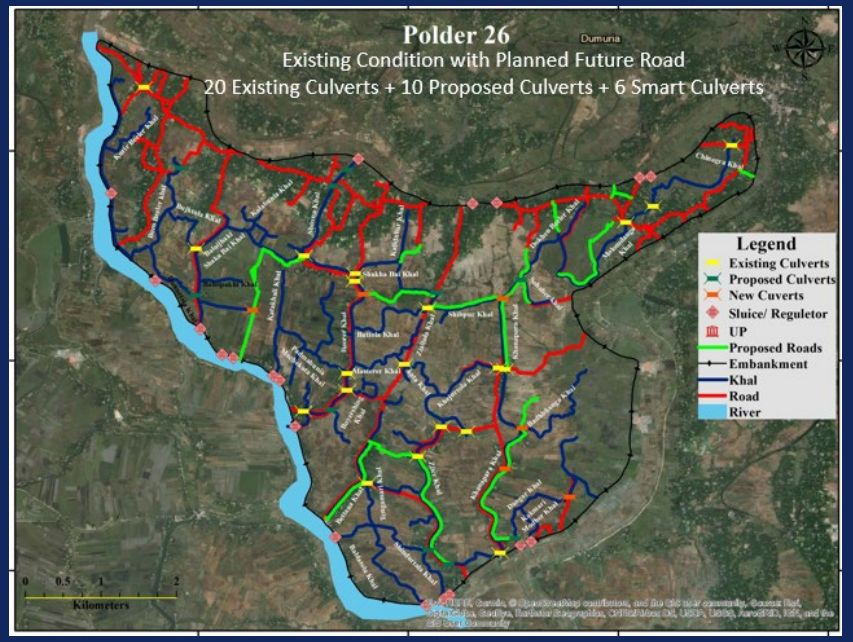
Zone	Effect of road network	
1. Coastal zone	Contribute to flood protection	Coastal embankments as roads: harmonize flood protection and transport functions
	Contribute to flood preparedness and recovery	Make roads at higher elevation (for instance, by using excavated sediment) in flood-prone high-risk areas and include widened sections as flood shelters
	Reduce water logging	Follow drainage lines and provide adequate cross-drainage
	Improve water control in irrigated crop areas	Position (minor) roads on the contour lines and equip culverts with gates
	Avoid sedimentation of rivers	Ensure adequate cross drainage and wide enough bridges so as not to disturb the sedimentation process, particularly in the tidal rivers
2. Barind and Drought Prone Areas	Use roads for water harvesting	Roads at slight elevation, guiding run-off to overflow areas to recharge zones and water storages
	Use roads for water storage	Construct water retention structures and local mini-dams using road bodies
3. Haors and Flash Flood Areas	Control flood recession	Roads at slight elevation, including controlled overflow sections and drainage to slow down and direct recession flows and feed into wetlands or shallow reservoirs
	Contribute to flood preparedness and recovery	Make roads at higher elevation (for instance, by using excavated sediment) in flood-prone high-risk areas and include widened sections as flood shelter
	Improve/protect fish movement	Provide sufficient and well-located culverts of appropriate design to guide and facilitate fish movement
4. Chattogram Hill Tracts	Use roads for water harvesting	Develop roads at mid-slope hills to maximize water retention and water harvesting potential
		Develop water retention structures alongside roads
		Use road profile and roadside drainage to collect water
	Stabilize hill slides and control erosion	Use bio-engineering or seed spraying
		Control erosion by baffle structures
		Avoid water accumulation in landslide-prone areas
	Protect and develop roadside springs	Reduced damage, more water availability at right places.
5. River Systems and Estuaries	Mitigate floods	Road networks to steer and compartmentalize floods by controlling the pattern of flood run-off.
	Contribute to flood preparedness and recovery	Make roads at higher elevation (for instance, by using excavated sediment) in flood-prone high-risk areas and include widened sections as flood shelter

Hotspot 1 : Coastal zone

Landscape of coastal zone

Landscape silted up tidal river

#	Opportunity	Operationalisation
1	**Unblock drainage congestion and reduce water logging**	Systematically equip roads with adequate cross drainage structures and install additional bridges and culverts in critical areas, avoid high bridge sills
2	**Salvage tidal rivers, prevent them from silting up**	Retrofit/ construct bridges with adequate spans and preferably no piers
3	**Support desilting of drains**	Use excavation material from silted up khals for local road construction
4	**Facilitate water management for high yielding Amon paddy**	Install gated culverts on local roads to allow field water ponding and release, when needed
5	**Improve flood preparedness**	Construct elevated roads in lower lying polder areas (for livestock evacuation) connecting to typhoon shelters; include wide sections for temporary shelter
6	**Improve flood protection**	Built in flood protection requirements in river facing roads – adequate height, armouring, salt-tolerant vegetative cover
7	**Optimize functions with well-planned roadside vegetation**	Vegetation planting and species selection for direct productive use, embankment stability, dust/ pollution control, noise reduction, biodiversity



Remove waterlogging by retrofitting adequate road cross drainage

Repurposing sediment from excavating khals for local road construction

Gated culverts: allowing water control for HYV Amon Paddy

Ensure wide bridge spans and no/ few piers to salvage tidal rivers

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Hotspot 2 : Barind and Drought Prone Areas

Landscape of Barind

#	Opportunity	Operationalisation
1	**Water harvesting with roads to address water scarcity**	Use variety of road water harvesting measures: routing water from drains to recharge areas or storage ponds; using porous pavement for percolation; using roadside excavation trenches for storage and recharge
2	**Responsible sourcing: avoid depleting sand and gravel from vulnerable rivers, as this will undermine their water holding and flood retention and recharge capacity**	Use alternative non-sand road pavements; use crushed sand instead; or use excavation material from derelict canals and ponds
3	**Road protection against flash floods – capturing as much as possible from flash floods**	Nature-based vegetative protection and armouring of exposed sections
4	**Optimize functions with well-planned roadside vegetation**	Vegetation planting and species selection for direct productive use, embankment stability, dust/ pollution control, noise reduction, biodiversity

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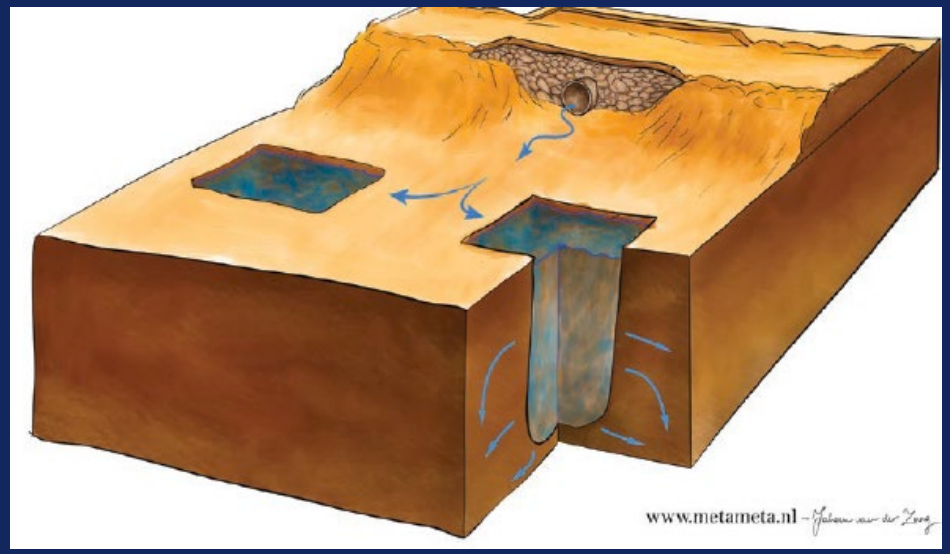

Water harvesting: guiding water from culverts to recharge areas and storage

Using porous pavement for water percolation

Responsible sourcing: use manufactured sand instead of sand from vulnerable rivers

Optimize roadside vegetation

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Hotspot 3 : Haor and Flash Flood Areas

Landscape of Hoars

#	Opportunity	Operationalisation
1	Improved flood retention, enhancing post-flood soil moisture for early season crops and fish breeding and capture fisheries	Carefully plan – even retrofit - roads, including drainage structures and overflow areas/ causeways to positively effect and flexibly manage to patterns of flood retention. Options: • Submersible road embankments • Road causeways with sluice gates// box culverts • Raised roads with designed spillways – preferably leading to recharge area or wetlands • Armoured road embankments to create water storage • Small ponds alongside roads that slowly release water and improve soil moisture and serve as fish spawning ground
2	Improve flood preparedness	Construct elevated roads with overflow capacity in lower lying areas (for livestock evacuation); include wide sections for temporary shelter
3	Facilitate fish migration	Sufficient culverts and bridges; well-designed and well-placed culverts, i.e. culverts that are not too steep, and have low/moderate velocity; that may have roughened surfaces; that have adequate water levels in dry season; and are connected to the downstream water body
4	Optimize functions with well-planned roadside vegetation, protect (submerged) roads from scour	Vegetation planting and species selection for scour control, but also direct productive use, embankment stability, dust/ pollution control, noise reduction, biodiversity and suitability to local soil and climate

