

Technology Fact Sheet for Adaptation

VIII. Climate resilient roads ⁱ

Introduction

Road transport plays an important role in the overall socio-economic development of a country. In Bhutan, roads are the main transport infrastructure enabling trade, public services delivery, governance, tourism, and so on. The Royal Government aims to provide road connectivity to all the 205 gewogs primarily to reduce poverty and promote rural development. However, road infrastructure, especially in the geologically fragile mountain terrain of Bhutan, is extremely environmentally challenging and highly vulnerable to the impacts of climate change such as flash floods and landslides caused by heavy rains. In addition, rapid growth in vehicle numbers and movement make road infrastructure vulnerable.

The road networks of developing countries are generally more vulnerable to climate change impacts due to poor condition, a high proportion of unpaved roads and limited resources and technology to adapt.

Technology characteristics

A climate resilient road comprises a set of technological measures rather than a single technology. The measures to make roads climate proof are generally classified in two categories¹:

1. Engineering and structural measures- Under these measures the technologies typically includes the following:

- Slope stabilization structures such as dry stone wall, gabion wall and jute bag wall. The choice of the structure is dependent on the gradient of the road and road construction materials.
- Paving of roads with durable materials
- Proper alignment of new roads to avoid vegetative loss
- Improved drainage systems to avoid erosion of road materials. The drainage system includes drainage and cross drainage structures such as cascades, small check walls, culverts and causeway.
- Improved planning of roads with proper cross section and standard dimensions

2. Bio-engineering measures-

Bio-engineering is the use of vegetation, either alone or in conjunction with civil engineering structures² such as small dams, wall and drains to manage water and debris thereby reducing instability and erosion on slopes³. Bio-engineering measures are also taken during earthwork and excavation activities of road construction. These include among others spreading of top soil, broadcasting seeds, grass slips and seedling of local plants. Typical bio-engineering methods include the following:

Grass Planting- Grass seed is spread or alternatively grass is hand-planted in lines across the slope. This results in slope stabilization by armouring and reinforcing of slopes.

Shrub and Tree Planting- Shrubs or trees are planted at regular intervals on the slope which later create a dense network of roots in the soil supporting the slope.

Brush Layering, Palisades and Fascines- In this system, woody cuttings are laid in lines across the slope usually following the contour which form a strong barrier, preventing the development of rill, and trap material moving down the slope. The system catches debris, armours and reinforces the slope.

¹ <http://www2.adb.org/Documents/RRPs/CAM/42334/42334-01-cam-oth-03.pdf>

² <http://himachal.nic.in/hpridc/RandD.pdf>

³ <http://www.scidev.net/en/features/landslide-victory-bioengineering-in-nepal.html>

Composite Systems- A range of composite systems are also used including live check dams, vegetated stone pitching and planted geotextiles later supplemented by the vegetation. The composite systems reinforce the soil thereby stabilising the slopes.

Country specific applicability and potential

Bhutan's terrain is intrinsically fragile, consisting of high ridges and deep gorges. The impact of extreme weather events like flash floods and landslides has high impact on country's road network. In Bhutan, each monsoon is accompanied by severe damages to road infrastructure across the country due to landslides, flash floods and road blocks. Owing to climate change, these events are likely to intensify further in the near future, hence there is an utmost need make the country's road infrastructure resilient to climate change induced events.

Bhutan's total road network length is 4,393 km out of which 1,659 km are rural roads⁴. While the rural roads are particularly vulnerable to extreme climatic events resulting in landslides and heavy erosion, the main roads are also vulnerable as these are also constructed in hilly terrains. In addition, the government is also planning to provide better mobility to further remote populations resulting in construction of additional rural roads. Therefore, the potential of applicability of climate resilient road infrastructure measures is very high in the country.

Status of technology in country

Under the Rural Access Project (RAP) of Department of Road, Bhutan the Environmental Friendly Road Construction (EFRC) technique was adopted to minimize the environmental degradation during construction and subsequent operation. In the first phase of this project, 122 km of roads were constructed based on the EFRC technique⁵. In the second phase, a total of 42.5 km of roads were included⁶. This signifies that adaptation of road infrastructure to climatic events have been considered in road construction in the country. However, according to local road and transport experts there is still a large scope of improving the construction quality by adopting latest technological improvements and there are many vulnerable regions where advanced technologies need to be adopted to reduce impact of natural disasters on road network.

Benefits to economic / social and environmental development

Investment in climate resilient roads takes away the need to invest in maintenance and reconstruction of damaged roads every year.

It helps in better distribution of supplies during natural disasters, which earlier would have damaged the road networks and obstructed distribution of relief.

Climate resilient roads are constructed in such a manner that the impact on bio-diversity is minimized and by adopting bio-engineering measures it attempts to maintain the existing biodiversity in the region.

Significant reductions in social and economic costs due to lesser occurrence of road blocks during rainy season and smoother mobility due to better road conditions, results in savings in times of travel time, fuel costs and vehicle repairs.

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<http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSARREGTOPTRANSPORT/0,,contentMDK:20694192~pagePK:34004173~piPK:34003707~theSitePK:579598,00.html>

⁵ National Report on Bhutan For World Conference on Disaster Management, Ministry of Home and Culture Affairs, Bhutan; 2005

⁶ http://www.dor.gov.bt/Publication/EA_R_DB_English.pdf

Climate change adaptation benefits

Roads that are built to be climate resilient can tremendously enhance the adaptive capacity of a country like Bhutan. It can augment other adaptation measures as well. Climate resilient roads can help in providing people a route to reach safety during calamities and ensure adequate service levels of the road network under extreme weather conditions.

Financial Requirements and Costs

Currently, no specific cost estimate exists for Bhutan for construction of roads focusing on climate change adaptation. The ADB programme in Cambodia, however, provides some reference estimate of costs related to adaptation measures in rural roads. The programme indicates that the cost estimate for climate change adaptation component activities is 5.4 Million USD. These activities primarily include bio-engineering measures, development and testing a pilot local early warning system and a pilot programme for emergency management planning for rural roads⁷. The EFRC project in Bhutan estimated that EFRC roads cost 15-25 percent higher than conventional roads during the construction phase. However, the additional costs would nullify in 7-9 years due to low maintenance costs and over the long-term, EFRC roads would be much cheaper than conventional roads⁸. The EFRC project estimated the cost of EFRC roads at around US\$ 60,000 per km.

ⁱ **This fact sheet has been extracted from TNA Report – Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation – Bhutan. You can access the complete report from the TNA project website <http://tech-action.org/>**

⁷ <http://www2.adb.org/Documents/RRPs/CAM/42334/42334-01-cam-oth-03.pdf>

⁸ Visser H and Richter I (2008). EFRC in Bhutan: Multi-stakeholder Sector Development and Complex Change Facilitation, Case Study by Netherlands Development Organization (SNV).