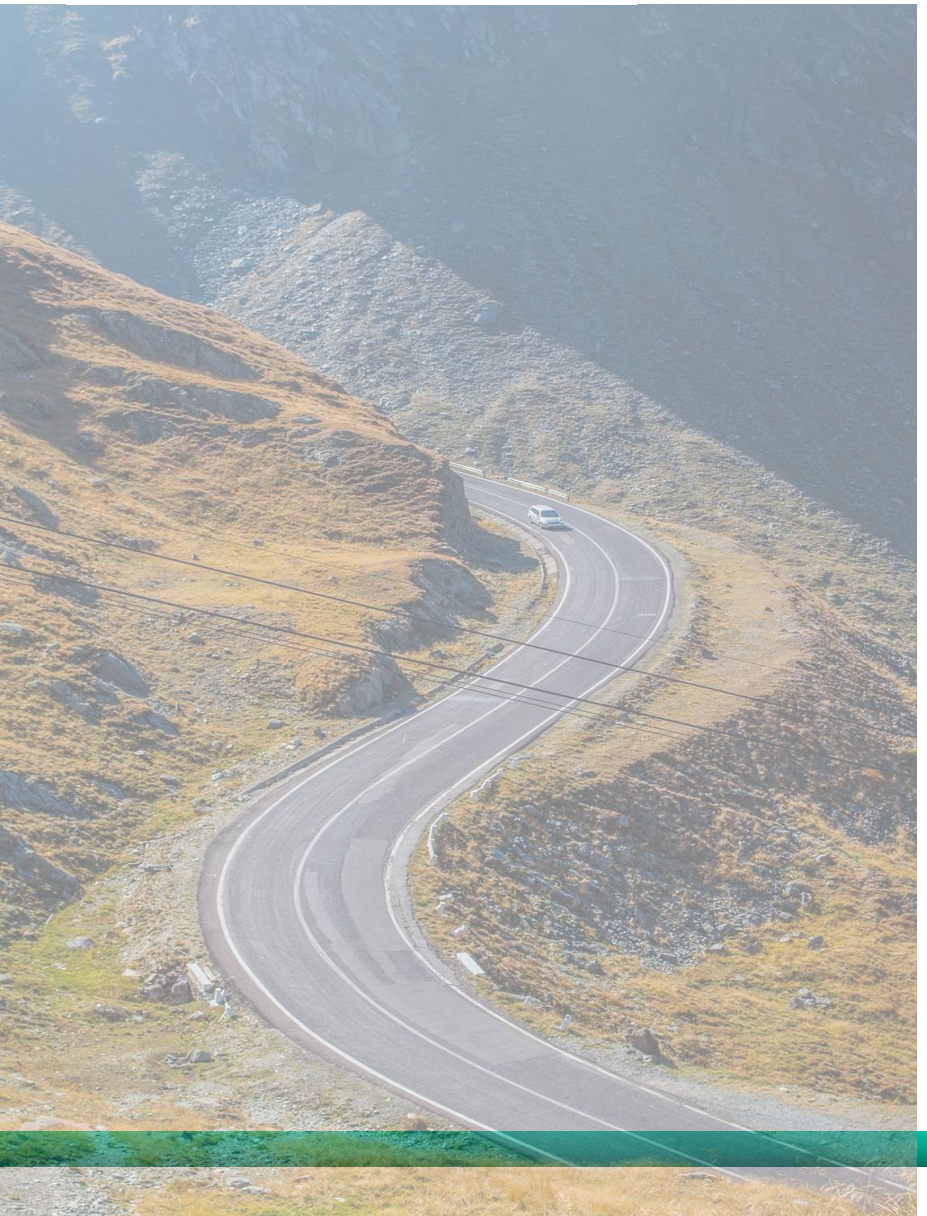
ESCAP
Economic and Social Commission for Asia and the Pacific

Towards an inventory of best practices for low carbon and resilient infrastructure along the Asian Highway Network

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UNIVERSITY OF SEOUL

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Contents

1. Introduction

2. Inventory of Best Practices

3. Case Studies

4. Conclusion

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1. Introduction



Infrastructure resilience and sustainability

- Developing Asia faces significant challenges related to infrastructure resilience – its ability to adapt to climate and geophysical hazards.
- Between 2004 and 2020, natural disasters caused more than $500 billion in losses across Asia, affecting 2.1 billion people. (Sirivunnabood and Alwarritzi 2020)
- Up to $1.7 trillion in annual capital expenditures are required to develop Asia's infrastructure resilience to match the demand between 2017 and 2030.