Overflow area with armouring and vegetative protection

Water reservoir created with road embankment

Vetiver grass as slope stabilizer

Fish friendly culvert

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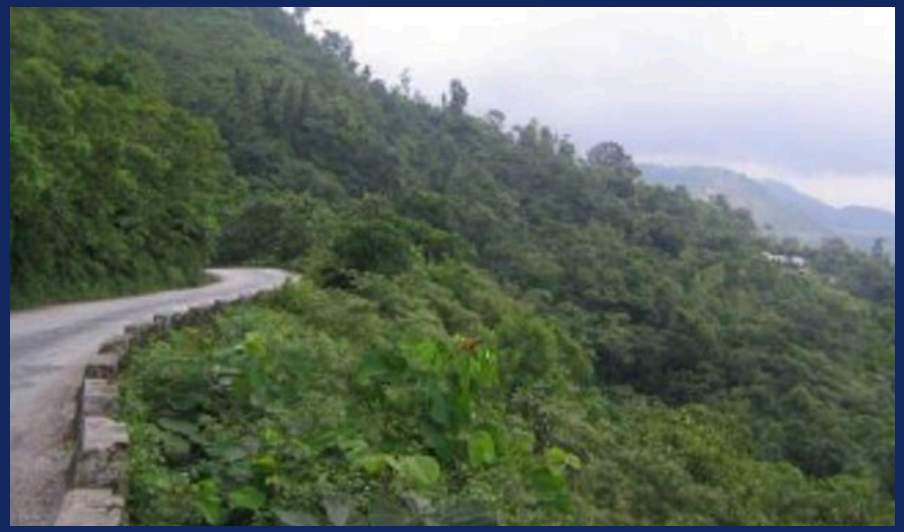
Hotspot 4 : Chattogram Hill Tracts

Landscape CHT

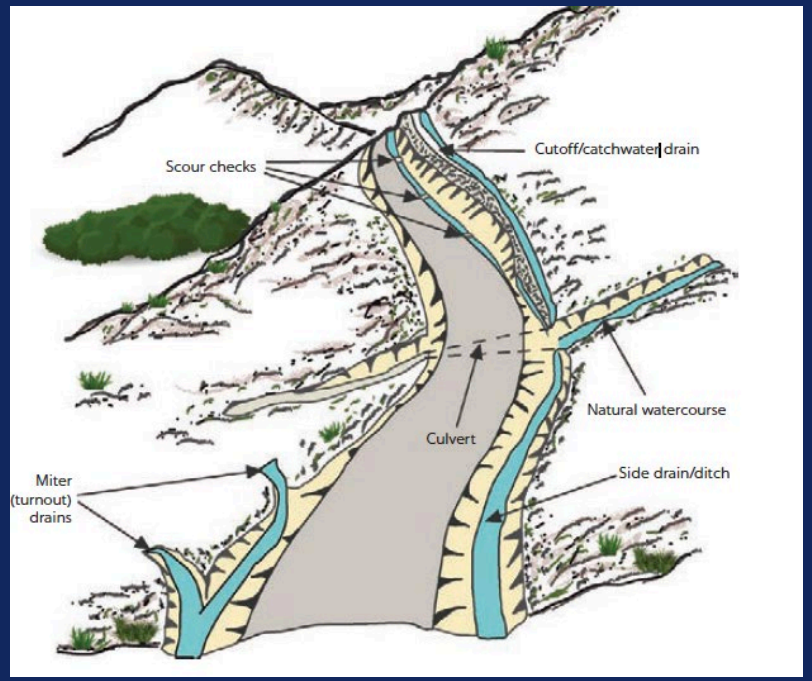
#	Opportunity	Operationalisation
1	**Preserve and capturing springs**	Develop roadside spring boxes with outlets and slope protection; also increase recharge in the spring sheds
2	**Stabilize roadside hill slopes, reduce erosion**	Use bio-engineering techniques to reduce risk of erosion, slips and landslides – with plants and small civil engineering measures catching, erosion, and armouring, reinforcing, anchoring, supporting and draining vulnerable slopes
3	**Water harvesting from roads**	Use road drainage system to collect run-off from road slopes and route to safe disposal recharge/ storage areas
4	**Optimize multiple functions with well-planned roadside vegetation**	Vegetation planting and species selection for direct productive use, embankment stability, dust/ pollution control, noise reduction, biodiversity

Roadside spring capture and protection

Spring shed improvement to enhance recharge



Bio-engineering to stabilize road slopes



Develop road drainage system to capture run-off and feed water storage

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Hotspot 5 : River Systems and Estuaries

Landscape River Systems and Estuaries

#	Opportunity	Operationalisation
1	**Unblock drainage congestion and reduce water logging**	Systematically equip roads with adequate cross drainage structures and install additional bridges and culverts in critical areas, avoid high bridge sills
2	**Improve flood protection**	Built in flood protection requirements in river facing roads – adequate height, armouring, vegetative cover
3	**Improve flood preparedness**	Construct elevated roads in lower lying areas (for livestock evacuation); include wide sections for temporary shelter
4	**Mitigate floods in critical areas**	Roads may constructed in critical areas to cordon off the area from floods and compartimentalize
5	**Facilitate fish migration**	Sufficient culverts and bridges; well-designed and well-placed culverts, i.e. culverts that are not too steep, and have low/moderate velocity; that may have roughened surfaces; that have adequate water levels in dry season; and are connected to the downstream water body
6	**Optimize functions with well-planned roadside vegetation**	Vegetation planting and species selection for direct productive use, embankment stability, dust/ pollution control, noise reduction, biodiversity and are suitable to local soil and climate

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Armouring of river facing roads

Elevated roads providing flood shelter for livestock

Sufficient cross drainage to avoid water logging

Mahogany roadside tree planting for productive use and as shelter belt

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3. Main Recommendations for Road Elements

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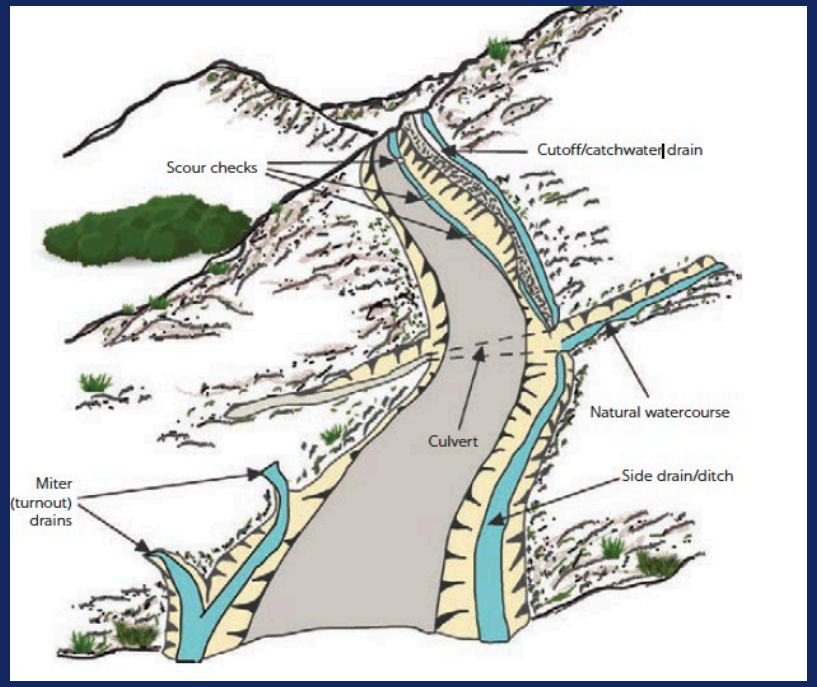
1. Cross drainage
2. Bridges and causeways
3. Road embankments
4. Pavements and construction materials
5. Bio-engineering measures and spring protection
6. Planning roadside vegetation
7. Selecting roadside vegetation

1. Cross drainage

Gated culvert

#	Key points
1	Cross drainage is important to evacuate water from the area around the road and avoid water logging in the landscape and prevent water accumulation around the road.
2	In many areas however roads are built with inadequate cross drainage – sometimes because of temporary funding constraints. This causes serious water logging in low lying areas, resulting in large agricultural losses and worsened public health. Such inadequate cross drainage should be corrected on priority basis.
3	A well-developed and well-maintained cross drainage system will prolong the life of the road and will also make it easy to collect the run-off water and direct to areas for beneficial use, i.e. a storage reservoir or recharge areas. This is particularly important in drought affected areas, where water supply Is critical, such as the Barind.
4	Another important beneficial application is in rice growing areas, in particular where improved *amon* varieties are introduced. These need more water control: the timely release and ponding of water. For this often road culverts equipped with gates are most suitable. The gates are usually placed at the outlet side of the culvert.



