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TITLE: Environmental Friendly Road Construction in Bhutan - Providing access to rural communities while protecting the environment

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1. Introduction

This paper presents main developments in the road sector of Bhutan and the Environmental Friendly Road Construction (EFRC) concept used by the Department of Roads, Ministry of Works and Human Settlement. First a brief overview is given of main characteristics of Bhutan and of rural access development. After that the scope of the EFRC Support Project is explained. The project goes beyond the Department of Roads and included farm and forestry roads, construction sector and district support and the development of curricula for technical training institutes. This is followed by a description of the technical features of EFRC which have been applied in Bhutan under the project. Thereafter the importance of quality assurance, mechanisation of road works and private sector participation is presented. Finally the economic feasibility of EFRC (and higher road standards in general) and the need for integrated transport master planning to justify the high public investments in the road sector are discussed.

2. Bhutan

The Kingdom of Bhutan, or the land of the thunder dragon, covers an area of approximately 38,394 square kilometres. It borders the Tibetan autonomous region of China in the north and India in the east, west and south.

The climatic conditions vary due to the mountainous nature of the country. The country has the monsoon rain in summer, with relatively dry winters. About 73 percent of the land area is covered by forests of temperate and sub-tropical varieties that are a natural habitat of a diversity of flora and fauna. The country has one of the richest biodiversity in the world with about 3,281 plant species per 10,000 square kilometres and has been declared one of the ten global biodiversity ‘hotspots’.

Bhutan is one of the least populated countries in South Asia. Most of the population is concentrated in the valleys, whilst large areas at higher altitudes in the north of the country are virtually unpopulated except for nomadic herders. The population was estimated to be 699,000 in 2001, with more than 40 percent of people aged below 15 years old.

The population is probably growing at between 2.5-3.5 percent per year, placing great pressure on natural resources in the villages and resulting in a high rate of migration from rural to urban areas. However, the current rate of increase is expected to decline to 1.6 percent per annum in 2011 and 1.3 percent in 2016. Approximately 80 percent of the population lives in villages in an extended family system. The average household is estimated to comprise between 6-8 members, with an average of 43 houses per village. There are approximately 80,000 landholdings in rural Bhutan. About 60 percent of farmers own less than 2 acres, which is usually insufficient to feed the averaged size family. Only 7-8 percent of the land can be cultivated and the population pressure on land and other natural resources has become a real challenge.

The livelihood of the rural population has improved significantly during the past 20 years; most villages have improved access to health, educational and agricultural services but some 30 percent of rural households may remain vulnerable, with consumption levels close to the poverty line. The improvement of rural livelihoods has to go hand in hand with the preservation of the bio-diversity, which will become an increasing challenge.

Rural-urban migration is a serious problem. The majority of Bhutanese live in rural areas but about 20 percent of the population now lives in urban areas. Centres like Thimphu, the capital with a population of almost 50,000, and Phuentsholing, the most important border post for goods flowing to/from India to Bhutan, have been growing very quickly.

3. Economic development through rural access

One of the keys to the economic development of the country is the provision of an efficient and cost-effective transport system for freight and passengers. This is particularly important in the context of Bhutan's difficult physical terrain. The country is land-locked and almost entirely located in the various mountain ranges of the Himalayas. This makes it highly dependent on road transport for trade and the provision of domestic road transport links difficult, particularly in the northern area of the country.

Because of the mountainous terrain, with altitudes ranging from 200 to 7,500 metres, the area of land suitable for agriculture is very limited and the population is distributed in remote scattered settlements. The above factors make the construction and maintenance of roads and the delivery of health, education and other socio-economic services extremely difficult and costly.

The Royal Government of Bhutan's (RGoB) Five Year Plans (FYP), which have since 1961 placed strong emphasis on improving the country's transport infrastructure, have resulted in a road network which covers almost all of the district capital towns (except Gasa) and main settlements.

Bhutan currently has over 4,000 km of road network, but many rural communities are still cut off from the road network and depend on animal and head-load transport. Almost one–third of all Geogs (sub-districts or blocks) are not connected to any roads and in another one–third of the Geogs the connection to the road network is very limited. In this situation, farmers remain dependent on subsistence agriculture, with no direct access to markets or education and health care services. There is therefore a clear need to expand the national road network to improve their quality of life.