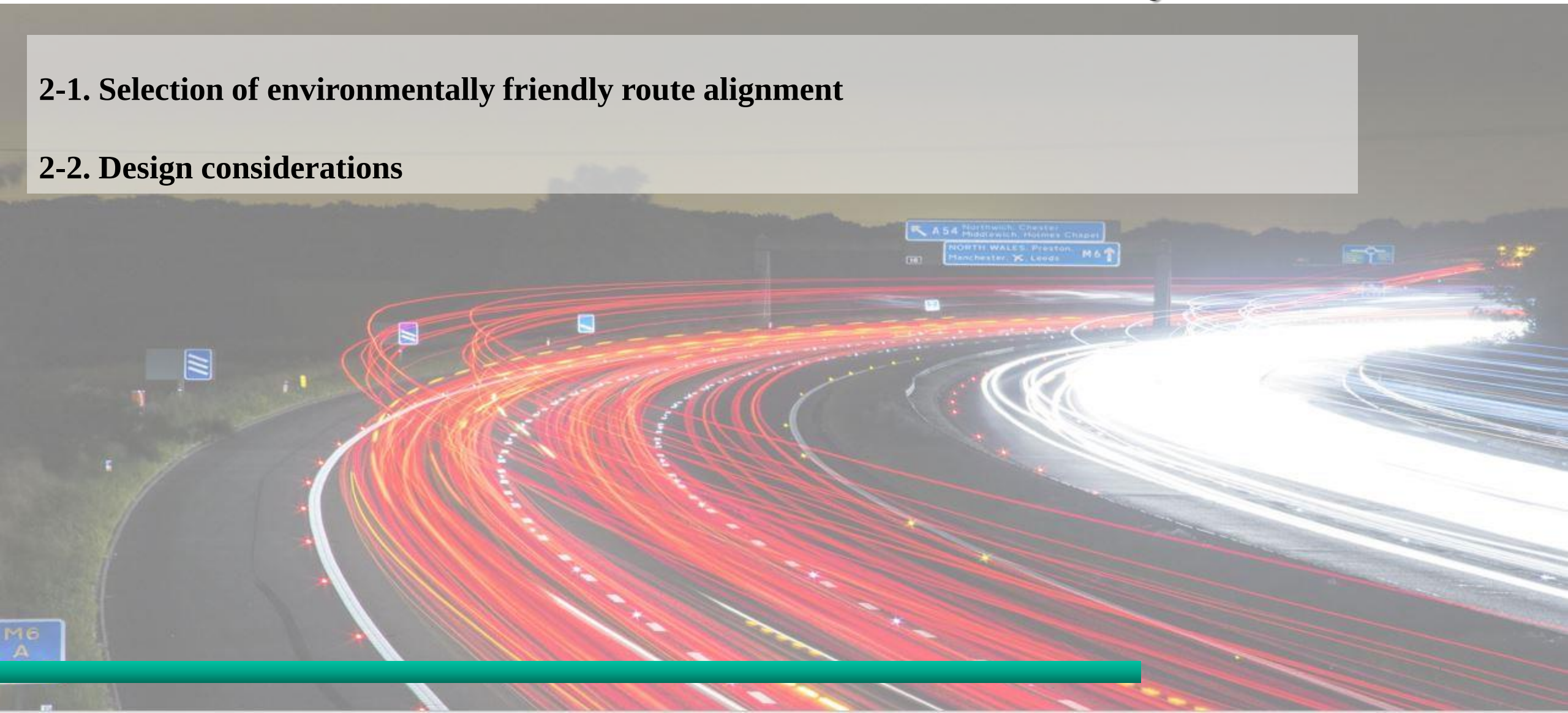
Supporting the policies on green and resilient transport infrastructure along the Asian Highway Network

- With the purpose of increasing the awareness and understanding amongst member countries regarding new construction and design elements, including state-of-the-art engineering technologies and construction materials

2. Inventory of Best Practices

2-1. Selection of environmentally friendly route alignment

2-2. Design considerations



2-1. Selection of environmentally friendly route alignment

- Multi-sectoral factors must always be considered when selecting an environmentally friendly route alignment.