Well-developed drainage system collecting water and making it possible to route to areas of beneficial use

Road drainage water channeled into farm trench to irrigate root zones of the plants

Gated culvert making it possible to control water levels in rice fields for optimum production

Arched culvert for easier passage of fish and other creatures

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Fish friendly culvert

Fish friendly culvert – connecting to the downstream water body. Road cross drainage affects fish movement – which is the basis of a major economic activity in Bangladesh

#	Key points
1	Bridges are recommended over other options where roads intersect key fish migration paths, as they maintain natural stream conditions and minimize disruption to fish movement. Culverts are however often the only cost-effective option
2	The water level within the crossing must remain above a minimum depth during fish movement periods to allow passage; shallow, standing water facilitates easier crossing
3	Maintain culverts so they remain free from debris and sediment buildup, which can block passage or increase turbulence
4	Add baffles or roughened beds to culverts where needed to reduce flow speed.
5	For causeways, install several distributed culverts/regulators to maintain connectivity across the embankment.

2. Bridges

#	Key points
1	Bridge spans should be wide enough and preferably with no or few piers, in order to: - Not restrict flood flows and cause flooding - Not cause upstream sedimentation - In case of tidal rivers, not hinder the tidal flows and disturb the riverbed load
2	Bridge sills are important in soft underground, but should not too high, impeding drainage
3	Protect entrance of bridge with combination of bio-engineering measures and armouring (NBS)

Determine bridge span	Determine level of bridge sill
Calculate active water channel	Survey streambed elevation
Measure flood plain adjacent to active water channel (for 50-year flood)	Deduct expected scour depth during design floods
Make provision for debris and floatsam (1-3 meter in small streams)	Assess foundation stability requirements
Note: avoid placing pier in active water channel and if so, provide reinforcement	Avoid drainage congestion at any cost

Bridge on tidal river too narrow and too many piers disturbs the tidal flow, causes riverbed to silt up and tidal effect to withdraw

Bridge sill too high and bridge too narrow: causes water logging and silting up of the stream

Bridge abutment and bridge approach vulnerable to erosion – need to solve with bio-engineering measures and armouring

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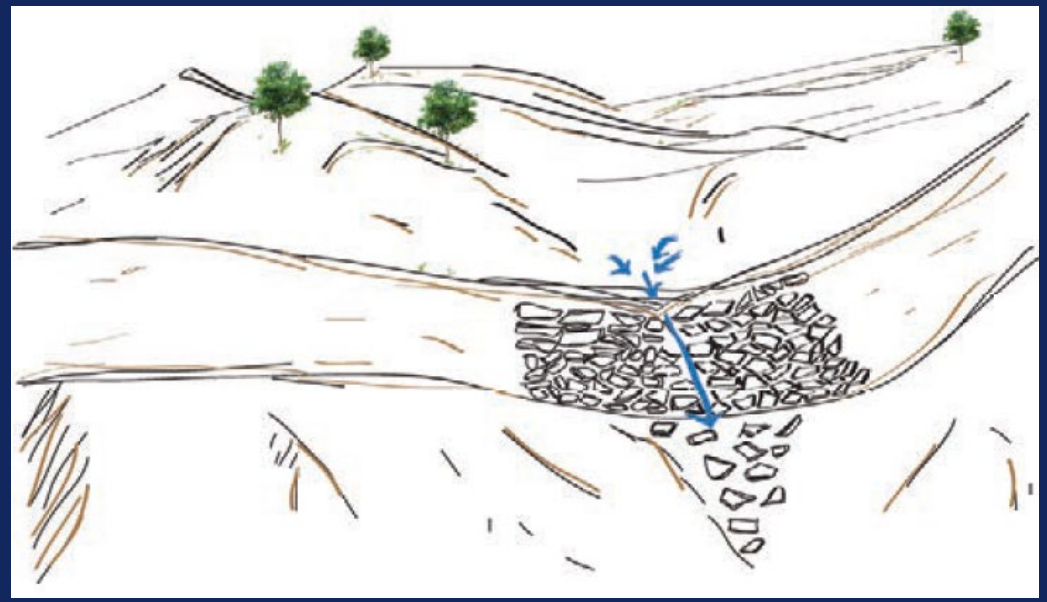
Causeways

- Causeways play a vital role in cross-drainage management for rural roads in Bangladesh.
- Causeways are low-level road segments designed to be overtopped during floods, allowing water to flow freely across the roadway.
- These submersible stretches are particularly common in areas prone to flash floods, where bridges and culverts alone are often insufficient to handle the high volumes of rapidly flowing water.
- Without such provisions, roads in these regions are at high risk of being washed away. Causeways are generally more cost-effective and quicker to construct than elevated road sections.
- However, they are exposed to strong water turbulence, which can lead to structural damage or displacement. Therefore, regular inspection and maintenance are essential to ensure their durability and performance.



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3. Embankments

Height of embankment

Sideslopes

Camber

3. Road embankments

Height of embankment

#	Key points
1	Height based on maximum flood level plus additional provision for wave action – in particular at sea fronts and river banks.
2	For roads close to rivers and sea, close coordination is needed with BWDB, to ensure road maintain width and height and are paved before the maximum height of the flood embankment has been achieved.
3	Inside low-lying flood prone area the height of roads may be increased so as to provide shelter and evacuation routes for people and livestock.
4	Also in areas prone to water logging road embankment must be raised with adequate drainage so that nearby houses are not inundated
5	Raising the height of these roads may be done with excavated material from *khals* and drains that is often easily available
6	In the haor areas road embankments may be made with appropriate heights that support water management and all-weather access – e.g. slightly elevated in order to influence the retreating inundation and to control soil moisture in the recession areas. Care should be taken not to interfere with the flooding patterns and deploy overflow structures, flood causeways or adequate cross drainage. When this is not possible or feasible, submersible roads may be made

Side slope

#	Key points
1	Road shoulders and embankments should follow recommended side slopes for road stability and safety and to accommodate roadside vegetation (see table). For higher embankments (4-5 mtr) more gentle side slopes apply.
2	Ownership issues of roadside side slopes should be addressed: this requires consultation and time, so as to agree on ownership by LGED and/or land use by communities of the side slopes.
3	Where it is not possible to ensure the proper side slopes, alternative reinforcement arrangement should be deployed such as (1) retaining walls properly anchored and backfilled; (2) face geotextile face wraps or geogrid bamboo matrasses with vegetation; (3) armouring with concrete block (with weepholes) or riprap with graded filter; (4) bio-engineering for short slopes, with native grasses, vertiver, creeper mats, especially on lower part of the slope; (5) toe drains.
4	One should prioritize slide slope protection by timely repair and building back better of the road embankments in case of erosion or flood damage.
5	Multi-purpose roadside ponds/trenches can be used to collect access drainage water and serve as a water storage – preferably at 3 meter from side slope. Deeper ponds/ trenches can be used for fish cultivation or aquatic crops.

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- The preferred side slope ratio is often not possible due to practical reasons, in particular the private ownership of roadside land.
- Therefore, special measures need to be deployed on slopes within 1:1.5:
  - retaining walls properly anchored and backfilled;
  - geotextile surface wraps or geogrid bamboo matrasses with vegetation;
  - armouring with concrete block (with weepholes) or riprap with graded filter;
  - bio-engineering for short slopes, with native grasses, vertiver, creeper mats, especially on lower part of the slope;
  - toe drains.

Method and User Preferences of Side Slope Protection (BUET, 2018)

#.	Method Name	Preferable Scenarios	Preferable Side Slope Ratio (V : H)
01	Slope Protection work with Long Routed Grass Turfing	General Road Embankments	1 : 2
02	Slope Protection work for High Embankment (Above 4.5 m) with Long Rooted Grass	High Embankments , Haor Areas / Coastal Areas	1 : 1.75
03	Slope Protection Work with Grass Turfing & Geo-Jute on Slope for Sandy Soil with Long Rooted Grass	Sandy Soil	1 : 2
04	Slope Protection Work with Grass Turfing, Geo-Jute & Geo-Bags on Slope for Clayey Soil	Clayey Soil	1 : 1.5
05	Slope Protection work with Long Rooted Grass* Turfing & Geo-Jute on Slope for Hilly Areas	Hilly Areas	1 : 2
06	Temporary Slope Protection work with Gunny Bagged Rip-Rap and Geo-Textile	Haor Areas / Coastal Areas	1 : 2
07	Slope Protection work with Gabions	Haor Areas / Coastal Areas	1 : 2
08	Slope Protection work with Long Rooted Grass*, Vegetation, Block and Gabions	Haor Areas / Coastal Areas	1 : 2
09	Slope Protection work with Masonry Brick and Pre-Cast Gabions	General Road Embankments	1 : 2

Grasses protecting side slope

Timely repair is important

Damage to side slope to be not just restored but be 'build back better'