At the same time, travel on the National Highways remains slow and costly, and existing roads will have to be upgraded or improved. Maintenance of the existing infrastructure is an equally important component of the development, management and maintenance of the road system.

Priorities for the next 20 years include further development of national trunk roads and the network of district and feeder roads. The expansion of access to rural areas and to vulnerable groups through farm roads, power tiller and mule tracks is also actively being implemented.

4. The Middle Path

Bhutan has realized the possible problems that could be caused by uncontrolled development. It has also recognized the importance of sustainable development with its fragile mountain ecosystem and extremely rich bio-diversity. Accordingly, Bhutan has chosen the “middle path” where economic development takes place while preserving natural resources and preventing environmental degradation. The Environment Assessment Act, 2000 and the regulation for Environmental Clearance of Projects, 2002, (both developed by the National Environment Commission NEC) ensure that environment assessments are conducted for all development activities that have potentially significant environmental impact.

Below: damage caused by traditional road construction of the first 7 km of Dakpai-Buli road, Zhemgang District.

Road construction has a large potential negative impact on the environment. Inadequate road construction techniques cause significant damage to forests, land and water sources and reduce the quality and lifetime of the road. A maximum effort therefore needs to be made to prevent and mitigate the negative impacts of roads. Road projects can therefore only commence upon receipt of environmental clearance from the NEC or authorized government departments. The terms and conditions and implementation of the environmental clearance are monitored on site and penalties are imposed for non conformance. The Ninth Plan also states that all road construction activities are required to follow the environmental assessment guidelines for roads, the Environmental Code of Practice for Highways and Roads and that environmentally sound construction techniques must be adopted.

5. The EFRC Support Project

At the end of 1999 SNV Bhutan started its support to the Department of Roads for the implementation of a World Bank credit for the construction of 122 km of feeder roads.

Since Environmental Friendly Road Construction techniques were new in the country, the project focussed on the development and use of EFRC techniques and on creating an enabling environment for EFRC. In 2002 SNV Bhutan, with support from the Sustainable Development Secretariat (bi-lateral funding from The Netherlands), agreed to continue its support to further develop and introduce the EFRC concept and to further strengthen the capacity of the Department of Roads (DoR) and other stakeholders involved. To this end the EFRC Support Project started in March 2003.

The support from SNV Bhutan in the EFRC Support Project is focused on strengthening the organisational and institutional capabilities of the Department of Roads and other stakeholders involved in road construction and ultimately to create sufficient in-house capacity within the client organisations to achieve sustainability. To effectively assist its clients, SNV provides a mix of technical-thematic and change expertise.

The main objective of the advisory services of SNV is to ensure that all future road constructions in Bhutan are well planned and environmental friendly. The aim of strengthening the cooperation between all the partners is ultimately to create a self-sustaining Bhutanese capacity to carry out environmental friendly road construction.

The (technical) advisory services include expertise for planning, surveying, design, supervision, execution, quality assurance and maintenance of the road construction projects. The current Technical Assistance team comprises of two international road engineering experts, five national road engineers, one environmental specialist, one construction development specialist and one community maintenance specialist.

A variety of short term national and international experts are available through the project in the areas of quality assurance, bio-engineering, engineering geology, curriculum development, equipment management, transport economy, community organisation development and construction sector development.

The EFRC Support Project will end in December 2005. Currently there is a high demand for (continued) services in the road sector, from RGoB as well as the international donor community. The demand particularly focused on strengthening the capacity for infrastructure development at district level; integrated district master planning and rural accessibility planning combined with rural enterprise development and marketing support.