Factors	Sub-factors	Checklists
Social factors	Social factors	- Demography, employment, housing, and socio-economic indexes - Suitability with existing and future development plans - Involuntary resettlement (building dismantling) - Land use
	Cultural assets	- Cultural assets - National treasures
Economic factors	Economy related	- Construction time - Construction cost - Operational cost and maintenance cost - Benefit-cost ratio
Environmental factors	Environment related	- Noise and vibration - Air quality -Water source - Groundwater - Wildlife
	Appearance and aesthetics	- Involuntary impacts on the landscape - Incorporation of leisure facilities

2-1. Selection of environmentally friendly route alignment

Factors	Sub-factors	Checklists
Technical factors	Technical function of the highway	-Design changes -Relation with national and regional road plans
	Traffic-related	- Origin-destination of traffic - Traffic flow direction and quality - Traffic volume during off-peak and peak hours - Road capacity - Design speed - Pedestrians - Availability of bicycle lanes
	Safety-related	- Demand for safety facilities - Availability of intersections and interchanges
	Civil engineering-related	- Site accessibility - Constructability and safety - Geotechnical conditions - Location of tunnel/bridge and length - Location of obstacles - Source of materials - Drainage plan

2-2 Design considerations: 1) Terrain and topography

- Since highway construction causes irreversible impacts to a vast area, areas with high conservation values should be free of impact if possible. In case impacts to those areas are inevitable, impact-reducing methods shall be employed.

Impact-evading methods	Impact-reducing methods
Total avoidance of the area with high conservation values	- Alignment adjustment to minimize earthworks - Cohesive soil treatment (surface, soil substitution, soil loading, vertical drainage, etc.)
Examination of relevant law to divert the alignment away from the area	- Application of structures (bridges) - Areas, where excessive cutting or banking occurs, can have their earthwork reduced by using bridges.
Involvement of social and environmental expert to minimize impacts by proposing alternative alignments away from the proposed site	- Application of tunnels - Tunnels can shorten the distance significantly and subsequently reduce the earthwork volume.

2) Wildlife

- Environment specialists should be involved in early stages or preparatory stages of the project to assess potential impacts to the existing wildlife, and if a severe impact is expected, the alignment should be planned to avoid the site. If it is not the case, impact-reducing methods should be implemented. One of the most widely used impact-reducing methods is wildlife crossing (eco-bridge)



Wildlife type	Considerations
Amphibian, insects	Bridge type or tunnel type is appropriate as spawn and habitat should be connected as well as the hibernation area. Side ditches along the road should not have sharp slopes
Mammals	A detailed pre-survey should be carried out to determine the size of wildlife crossing, as the requirements differ vastly depending on the size of animals and habits. Small mammals require linear at-grade crossing, whereas larger mammals need tunnels and bridges.
Birds	A thorough consideration of vegetation that the birds can use as their habitat is needed. Unlike amphibians, insects, and mammals, larger areas are covered, and trees larger than vehicle heights are needed to prevent birds from flying at lower levels.

3) Hydraulics/hydrology

- Since highways are likely to be constructed along rivers or cross them, impacts to waterways are inevitable. The alignment in principle should not cross designated conservation areas, but bridges may be installed in case it does.

Impact-reducing methods	Details
Bridge construction	Alignment, constructability, maintainability, economic feasibility, harmony with the environment, construction location, type of bridges should be considered, as well as opinions of local stakeholders. Location of piers and bridges should provide sufficient surface area for waterways and existing current flow.
Relocation of existing river	The relocation of the existing river should always aim to preserve the formation and shape of the existing river as much as possible, including the hydraulic flow, slope, vegetation, fish breeding ground block, rapids, etc. On river banks, bank protection works using riprap, rocks, gabion, green slope construction, green mat, etc., shall be considered.
Drainage system	Insufficient drainage from the road pavement surface can damage surrounding areas with inundation, decrease driving quality and lead to the deterioration of pavement structure. Thus, side ditches, stone-filled dummy ditches, and drainage pipes are to be provided on road shoulders.

4)Land use and 5) Air quality

- Both land use plan and air quality should always be considered to make the highway sustainable and environmentally friendly

Land use	Air quality
Minimization of integration of land and agricultural land to road area	Surveying vulnerable facility locations (schools, kindergartens, hospitals, senior-citizens centers, villages, etc.) and providing sufficient distance from the road
Efficient land use plan	Introduction of sprinklers at construction site
Balance between earthwork volumes (cutting versus banking)	Vehicle and vehicle wheel washing facility
Consideration of surrounding urban and regional development plan	Tunnel ventilation system – considering tunnel length, conditions, ventilation quality, etc.
Installation of pedestrian facilities to generate pedestrian traffic demand	Strict truck/construction equipment control system to minimize air quality deterioration
Plan to use abandoned road land, restoration plan, plan to convert it into minor road, etc.	