Retaining wall to be anchored (1/3) and backfilled

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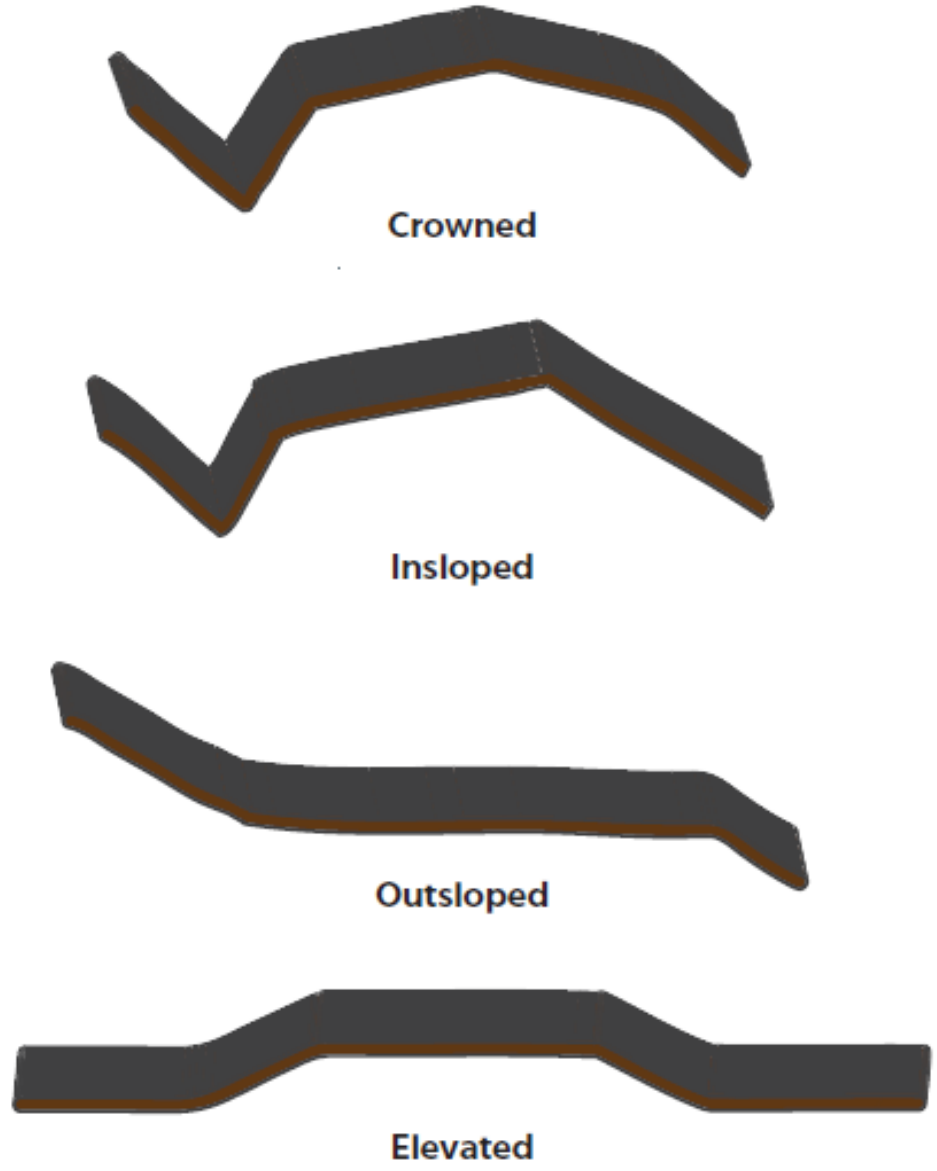
Camber

#	Key points
1	The road camber is important to remove standing water from road surface
2	CReLIC advises that with climate change the camber should have - A minimum of 3.0 % on carriageways, with increased cross falls of up to 5.0% on hard shoulders draining to filter drains. - Longitudinal gradients should be at least 0.5% on curbed roads. - Flat areas should be avoided, and consideration of surface water drainage is critical at rollovers, roundabouts, and junctions.
3	There are several shapes of camber. Crowned or in sloped surfaces are preferred to connect to side drains. Out sloped may discharge direct in adjacent land but should be provided by grass or dense stones to reduce erosion and facilitate infiltration of the road based on presence of roadside drain.



Source: MetaMeta, (www.roadsforwater.org).

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4. Pavements and construction materials

High performance pavements – suggested recommendations

Zone	Surface Layer Type	Binder/ Modifier	Base Layer Type	Rationale
Coastal Zone	Uni-block Pavement / Hot Sand Asphalt / RAP	Polymer Modified Bitumen (PmB)	ETB / Steel Slag (Unbound) / Demolition Waste + Geosynthetics	Resists salinity, waterlogging, and erosion; durable in high humidity; geosynthetics enhance structural stability and erosion control.
Barind and Drought-Prone	Steel Slag Asphalt Concrete / RAP	WEP Modified Asphalt	CTB / Brick Aggregate	Handles high temperature and dry conditions; WEP enhances flexibility and sustainability; CTB provides strength in hard soils.
Haors and Flash Flood Zones	Hot Sand Asphalt / RAP	Polymer Modified Bitumen (PmB)	Demolition Waste / ETB + Geosynthetics	Performs under frequent submersion and drying; RAP adds stiffness; geosynthetics improve drainage and flood resilience.
Chattogram Hill Tracts	Double Surface Dressing / Asphalt Wearing Course	Polymer Modified Bitumen (PmB)	CTB + Geosynthetics	Suitable for steep, erosion-prone terrain; reduces emissions and improves compaction; geosynthetics aid slope stabilization.
River Systems & Estuaries	Asphalt Wearing Course / Rigid Pavement with Recycled Aggregate	Polymer Modified Bitumen (PmB)	CTB / Demolition Waste + Geosynthetics	Ensures durability in areas prone to water fluctuation and erosion; reduces carbon footprint; geosynthetics manage drainage.

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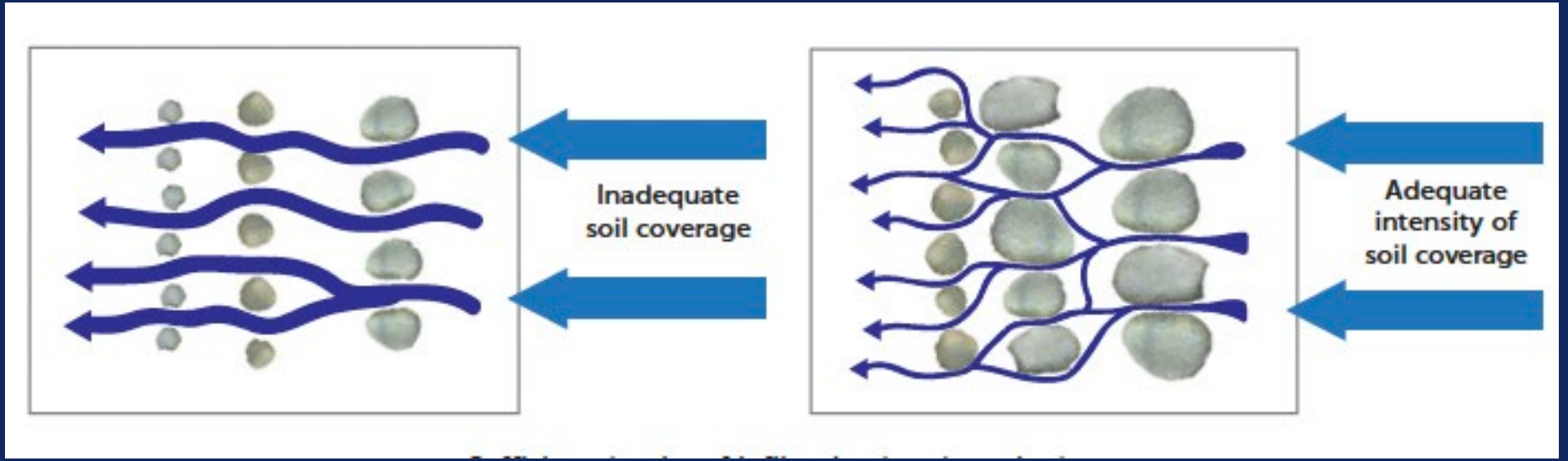
Safe sourcing of construction materials

#	Key points
1	Phase out use of bricks for road pavement, following the Brick Manufacturing & Kiln Establishment Act, 2013 (Amended 2019)
2	Avoid use of sand and gravel, sourced from vulnerable river in drought prone areas (for instance Barind), following the Balumohal and Soil Management Act, 2010 (amended 2023)
3	Repurpose excavation material from silted up drainage canals in road development and maintenance. When the material is highly plastic, mix with cement, lime or brick dust. Asses it is not contaminated with organic or chemical material
4	Repurpose excavation material (rock rubble) from road building in CHT, for instance in water recharge and slope protection
5	Explore new road building techniques in which waste material (plastic, rubber tyres, used asphalt) can be recycled
6	Consider employment factor in road construction and maintenance – preserving importance of road construction and maintenance in rural job creation

Use rolling dips or water bars (slightly elevated hump at angle with the road) to remove water from unpaved surface

Managing unpaved road surfaces

Use rocks (where available) or grasses on the road sides to dissipate water running from the unpaved road surface and avoid erosion