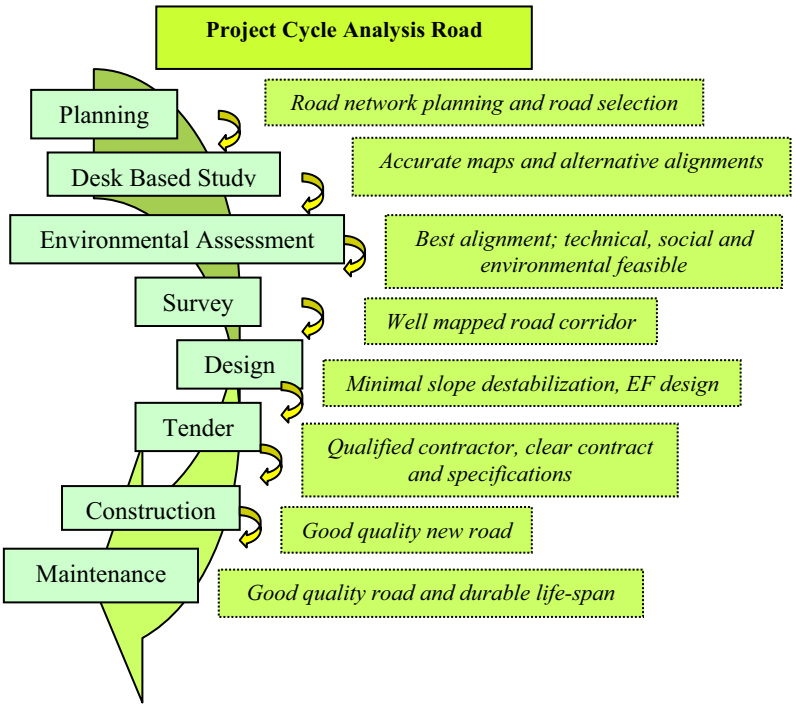
6. Environmental friendly roads – the process

For the introduction of EFRC the existing project cycle for building roads was analysed and adapted to include environmental friendly features. Firstly, it was important to develop a realistic implementation plan for the road project, as well as a proper monitoring and evaluation system. A key task at the start of the project was also to develop an Environmental Code of Practice, which provides environmental guidelines for all the stages of the road project cycle.

Environmentally friendly design takes into account specific site conditions such as geologically sensitive areas, wet areas, rocks, paddy fields and areas with high environmental and cultural value, to prevent and mitigate environmental damages, as much as possible. Such important site conditions are first identified through a “desk based study”. The desk based study uses accurate maps (1:5,000) and aerial photograph interpretation to identify the geologically-hazardous and environmentally and culturally

vulnerable areas. These areas are marked on the map after which the alternative road networks and road alignments can be plotted to design a low-cost road network with an as large as possible area serviced by the network. The desk based study is followed by a feasibility study and an environmental impact assessment (EIA), which includes social, ecological, technical and economic aspects. The proposed road alignments must also be verified in the field from an economic, technical, social, geological and environmental point of view. Therefore the Department of Roads survey team collaborates with the Environmental Assessment team and when necessary with a team of the Department of Geology and Mines to identify the best possible alignment.

The National Environmental Commission Secretariat then reviews the EIA report, in order to issue the environmental clearance. Based on the approved alignment an inventory is produced of the affected households and loss of land and other property resulting from the (future) road. Compensation is made available to ensure that the costs and benefits of the road are equally distributed.



By building the roads away from geologically-hazardous and culturally-vulnerable areas, many problems can be avoided during construction and this increases the quality and life span of the road. The design engineer needs to find the optimal balance in the design between prevention of (environmental) damage and investment and maintenance costs over the life-time of the road. In order to make an optimal environmentally friendly design, detailed survey data must be collected about forest cover, soil classification, slope steepness, water sources, cultural heritage, and other site conditions. For this purpose, survey teams have been trained to collect detailed information and make site assessments. Based on the survey data locations of spoil deposits, barriers, walls, drainage points and other structures are taken up in the design and drawings.

7. Environmental friendly roads – the method

Environmentally friendly design aims to minimize where possible cuts into mountain slopes. Where the slopes are fragile and prone to landslides, part of the road width will be made in fill, by constructing retaining walls.

Box cut designs are avoided as much as possible in order to reduce the volume of cut and the height of cut. Based on experiences from completed projects, it is estimated that the

volume of cut decreases by roughly four times if box cuts are avoided in the design. It is also estimated that by shifting the road's centre line to the valley side by 1 meter, the reduction in cut volume amounts to 35 % and that by shifting 2 meters the reduction of cut volume amounts to 65%. The design engineers must find a balance between less cutting into the slopes and higher investment required for retaining walls.