6)Water quality and 7) Soil quality

- Construction of a highway impacts water quality and soil quality due to its nature requiring a considerable amount of earthworks.



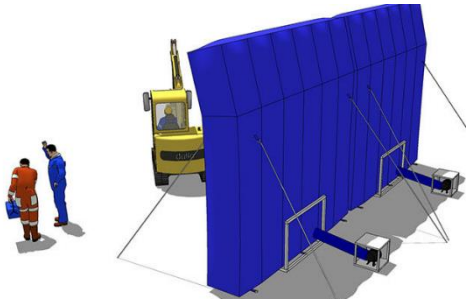
Water quality	Soil quality
Establishment of soil erosion reduction and prevention measures such as installation of drain, cover for cutting and banking, preliminary greening works, and sand basin. Sand basins shall be planned considering their shape, waterproofness, structure, average flow speed, detention time, depth, surface load, capacity, location, etc.	Revegetation to reduce and stabilize sedimentation of slopes and provide drainage through evapotranspiration
	Improved drains (side ditch and cross drainage). Vegetation within drains to reduce drain flow energy. Sedimentation basins to settle unwanted silt and pollutants, preventing unwanted spills through drains
Installation of impact-reducing facilities such as cofferdam, flow diverting works, silt protectors, etc.	Waste oil treatment and human and livestock manure treatment (Consigned treatment company to collect them)
Groundwater and runoff treatment facilities nearby road and tunnel construction sites	SVE method (Soil vapor extraction), SFE (Supercritical fluid extraction method, chemical oxidation treatment, etc.

8) Construction waste management and 9) Noise & vibration

- Both domestic waste and construction wastes should be treated carefully to make highway construction sustainable, whilst noise and vibration should also be considered.

Construction waste management	Noise and vibration
Incineration of wastes that cannot be recycled	During earthworks Installation of temporary soundproof walls, use of low-noise heavy equipment, limits on size and number of equipment
Separation of construction wastes from non-wastes, and clear marking of construction wastes with a visible sticker	During blasting Impact reducing plan and test blasting
Classification of wood waste biomass from tree removal (into branch, root, etc.) for storage and drying.	During pile driving Use of hydraulic pile driver after pre-boring, application of the SDA (Separation Doughnut Auger) method





