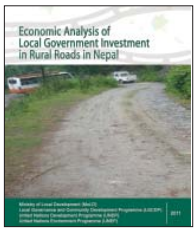

Economic Analysis of Local Government Investment in Rural Roads in Nepal 2011

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PEI Nepal Brief

The Poverty-Environment Initiative (PEI) in Nepal will support poverty reduction and inclusive development by integrating pro-poor climate and environmental concerns into development planning and economic decision-making. The PEI is not designed as a stand-alone project as such, but rather it aims to provide a programmatic framework for targeted support to national and local planning, budgetary and economic decision-making processes through ongoing UNDP-supported programmes, in particular, Strengthening Planning and Monitoring Capacity of NPC (SPMC-NPC) and the Local Governance and Community Development Programme (LGCDP). At the national level, the PEI will help strengthen the NPC's capacity to integrate pro-poor climate and environment concerns in the national planning, budgeting and monitoring processes. Similarly, at the local government level, it will provide technical support to the Ministry of Local Development (MoLD), and select District Development Committees (DDCs) and Village Development Committees (VDCs) to integrate pro-poor climate and environment priorities into local planning and budgeting processes with a particular focus on rural infrastructure. The proposed timeframe for PEI in Nepal is 35 months from February 2010 to December 2012. The PEI Programme Framework will complement the existing project documents of the above two projects, which will include the stipulated PEI activities in their respective project annual work plans (AWPs).

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As a land-locked country, Nepal remained secluded from the rest of the world until the 1960s, with no motorable road connections. Considering the economic value of connectivity, roads have now become a priority at all levels. In a bid to build roads quickly, heavy-equipment-based construction has started to substitute traditional labour-based and green-road construction technologies. Both types of technology have their respective advantages and disadvantages. While labour-based road construction technologies are considered environment-friendly, they can be slow and expensive. Conversely, equipment-based technologies can generally open up roads quickly but are often environmentally damaging.

To assess how Nepal is faring in its use of these two technologies in rural road construction, the Government of Nepal's Local Governance and Community Development Programme (LGCDP) and the United Nations Development Programme (UNDP), under the Poverty-Environment Initiative (PEI), awarded a study entitled **Economic Analysis of Local Government Investment in Rural Roads in Nepal** to a team comprising Govind P. Koirala, team leader/economist, and Sudarshan Karki, environment expert. This team received external support from Hendrik Vessier, an expatriate expert. The team deserves accolade for completing the study in a timely and professional manner.

The study received technical guidance from Paul Steele, Mika Korkeakoski and Seon-Mi Choi from the regional PEI team in Bangkok, Thailand. The team was also provided with substantive support from the Ministry of Local Development and UNDP, particularly from Som Lal Subedi, Joint Secretary and former National Project Director, LGCDP; Gopi Krishna Khanal, National Program Manager, LGCDP; Vijaya P. Singh, Assistant Country Director, UNDP; Dibya Gurung, Programme Officer (Biodiversity), UNDP; Dinesh Karki, Environment Programme Analyst, UNDP; and PEI Advisors Mohan Wagley and Mukunda Raj Pandeya.

The preparation of this report has been made possible through generous financial support provided by all PEI development partners: Belgian Development Cooperation, Danish Ministry of Foreign Affairs, European Commission, Irish Aid, Norwegian Ministry of Foreign Affairs, Spanish Ministry of Foreign Affairs and Cooperation, Swedish Environmental Protection Agency, Swedish International Development Cooperation Agency, UK Department for International Development, and US Department of State. The support from these organizations is duly acknowledged.

It is hoped that the study will provide environmentally ethical suggestions and foundations for use by local bodies in Nepal (DDCs and VDCs) during construction of rural roads in the future.

Mr Teertha Raj Dhakal
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ACRONYMS

ADB	Asian Development Bank
BCR	benefit/cost ratio
CD	cross-drainage
DDC	District Development Committee
DoR	Department of Roads
DTMP	District Transport Master Plan
EB	equipment-based
GTZ	German Technical Cooperation
IRR	internal rate of return
LB	labour-based
LGCDP	Local Governance and Community Development Programme
LSGA	Local Self-Governance Act
NPV	net present value
NRs	Nepali rupee (US$ 1 = NRs 75 in December 2010)
UNDP	United Nations Development Programme
VDC	Village Development Committee

EXECUTIVE SUMMARY

Roads are an important priority for local government bodies in Nepal. This is because, if operational, they will open up a multitude of opportunities to enhance local livelihoods. Historically, rural communities have created local roads and other necessary infrastructure using both voluntary and paid local labour. Since the early 1990s, when resources and authority began to be channelled through local government bodies, the use of heavy equipment for road construction such as bulldozers and excavators started to increase. Furthermore, the desire to establish road connections quickly also resulted in the increased use of unsustainable road construction approaches and methods. Unsustainable roads are those that have: (i) no drainage arrangements; (ii) high gradient; (iii) no protection structures in critical places; (iv) no biological protection; (v) no operation and maintenance arrangements or fund; etc.

The overall objective of this study is to inform policy-makers of the costs and benefits of alternative road construction approaches, including social and environmental concerns, and propose specific recommendations on sustainable rural road construction tailored to different stakeholders—central government agencies, District Development Committees, Village Development Committees (VDCs) and communities.