The cutting of trees is kept to a minimum and only within the road corridor. The previously used bulldozers have now been replaced by excavators, which allows for the loading of tippers and the transport of excavated surplus material and debris to selected disposal sites. Excavated materials have now also been segregated in order to optimise re-use. Excavation is undertaken in benches starting from the top batter with a smaller excavator and subsequently excavation to the final level with a medium sized excavator.

Controlled blasting is adopted in order to minimize damage to the surrounding hill environment and to prevent destabilization of the slopes. Marshy areas are drained before excavation is allowed through the construction of gravel drains and other water management structures such as catch drains.

Barriers are constructed out of logs or boulders at about 10-15 metres below the road are used to catch falling materials and in some cases to allow for controlled dumping of excavated materials. Trenches, excavated by excavator below the road alignment, are also used for the same purpose. These features are especially important to protect the valley side vegetation from damage and to create spoil disposals near the excavation site. The latter is important since transport of excavated materials is relatively expensive.

Pictures left: Log barrier and stable slope after controlled blasting

Permanent structures and road foundation and surface layers are now taken up with the formation-cutting works in one contract. This provides an incentive for the contractor to ensure that excavated useful materials like boulders are kept aside and are used as construction materials for the structures and base course. It also ensures that proper water drainage is available right from the first monsoon, to avoid the risk of erosion and landslides.

A new design for retaining walls, with gabion boxes, has been introduced. These walls are permeable and are flexible enough to adapt to small slope movements. Bioengineering works are carried out in conjunction with the construction of support structures like breast- and retaining walls. The use of selected vegetation to stabilize and protect slopes against erosion in the monsoon has proven to be very successful and cost-effective.

During construction, environmental management plans are used to prevent and mitigate environmental hazards. The DoR is monitoring the environmental stipulations and

management plans on site and the NEC is conducting environmental audits on selected sites. Health and safety measures for personnel, like helmets, safety shoes, noise-, eye- and dust protection are also stipulated and enforced.

Maintenance of finished works is enforced stringently during the construction phase and the liability period of the contractor. In the past damage occurred regularly during monsoons because side drains were blocked and not well maintained. On selected roads, routine maintenance is contracted out to communities and petty contractors through output based contracts, which increase the ownership and efficiency of routine maintenance.

8. Mechanisation of road construction works

As mentioned above, the EFRC techniques have necessitated a more intensive use of equipment for road construction. The Ninth Plan also promotes further mechanization of the construction sector: “Automation of road works have been a key strategy in the past plans and it will be continued during the Ninth Plan to further enhance productivity, overcome labour shortages as well as to create employment opportunities for school leavers. Towards this, adequate provisions for purchase of critical additional construction and earth moving equipment and machinery have been kept in the plan outlay. Up gradation of skills among operators and managers to complement automation strategy are also envisaged in the road sector Human Resource Development programs.”

With the introduction of the environmental guidelines and EFRC in Bhutan, the Department of Roads prescribes the use of different construction techniques and appropriate equipment in the construction contracts. Excavators and dump trucks have already replaced bulldozers. The higher quality standards now enforced by DoR also require more appropriate equipment such as vibrator compactors and stone crusher plants. Further mechanisation will, however, be required to minimise the import of unskilled labour and to increase the number of skilled jobs.

The increase in equipment also results in the need to improve construction management, since inefficient and ineffective management of equipment is a high cost factor for the contractors. Environmental safeguards in equipment management, such as fuel, lubricants, parts and repairs, need to be planned right from the start. Cooperation with the Ministry of Labour and Human Resources has been initiated to attune the provision of vocational training to the new demands of the private sector, especially those related to mechanisation.