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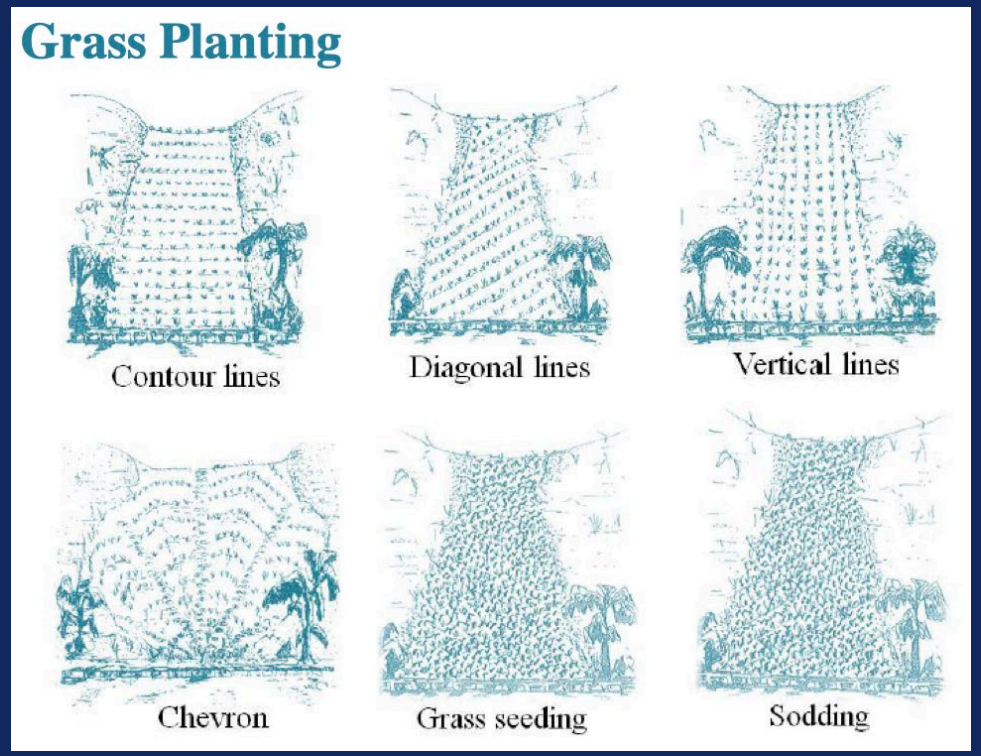
5. Bio-engineering measures and spring protection

Bioengineering is a subset of green infrastructure that uses vegetation (trees, shrubs, grasses) to serve engineering functions – combined with civil engineering measures.

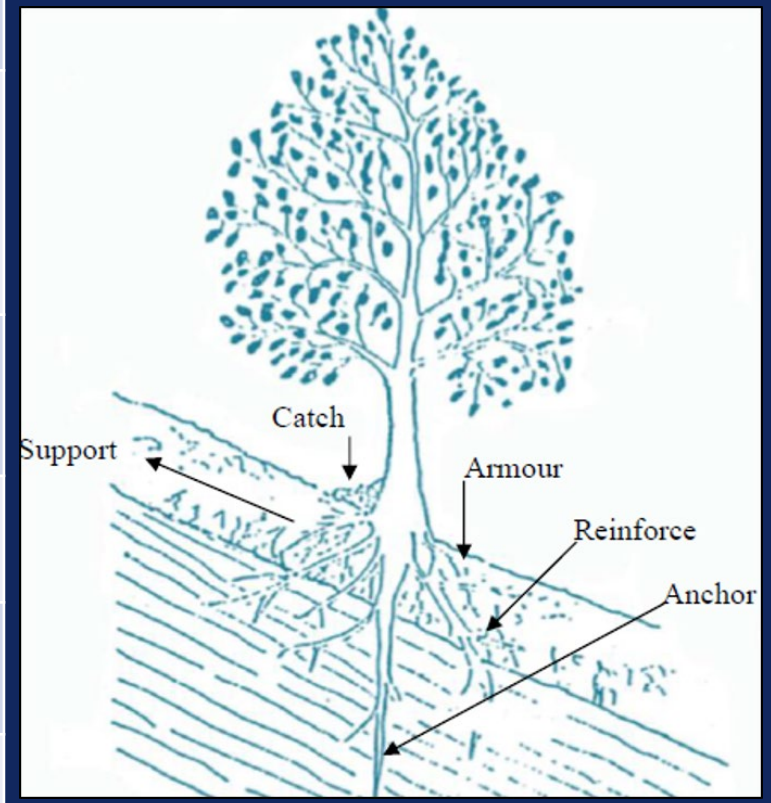
Bioengineering helps to reduce soil/slope instability and erosion, increases the slope's factor of safety, is versatile in its application and cost-effective.

Bio-engineering



#	Key points
1	Integrate bioengineering systematically into rural road designs, especially in flood-prone, erosion-prone, and hilly areas.
2	Tailor the different functions of bioengineering to the specific location.
3	At sensitive / dangerous areas, strategically combine bioengineering with grey infrastructure for optimal impact of both.
4	Consider bioengineering as a Building Back Better option when the initially employed stabilization method failed or did not perform
5	Promote co-benefits.

Engineering function	Bio-engineering measures	Civil engineering measures
Catch: Stop material from falling or sliding down a slope	- Contour lining of grasses, brush layers - Live check dam - Stems of shrubs and bamboo	- Check dams - Catch walls - Jute netting
Armour: Protect the surface from erosion	- Storeys of mixed plants providing complete cover - Grass carpet of clumping or spreading grass with dense and fibrous roots - Use green soil bags	- Revetment wall - Stone pitching
Reinforce: hold particles together and reduce the risk of shallow-seated movement	- Grasses, shrubs, and trees that are densely rooting - Most vegetation structures	- Soil nailing - Reinforcing earth
Anchor: reduce risk of deeper-seated movement	- Trees and shrubs that are deeply-rooting with long string roots	- Rock anchors by bolting
Support: hold material on the slope	- Large trees and bamboos having deep and dense root system	- Retaining walls - Prop walls
Reduce: reduce material and water movement	- Strong, numerous, and flexible stems - Many strong, fibrous roots	- Check dams - Catch walls
Drain: remove excess water	- Down slope and diagonal vegetation lines - Angled fascines	- Surface drains - French drains



Selecting bioengineering techniques

Applications, site requirements, and effectiveness

System	Functions	Method of operation	Applications and site requirements	Effectiveness / Full strength
Horizontal line grass planting	Catch, armour, reinforce	Dense line retards surface water flow	Dry, slope <45°, erodible, cut slope	Immediate / 2 seasons
Diagonal line grass planting	Catch, armour, reinforce	Dense line guides water along the line	Wet, permeable, fine, cut slopes	Immediate / 2 seasons
Grass seeding	Armour, Catch, reinforce	Dense grass, mat, rooting system	Consolidated debris slopes <45°	1 season / 3 seasons
Palisades	Catch, reinforce	Dense line above and below the ground retards surface and shallow water flow	Slope <35°, dry, erodible and consolidated debris	Immediate / 2 seasons
Brush layering	Catch, reinforce	Dense line, strong buried branches retard surface and shallow ground water flow	Slope <45°, dry, erodible and consolidated debris	Immediate / 2 seasons
Fascines	Catch, support, drain	Woody bundle, dense stems, porous, can drain soil if laid down slope	Consolidated debris slopes, <45°	Immediate / 3 seasons
Shrub planting	Catch, armour, reinforce, anchor	Bunchy leaves, multiple stems, lateral roots, tap roots	Any slopes < 45°.	2 seasons / > 3 seasons
Tree planting	Support, reinforce, anchors	Lateral and near vertical rooting systems, root cylinder	Any debris slopes <30°, gully side slopes	3 seasons / > 4 seasons
Bamboo planting	Catch, armour, reinforce, support	Dense poles, massive rooting systems, dense leaves, grows all year	Slope <35°, base of slope, erodible slopes, preferably wet places	2 seasons / > 4 seasons