3. Case Studies

3-1. Dynamic Adaptive Policy Pathways for Road Resilience in Cambodia

3-2. Smart Highway Representative Projects in China

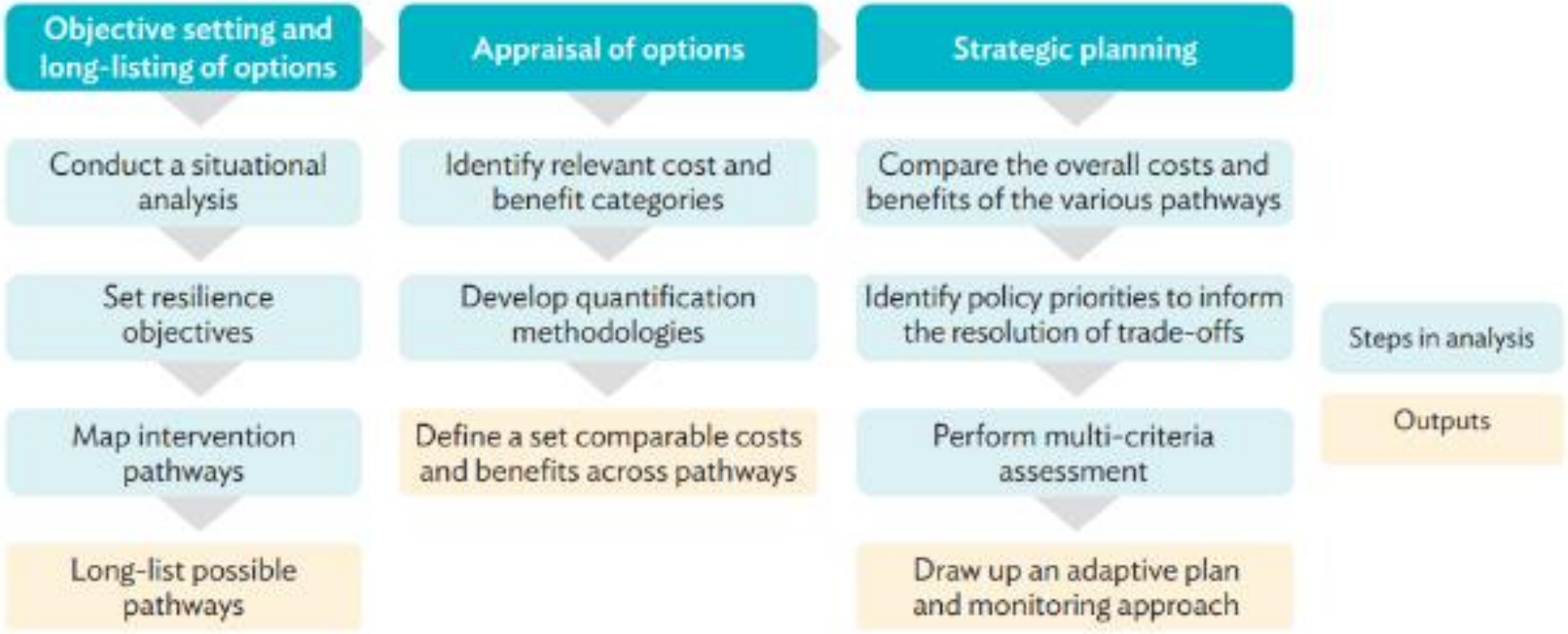
3-3. Best practices from the Smart Expressways, Republic of Korea

3-4. Best practices from Türkiye

3-5. Geosynthetic Reinforced soils for Low-cost bridges in Sri Lanka

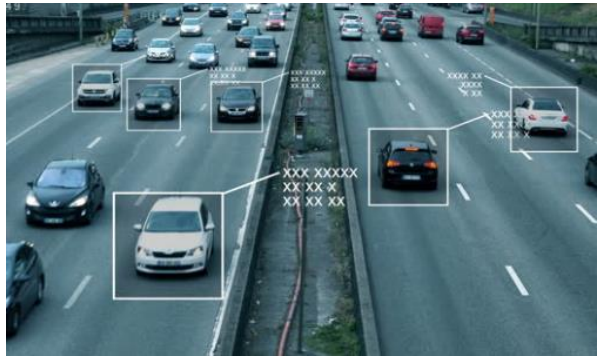
3-1. Dynamic Adaptive Policy Pathways for Road Resilience in Cambodia

- Cambodia has adopted DAPP (Dynamic Adaptive Policy Pathways) to assist decision-makers in addressing climate risk policy-related issues.
- The three-step approach consisting of objective setting and long-listing of options, appraisal of options, and strategic planning has been provided.



3-2. Smart Highway Representative Projects in China

- In 2019, China had 5 million kilometers of highways with 161,000 kilometers of expressways.
- Since there was an imbalance between the mileage and inefficiency of highway operation, the Ministry of Transport aims to digitalize highways by 2035.
- Smart highway pilot projects such as S342, Jiangsu, and Superhighway pilot projects like G92, Zhejiang have been introduced.
- While the former included video surveillance, meteorological monitoring, de-icing, and snow removal to deal with extreme weather effectively, the latter focused on adaptation of new materials such as Hot in-place recycling and EPS lightweight mixed soil technology.







3-3. Best practices from the Smart Expressways, Republic of Korea

- In response to the increasing demand for emission reduction in the transportation sector, the Republic of Korea introduced environmentally friendly heavy construction equipment.
- Conglomerates such as Hyundai Motors Group and Doosan Bobcat have introduced electric, hydrogen fuel cell, and lithium-ion battery-run construction equipment that can significantly reduce CO2 emission and energy costs.
- A charging station that can fuel electric loaders and hydrogen vehicles at the same time has also been developed.