9. Quality Assurance

Quality Assurance has got a high priority in the Ministry of Works and Human Settlement and the Environmental Friendly Road Construction Support Project. The Standards and Quality Control Authority and DoR have developed a quality assurance framework with support from the EFRC Support Project. This framework comprises the whole of the road construction project cycle from identification to maintenance and provides quality assurance strategies and measures in each of the steps of the project cycle. The following quality aspects have been identified:

a. **Identification and selection of road works**: an improved prioritization process of road works (DRAP see section 12) is under development in which economic, technical, environmental and social aspects are all taken in consideration. The

different criteria for these aspects are clearly described to enable an optimal evaluation and selection processes.

b. **Survey and design**: the survey and design of the road works needs are based on proper and detailed information and assessments (like maps, and environmental and geotechnical assessments) and worked out with appropriate methods (like ghat tracing and software). There is still a need to produce/obtain better maps and to upgrade the qualification of the surveyors. Also additional equipment may be needed, especially for soil investigation. Designs have to be double-checked and surveyors and designers will be trained further, especially in producing mass-haul diagrams and to adjust designs in a rapid but appropriate manner.
c. The **standard bidding documents**: have been made legally and technical sound. Technical and financial criteria are being developed in such a way that the quality of the works can be assured as much as possible. Environmental terms and conditions and provisions for environmental site management and monitoring are also taken up in the documents. Technical specifications are standardised where possible. Unit rates are made up-to-date and comprehensive. The bidding documents and Technical Specifications used by the EFRC project have been tested in previous years and are ready to be introduced within DoR. A contract (management) unit within the DoR enables standardisation and ensures that all documents are legally correct and in line with the Financial Manual. This unit also supports the Field Divisions in contract management and dispute resolution.
d. **Tendering**: the tendering process has been made more clear and verifiable. Evaluations are carried out in a sound, objective and standard manner. A contract management unit plays an important role in implementing or monitoring the tender evaluations.
e. **Construction and supervision**: both contractors as well as the clients have to make quality assurance plans with a simple checklist and should have proper quality control tools and equipment. Site managers from contractors and site supervisors from DoR carry out simple quality tests and visual inspections of construction materials. The Technical Specifications and contract documents provide a sound basis for the construction phase. The specifications, drawings and manuals used on site are now also reflected in a Field Handbook, which makes them easily accessible for field engineers and inspectors. The Standards and Quality Control Authority is supporting quality assurance during the construction period through audits and training in the field of quality assurance.
f. **Maintenance:** the road maintenance management system is under improvement within DoR to further standardise and prioritise the maintenance works, and to develop specifications (manuals) and quality assurance checklists.

10. Increasing private sector participation and capacity

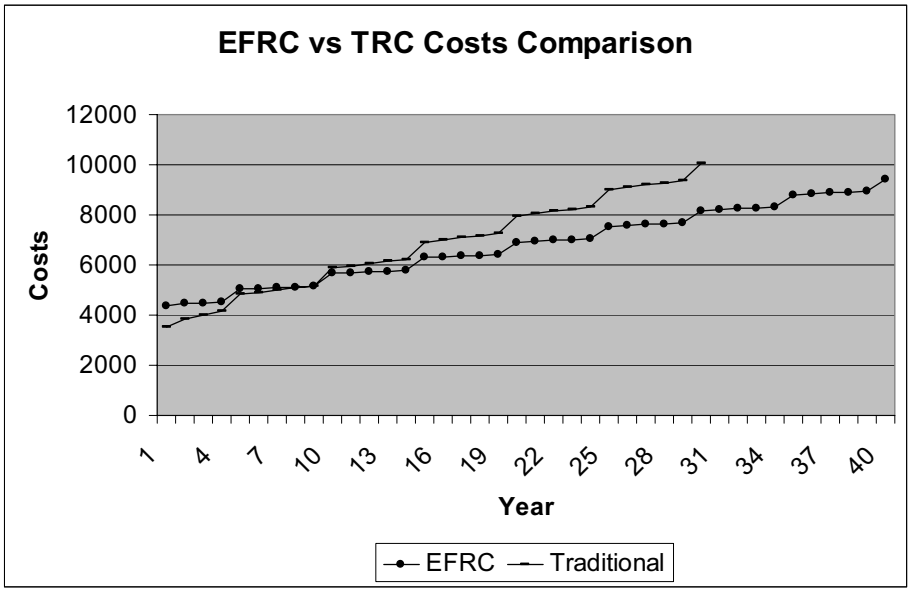
The Ninth Plan indicates that “The Department of Roads will make an attempt to move away from direct involvement in the execution of road works including road maintenance and concentrate increasingly on design, supervision, quality control and regulatory role. Road works shall be executed through engagement of national contractors.” This policy is under implementation for all new road construction works and at present DoR is piloting contracting out maintenance works to communities and contractors. The subsequent change in the role of the DoR staff contract and construction supervision is one of the areas for focus in coming years.