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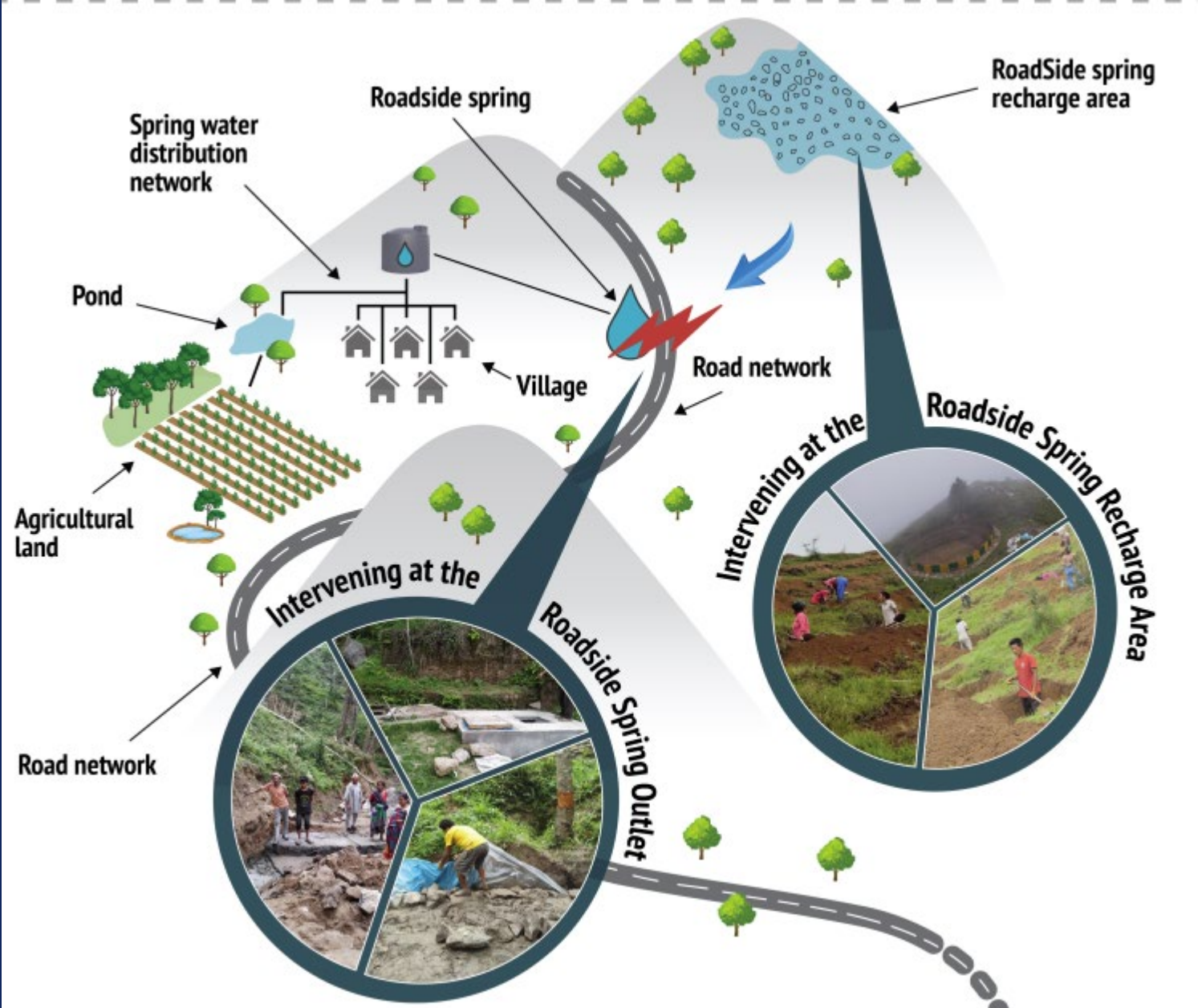
Spring protection

#	Key points
1	In hilly areas springs and seeps are opened up with road development. **This can cause the 'emptying' of local aquifer systems**
2	We need to intervene at the new **spring outlet** and capture and protect the spring
3	We need to intervene in the **spring shed** (and enhance recharge of the spring



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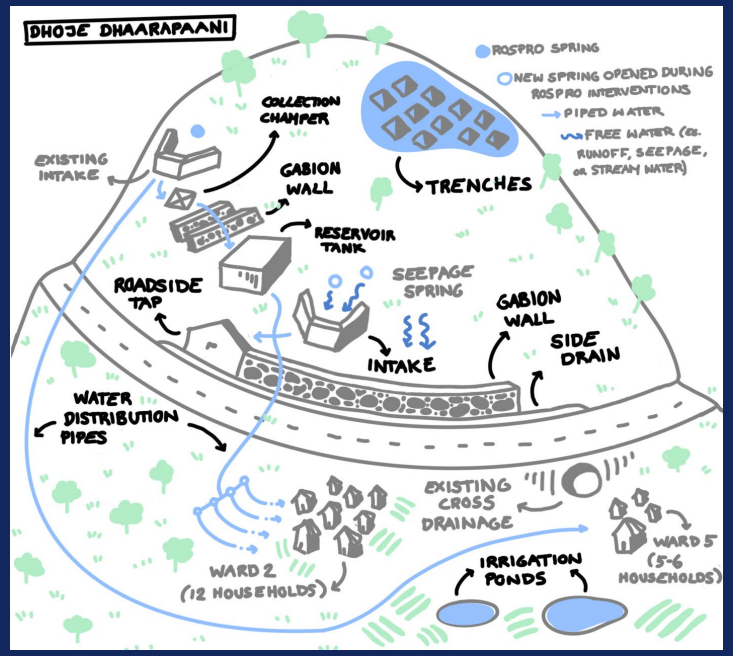
Spring protection



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6. Planning roadside vegetation

#	Key points
1	Plan roadside vegetation with the full scope of potential benefits in mind, to optimize them.
2	Address ownership and community management as a precondition, making use of the Social Forestry Rules.
3	Build in adequate time and community consultation to secure the roadside verges for common beneficial use.
4	Prevent and manage unplanned roadside plantation, which can have negative impacts including road safety, moisturizing, and shading of pavement.

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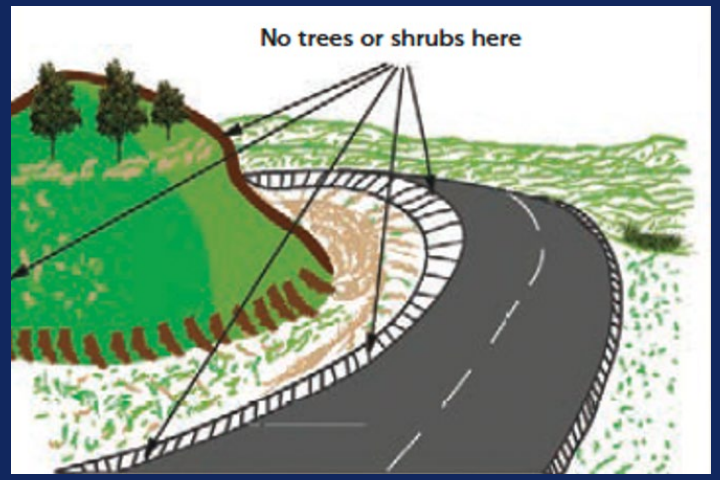
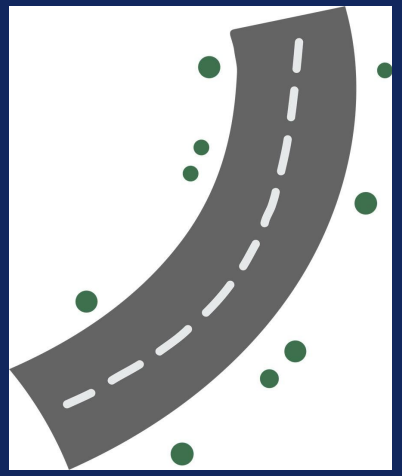
Function	Application
Protection of road surface	- Define productive use (timber, fruits, medicine, fodder, fuelwood) against preferably extended lifespan to avoid regular replanting
Protection of road surface	- Prefer deep-rooted over broad-rooted species - that may interfere with the road surface - Roadside vegetation – in directions of sunlight - slows down heat-related wear such as softening of asphalt and thermal cracking. The effect of shade may on the other hand prolong the drying of roads after rainfall.
Stabilizing road embankments	- Combination of stable roadside grasses (vetiver and others) and tree species to minimize erosion of embankments - Deep-rooted trees can stabilize the roadsides
Protecting submersible roads	- Use appropriate species that reduce eroding effects on submersible roads and that are adjusted to flooding conditions
Improved micro-climate and reduce heat stress	- Tree planting to reduce exposure to desiccation and heat extremes - High foliage, broad-leaved trees with overlapping canopies to optimize shade effects - Position vegetation so as to optimize shade on the road surface - Create wind tunnel effects to allow breezes to cool road surface
Dust control	- Tree planting in road sections that are perpendicular to the prevailing wind directions will serve as dust barriers and windbreaks, slowing down windspeed and the uplift of dust - Double-layered permeable vegetation (especially on level roads) to optimize dust capture
Pollution control	- Use of bio-accumulator species in pollution-sensitive areas to convert heavy metals (see also annex 1) - Vegetation captures Nox, CO2 and other pollutants.