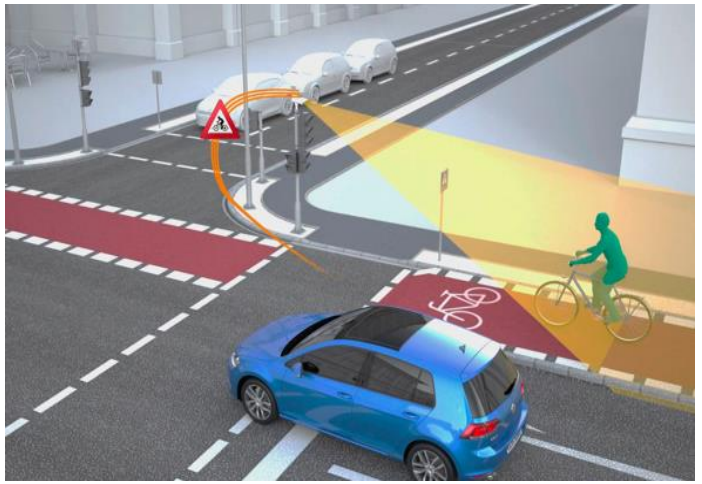




3-4. Best practices from Türkiye

- In Türkiye, it was found that dual carriageways with central barriers produce approximately 4.68 million tons less CO2 emissions per year than undivided highways. Consequently, the government set to convert undivided highways into dual carriageways.
- Similarly, ITS (Intelligent Transport System) in crossroads has been introduced for efficient traffic management, optimum sharing, and improved vehicle safety.
- In addition, bicycle lanes along the highway shoulders have been constructed to discourage the use of motorized vehicles and to divert existing traffic volume to other public transport modes.

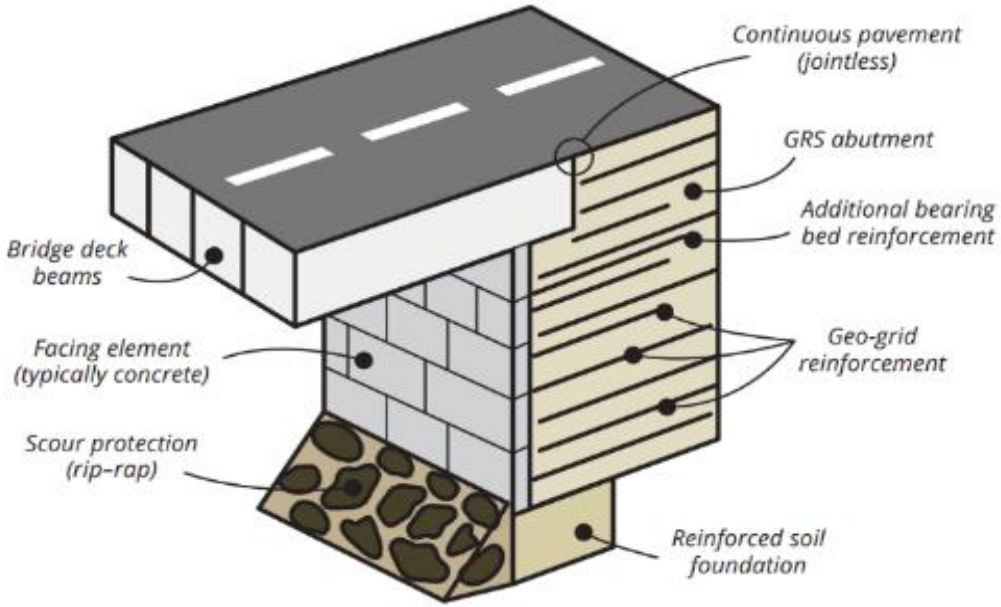






3-5. Geosynthetic Reinforced soils for Low-cost bridges in Sri Lanka

- Most of the bridges in Sri Lanka had suffered significant deterioration due to poor maintenance and extreme weather conditions and were left vulnerable to high floods.
- A World Bank-funded study provided an option where GRS (Geosynthetic Reinforced Soil) technology is adopted for bridges in Sri Lanka.
- The study result suggested that locally sourced materials can be used in addition to GRS to construct bridges faster with lower cost than traditionally piled abutments (As little as five days and at a cost of 30-50 % below traditional methods).



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4. Conclusion



4. Conclusion

Inventory of best practices

- Various methods to either evade or reduce environmental impacts should always be considered when constructing expressways to make them more resilient and sustainable.

- Different standards and regulations may benefit each country's highway at the national level. Still, interoperability between neighboring countries must always be considered so that ESCAP member countries can benefit from the advantages of cross-border connectivity.

Sustainable road development is not just an investment in infrastructure, it's an investment in the future!

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