The national construction industry is in its infancy and is still in the development phase. At present this is one of the main constraints to achieving a good quality and a cost effective road. Strengthening the private construction sector is identified as a pre-condition for sustaining EFRC in Bhutan.

The creation of sound and competitive contract management will eventually lead to lower road construction and maintenance cost. The construction sector needs to be enabled to cope effectively with the required quality standards. With assistance of the EFRC SP the capacity of national support agencies, such as the Construction Development Board, the Construction Association of Bhutan and the Bhutan Chamber of Commerce and Industry are strengthened. Together with DoR the stakeholders have developed a strategy for the development of the private construction sector, which will be implemented in the forth coming years. Adequate technical, managerial, organizational and environmental guidelines and handbooks are introduced for this purpose as well.

11. Economic feasibility of EFRC

An EFRC feeder road costs about Nu. 4.8 million/kilometre (about 110,000 USD/km). The initial investments in the first (two) year(s) of construction of an EFRC feeder road is about 30% higher than that of the feeder roads constructed in the traditional way in the past. The increase in investment goes, however, hand in hand with higher road standards and quality. The maintenance and monsoon restoration costs are therefore substantially lowered over the total life time of the road. The improved quality of the roads also leads to lower vehicle operation costs, which has a significant positive impact on the economic benefits of the roads. Other economic benefits are: fewer road blockages, less stocking of essential supplies by communities, less damage to flora and fauna and fewer damages to (private) properties and cultural heritage sites.



As shown in the graph the lower repair and maintenance cost and the higher economic benefits of the EFRC roads compensate for the higher investment costs. EFRC roads become economically feasible based on cumulative expenditures and benefits after about nine years.

12. District Rural Accessibility Planning

Due to the low population density in Bhutan, investments in single roads are difficult to justify based on the assessed economic rates of return. The RGoB and World Bank have prepared a Transport Sector Note in which a more integrated approach to road investments is proposed. The development of Rural Access Plans at district and national level are needed, where different road categories (and other transport means) are combined in transport networks.

Integrated rural accessibility planning is especially important for Bhutan because:

- Investment in new roads and maintenance of the present road network is a priority of RGoB with a Ninth Five Year Plan budget allocation of Nu. 6.66 billion (about 150 million USD) .
- Although the number of vehicles increases annually by about 15% (24,000 in 2001) the traffic intensities on the roads remain low (average: high ways 70, district roads 23, feeder roads 19) and the revenue from road users only covers about 10% of the routine maintenance costs.
- The costs of roads per km are high due to the natural terrain conditions and investment levels still need to increase to ensure higher standards and quality as well as long term technical and financial feasibility (maintenance and repair costs are presently too high).
- Present Economic Rates of Return are relatively low due to low population densities and are based only on the benefits from the service area of a single (feeder) road.
- Good maps (1:5,000) and photographic interpretation are not yet systematically available for road alignment selection, which results in semi-optimal (technical and economical) alignments with additional difficulties and costs in the later project stages.

Road/network prioritisation and selection is to be based on clear criteria such as service area of the road network, agricultural potential, number of households, population densities, health and education services, non-agricultural development potential, geo-technical and terrain conditions and actual walking distance from existing roads. These indicators need to be mapped at district level and should form the basis for the sector interventions at district level; resulting in the District Master Plan. Environmental safeguards can also easily be addressed in the planning stage. Once the areas with the highest priority for creating access have been selected, the transport network can be designed; resulting in the District Rural Access Plan.

To justify (higher) investment levels for roads in Bhutan access to rural areas has to be provided through integrated (road) networks. A feeder road will be the backbone of the network and access from villages to the feeder road can be created through other infrastructure like farm roads, power tiller and mule tracks, suspension bridges and rope ways.

The relatively expensive feeder road therefore does not need to connect multiple villages and can be shortened in length. The service area will increase substantially with a network approach and the overall socio-economic benefits in the service area will also increase due to the multi-sectoral interventions identified in the district master plan. The additional social interventions can also be more targeted to the most disadvantaged, which will result in increased poverty alleviation in the area serviced by the road network.