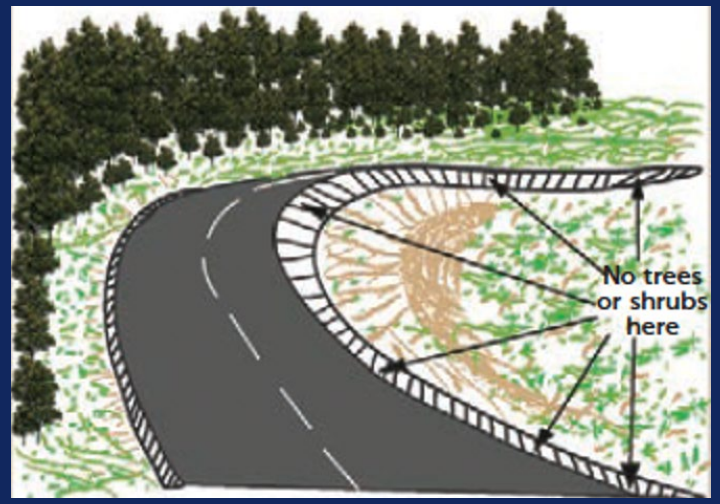
Function	Application
Sound proofing	- Vegetation close to the road will reduce sound pollution - Dense, layered planting, multirow vegetation is most effective - Combine ground vegetation with shrubs and larger trees - Evergreen is preferred
Promoting biodiversity	- Create variety of habitats, integrate rocks, logs and mini-wetlands in the roadside vegetation - Connecting to landscape hedges to create biological corridors - Selective mowing and removal of biomass to enhance plant species diversity - Avoid mowing in flowering or breeding season, leave some strips totally unmowed
Carbon sequestration	- Use native, fast-growing and long-lived tree species suited to local conditions. - Use deep-rooted perennials, grasses, and legumes to increase soil carbon
Road safety	- Roadside greenery in general improves driver alertness and tranquillity – and encourages responsible traffic behaviour. - Preference is for low growing shrubs and groundcovers near road edges and light-canopy trees set back from the road, allowing regular visual breaks - Avoid tree planting in high-speed sections (>60 kilometres/hour). - Support visibility (no tree planting in inner bends) - Glaring can be avoided by planting dense evergreen trees in direction of rising or setting sun - Irregular and varied spaced planting can avoid speeding behaviour
Beautification and comfort	- Provide shade and space where there is much pedestrian movement - Consider iconic trees for beautification and local identity
Avoiding interference	- Do not grow high trees near electricity lines - Avoid root penetration in culverts

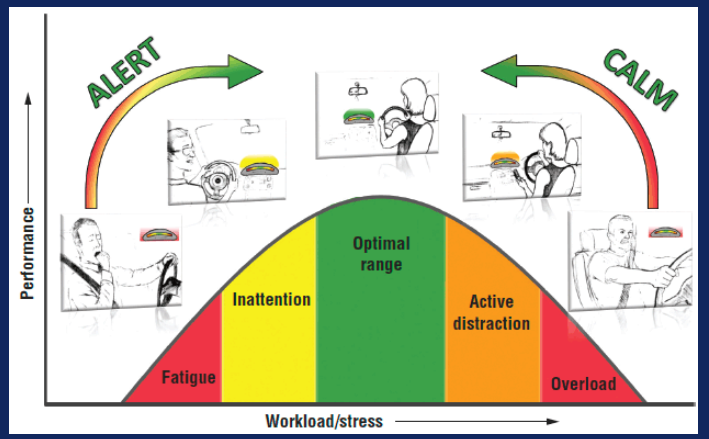


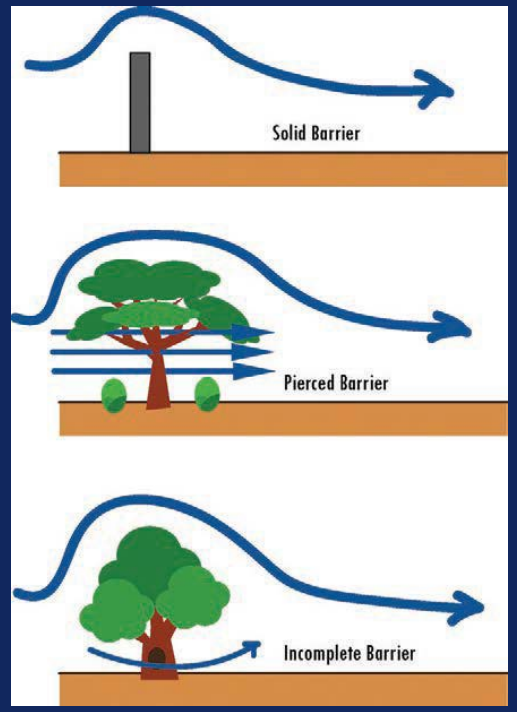
Steering visibility on roads



Driver's alertness stimulated by greenness and by interrupted monotony







Dust trapping in pierced tree wall

Many considerations in planning roadside vegetation

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7. Selecting roadside vegetation

The table on the next slides has been developed based on a review of authorative (agro)forestry and botanical references specific to Bangladesh and tropical Asia, and has been verified with experts.

#	Key points in selecting roadside vegetation
1	Mix of trees, shrubs and grasses for full range of benefits that vegetation can provide.
2	Decide on importance of different qualities and select species accordingly: carbon sequestration, timber value, non timber value, pollution abatement, noise reduction, soil improvement wind break, biodiversity harbour, shading effect, esthetic value, and reduced storm exposure.
3	Look at suitability for the concerned hotspot region: the Coastal Zone, the Barind and Drought Prone Areas, the Haor and Flash Flood Areas, the Chattogram Hill Tracts, and the Flood Plains and Estuaries

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Tree Species	Flood Plains and Estuaries	Coastal Zone	Haor and Flash Flood Areas	CHT Hill Tracts	Barind and Drought Prone Areas	Storm-proof (wind-firmness)	Stable Root System	Time to Maturity / End of Life	Height at Maintenance
Shorea robusta (Sal)	No	No	No	No	Yes	Moderate	Deep taproot, good for stability	15–20 yrs / up to 100 yrs	15–20m
Heritiera fomes (Sundari)	No	Yes	No	No	No	Moderate	Stilt roots, saline-tolerant	15 yrs / 70–100 yrs	15–20m
Barringtonia acutangula (Hijol)	Yes	No	Yes	No	No	Moderate	Deep-rooted, flood-tolerant	10–15 yrs / 50 yrs	8–12m
Artocarpus heterophyllus (Jackfruit)	No	No	No	Yes	Yes	No	Deep-rooted, pavement-friendly	7–10 yrs / 40 yrs	10–15m
Melocanna baccifera (Bamboo)	Yes	No	No	Yes	Yes	Yes	Fibrous root binds soil on slopes	3–5 yrs / 10–15 yrs	5–10m
Aegle marmelos (Bael)	Yes	No	No	Yes	Yes	Yes	Taproot, drought-resistant	8–10 yrs / 50 yrs	8–10m
Albizia lebbeck	Yes	No	No	Yes	Yes	No	Spreading roots, nitrogen fixer	4–5 yrs / 30 yrs	10–15m
Azadirachta indica (Neem)	Yes	No	No	Yes	Yes	Yes	Deep-rooted, low maintenance	3–5 yrs / 40 yrs	10–15m
Acacia auriculiformis	Yes	Yes	No	Yes	Yes	Yes	Fibrous roots, soil stabilizer	4–6 yrs / 30 yrs	10–12m
Ficus religiosa (Peepal)	Yes	No	No	Yes	Yes	No	Deep roots, pavement-safe	10–15 yrs / >100 yrs	20–30m
Terminalia arjuna	Yes	No	Yes	Yes	No	Yes	Strong roots for erosion control	10 yrs / 70 yrs	15–20m
Dalbergia sissoo (Sheesham)	Yes	No	Yes	No	Yes	No	Taproot, strong wood	10 yrs / 60 yrs	15–20m
Syzygium cumini (Jamun)	Yes	No	Yes	Yes	Yes	Moderate	Deep-rooted, fruit-bearing	6–8 yrs / 50 yrs	10–15m
Moringa oleifera	Yes	No	No	Yes	Yes	Yes	Light roots, fast-growing	2–3 yrs / 20 yrs	8–10m
Dipterocarpus turbinatus	No	No	No	Yes	No	No	Deep taproot, stabilizing	15 yrs / 80 yrs	25–30m
Terminalia bellirica	Yes	No	No	Yes	Yes	No	Strong root, drought-tolerant	8–10 yrs / 60 yrs	15–20m
Saccharum spontaneum	Yes	Yes	Yes	No	No	Yes	Fibrous roots, soil binder	1–2 yrs / 3 yrs	1–2m
Swietenia macrophylla (Mahogany)	Yes	No	No	Yes	Yes	Yes	Taproot, invasive risk	10 yrs / 60 yrs	20–30m
Areca catechu (Betel Nut)	Yes	Yes	No	No	No	Moderate	Fibrous roots, fairly stable	7–8 yrs / 60–100 yrs	15-20m
Palmyra palm	Yes	Yes	No	No	Yes	High	Deep anchorage	14-15 yrs / 60 yrs	25-30m

Tree Species	Carbon Seq.	Timber Value	Non-Timber Value	Windbreak Value	Shading Value	Biodiversity Harbour	Pollution Absorption	Dust Trapping
Shorea robusta (Sal)	High	High (furniture)	Resin, leaf plates	Moderate	Moderate	Supports birds, mammals, insects	Moderate	High
Heritiera fomes (Sundari)	Very High	High	Medicinal, tannin	High	Low	Nurseries for fish, birds, reptiles	High (heavy metals)	Moderate
Barringtonia acutangula (Hijol)	Moderate	Low	Flowers used locally	Low	Moderate	Attracts wetland birds, bees	High (nutrient filter)	High
Artocarpus heterophyllus (Jackfruit)	High	Medium	High-value fruit	Moderate	High	Habitat for insects, squirrels	Moderate	Moderate
Melocanna baccifera (Bamboo)	High (fast growth)	High (construction)	Crafts, shoots, fencing	Moderate	Moderate	Understory wildlife shelter	Moderate	High
Aegle marmelos (Bael)	Moderate	Low	Fruits, medicinal uses	Moderate	Moderate	Attracts bees, birds	High	Moderate
Albizia lebbeck	Moderate	Moderate	Shade, fodder, medicine	High	High	Insect and bird-attracting	Moderate	High
Azadirachta indica (Neem)	Moderate	Low	Medicinal, pest repellent	Moderate	Moderate	Habitat for beneficial insects	High (air purifying)	Moderate
Acacia auriculiformis	Moderate	Medium	Pods, firewood, gum	Moderate	Moderate	Shelter for birds	Moderate	Moderate
Ficus religiosa (Peepal)	High	Low	Shade, cultural	Moderate	High	Hosts birds, insects, epiphytes	Moderate	High
Terminalia arjuna	High	Moderate	Bark (medicinal)	Moderate	Moderate	Bird nesting, bees	High	Moderate
Dalbergia sissoo (Sheesham)	High	High	Fuelwood, shade	Moderate	Moderate	Hosts insects, birds	Moderate	Moderate
Syzygium cumini (Jamun)	Moderate	Low	Fruits, medicine	Low	High	Birds, bats	Moderate	Moderate
Moringa oleifera	Moderate	Low	Nutrient-rich leaves	Low	Moderate	Bees, insects	High	Moderate
Dipterocarpus turbinatus	Very High	High	Resin, medicinal	Moderate	Low	Birds, insects	Moderate	Moderate
Terminalia bellirica	High	Moderate	Medicinal fruits	Low	Moderate	Birds, bees	Moderate	Moderate
Saccharum spontaneum	Low	None	Fodder, erosion control	Low	Low	Hosts small wildlife	Low	Moderate
Swietenia macrophylla (Mahogany)	High	Very High	Shade	Moderate	Moderate	Limited biodiversity support	Moderate	High
Areca catechu (Betel Nut)	Moderate	Moderate	Nuts, fronds and fibers	Low	Moderate	Attracks polinators, bees, insects	Moderate	Moderate
Palmyra palm	Moderate	Moderate	Fruit, sap, leaves	Low	Moderate	Attracks wildife, supports local fauna	Moderate	Moderate

Tree Species	Sound Proofing	Esthetic Value	Soil Improvement	Other Benefits
Shorea robusta (Sal)	Moderate	Moderate	Adds organic matter	Cultural, ecological forest species
Heritiera fomes (Sundari)	Moderate	Low	Stabilizes coastal soils	Salt-tolerant, rare mangrove species
Barringtonia acutangula (Hijol)	Moderate	High (beautiful flowers)	Water purification, shade plant	Flood-resilient
Artocarpus heterophyllus (Jackfruit)	Low	High (massive foliage)	Enriches soil with leaf litter	Widely cultivated and loved species
Melocanna baccifera (Bamboo)	Moderate	Moderate	Prevents erosion	Renewable, grows fast
Aegle marmelos (Bael)	Moderate	High (fragrant flowers)	Improves soil with organic matter	Sacred in culture, pest repellent
Albizia lebbeck	High	High	Nitrogen fixing	Reduces urban heat island effect
Azadirachta indica (Neem)	High	Moderate	Adds leaf litter to soil	Mosquito repellent, antifungal
Acacia auriculiformis	High	Moderate	Nitrogen fixer	Wind-resistant, erosion control
Ficus religiosa (Peepal)	High	High (sacred fig)	Improves microhabitat	Cultural significance, oxygen release
Terminalia arjuna	High	High	Improves bank soil	Flood-control, medicinal
Dalbergia sissoo (Sheesham)	Moderate	Moderate	Fixes nitrogen	Agroforestry value
Syzygium cumini (Jamun)	Moderate	High (fruit tree)	Leaf litter	Food source
Moringa oleifera	Moderate	High	Improves nutrition	Climate-resilient, food security
Dipterocarpus turbinatus	Moderate	Moderate	Enriches forest soil	Supports evergreen forest biodiversity
Terminalia bellirica	Moderate	Moderate	Improves dry soil	Used in Ayurveda, traditional uses
Saccharum spontaneum	Low	Moderate	Prevents river erosion	Native grass, quick regeneration
Swietenia macrophylla (Mahogany)	Moderate	Moderate	Minimal soil benefit	High-value timber, ecological concern
Areca catechu (Betel Nut)	Low	High (tall, graceful palm)	Adds organic leaf litter	Valuable cash crop and cultural plant
Palmyra palm	Moderate	High (majestic palm)	Stabilizes coastal soils	Products support rural livelihoods

4. Way forward

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Next steps

A. Prioritization, program of action and capacity support
B. Improved methods of operations
C. Review enabling factors
D. Towards Green Roads

Priority list			
Opportunity to improve	Which area	Description	Severity
Are there areas with water logigng related to road development			
Are therceproblematic bridges (siltation, scouring)			
Are there road section with repeated maintenace problems			
Are there areas with special biodiversity			
Is contruction material sourced from fragile rivers			
Are there new road side springs - what is there condition			
Are there areas with marked decline in springs			
Are there areas that suffer from severe erosion			
Are there area where decline in fish capture is reported			
Which areas are most exposed to typhoons and devastative flooding			
Which areas are transitioning to high yielding amon paddy			
Which areas are effected by water scarcity			
……			

Improved methods of operation (1)
A number of changes in operational practices will facilitate GR4W

Need for a lifecyle perspective where:

- The total functionality of the roads is taken into consideration, including the effect of roads on the landscape of which they are part and vice versa.
- Decisions are not made piece-meal but are based on the total life-cycle of the road, including after care and asset management

Improved processes in planning and budgeting

- Planning roads with due cognizance of the natural topography and hydrology
- Make use of opportunities in land use planning.
- Construct all roads with cross drainage from the beginning
- Mainstream roadside vegetation
- Changing the choices in construction material.
- Improved budgeting: Increasingly working with a ‘life cycle’ approach, whereby long-term reliability of the infrastructure is served, and overall maintenance costs are reduced.

Improved methods of operation (2)

Improved processes in implementation and asset management

- Addressing the availability of land for roads and road shoulders
- Undertake responsible sourcing of the sourcing of materials
- Combine maintenance and repairs with a ‘building back better’ approach
- Further synchronize the fund disbursement with the timing of road development/improvement activities.

Improved processes in coordination

- Strengthen coordination between LGED and water organizations (BWDB (for roads cum embankments owned by BWDB), WARPO, WMOs).
- Improve coordination between LGED, LGIs and local communities in road construction, upgrading and maintenance
- Cooperation between LGED and NGOs
- Vetting of bridge and culvert design by BWDB in sensitive areas

Improved methods of operation (3)

Improved processes in aftercare and asset management

- Engage local community organizations in maintenance and avoiding disruption
- Consider engaging Labour Contracting Societies (LCS) on long-term basis in road maintenance, and where possible also in construction of local measures.

Local engagement and locally-led adaptation

- Important in the integrated approach of the Green Roads for Water concept is local participation, where the voices of roadside communities and the priorities of local governments inform and shape road development and maintenance.

- Shift from 'community engagement' to 'enhancing community resilience and promoting local leadership', paving the path for the integration of Locally Led Adaptation into the day-to-day reality. This also applies to the road sector.

- When road developments are tailored to these local priorities and realities, including bio-physical and socio-economic circumstance, the benefits gained by road development – particularly when embracing Green Roads for Water – have the potential to go far beyond transport-related benefits. Hence, engaging communities living in the hinterland in planning, design, and even O&M of roads, can have far-reaching knock-on effects in various sectors.

- This way, one will not only maximize benefits such as improved mobility and access to essential services but also enhancing water management by better managing road runoff and making it available for various purposes, such as agriculture and groundwater recharge.

Currently gong on: Supporting women groups in Rajshahi in the development of Locally-Led Adaptation Plans for Green Roads for Water. Supported by GCA and Global Affairs Canada, implemented by MetaMeta, Socioconsult, and WAVE Foundation

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C. Changing enabling factors

- The Guideline on Green Roads for Water is an important step forward towards combining road development and maintenance with achieve better water management and climate resilience and in the process improving the durability and quality of the road network itself.

- To introduce and institutionalize the approach enabling factors may be developed and modified – see table.

- The Enabling Framework Maturity Assessment – part of the ADB Green Roads Toolkit may be used to evaluate the current status regarding essential enabling factors for Green Road implementation

- Aim is to anchor and mainstream environmentally and socially sustainable road for water practice by providing a structured framework for assessing and enhancing all relevant enabling factors.

- The Maturity Assessment checklist helps identify gaps, prioritize areas for improvement, and facilitate broader adoption of Green Roads for Water Practices

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

Enabling factors required for the mainstreaming of green roads
(Source: ADB Green Roads Toolkit)

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TOWARDS GREEN ROADS

- Beyond Green Roads for Water there are several other Green Roads Dimensions: decarbonization, climate resilience, controlling pollution, improving the quality of life, promoting biodiversity, improved disaster risk reduction, safe sourcing and inclusive growth

- As with Green Roads for Water, LGED through its extensive road network can make a contribution on all those agenda as well.

- For the many related practices, see the Green Roads Toolkit

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10. Annexes

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