Two districts—Dolakha and Makwanpur in the Central Development Region—were selected for field work because they have the simultaneous presence of both labour-based (LB) and equipment-based (EB) technologies and processes for rural road construction in adequate numbers. A total of six roads were selected (see table below), of which analysis of financial and economic returns was done for five (Roads 1–5); vehicles were not yet plying Road 6. Data were collected from local bodies, construction contractors, members of user committees and general beneficiaries, using focused group discussions and individual interview tools. The study also reviewed relevant documents and secondary data.

Rural roads selected for detailed study in Dolakha and Makwanpur districts

	Road	Total length (km)	Length considered (km)	Technology
Dolakha				
Road 1	Mude–Melung	44	21	Mixed
	Mude–Deurali	11.5	11.5	EB
	Deurali–Bhainse	14	14	LB
Road 2	Bhirkot–Chhaunde	–	14	LB
Road 3	Barabise–Bigu	63	15	EB
Makwanpur				
Road 4	Dandabas–Pakani	15	15	LB
Road 5	Pakani Kharka–Baikuntha	13	13	EB
Road 6	Sitalchowk–Jatiya Pokhari	6	2.5	EB

The direct quantified costs of selected roads are presented in the tables below.

Direct financial costs of selected roads in Dolakha district and share of labour cost

	Mude–Melung (Road 1)			Bhirkot–Chhaunde (Road 2)			Barabise–Bigu (Road 3)		
	Cost ('000 NRs / km)	Share of labour (%)	Labour wages ('000 NRs)	Cost ('000 NRs / km)	Share of labour (%)	Labour wages ('000 NRs)	Cost ('000 NRs / km)	Share of labour (%)	Labour wages ('000 NRs)
Survey and design	18.3	18	3.30	14.1	20	2.82	26.1	15	3.92
Social mobilization	80.4	65	52.28	80.4	80	64.34	15.7	80	12.53
Track opening	633.9	70	443.71	690.0	90	621.00	–	–	–
3-m widening	788.8	65	512.73	861.0	80	688.80	–	–	–
5-m widening	1,408.6	65	915.59	1,530.6	80	1,224.49	522.0	20	104.40
CD* structures	283.1	30	84.94	308.2	30	92.45	41.8	30	12.53
Bioengineering	39.7	50	19.84	79.4	50	39.68	23.8	50	11.90
Supervision	75.0	–	–	125.0	–	–	10.0	–	–
Total direct cost	**3,327.9**	**–**	**2,032.39**	**3,688.7**	**–**	**2,733.58**	**639.3**	**–**	**145.28**
Routine maintenance	10.0	95	9.50	14.3	95	13.57	19.6	95	18.62
Periodic maintenance	53.6	65	34.82	28.6	95	27.14	142.9	20	28.57

*Note: *CD = cross-drainage.*

Direct financial costs of selected roads in Makwanpur district and share of labour cost

	Dandabas–Pakani (Road 4)			Pakani–Baikuntha (Road 5)		
	Cost ('000 NRs / km)	Share of labour (%)	Labour wages ('000 NRs)	Cost ('000 NRs / km)	Share of labour (%)	Labour wages ('000 NRs)
Survey and design	15.0	25	3.75	25.6	20	5.12
Social mobilization	74.0	80	59.20	30.7	80	24.59
Track opening	311.0	90	279.94	–	–	–
3-m widening	389.1	80	311.32	–	–	–
5-m widening	693.2	80	554.56	512.3	10	51.23
CD* structures	139.3	25	34.84	41.0	20	8.20
Bioengineering	75.0	50	37.50	–	50	–
Supervision	125.0	–	–	10	–	–
Total direct cost	**1,821.7**	**–**	**1,281.02**	**619.6**	**–**	**89.14**
Routine maintenance	16.0	95	15.20	22.7	95	21.57
Periodic maintenance	33.5	95	31.83	166.2	25	41.55

*Note: *CD = cross-drainage.*

The indirect costs including the environmental costs are also estimated for each road, and are considerably higher for EB roads than for LB roads. The sources of benefits include local peoples' movement and migration, incremental income from agricultural products, savings in food purchases, incremental income from business merchandise, income from labour during construction, etc. There are also some unaccounted benefits.

While financial analysis of each road has been done using the market prices, the costs are also converted to societal costs using economic prices. The results for net present value (NPV), benefit/cost ratio (BCR) and internal rate of return (IRR) are presented in the table below.

Findings from economic analysis

- All roads have a positive return on both financial and economic investments and returns to the country/society are more than returns to households in all cases. This justifies state investment in and support for development of rural roads.
- LB roads had higher returns (about 30 percent more) than EB roads. This is owing to the higher number of vehicles and days of movement per year on LB roads (3–7 months for EB roads and 7–12 months for LB roads).

Conclusions

- Roads are the number one priority for local communities and, rightly so, considering the spatial nature of poverty in rural areas. However, if roads cannot be plied or the poor do not adequately benefit from them (because the roads are not developed properly), the present high priority allocated to them can itself become a source of problems. LB roads are more pro-poor than EB roads and can provide employment to the poor. Hence, rural road construction can be made into a pro-poor initiative with the use of LB technology.

Estimated NPV, BCR and IRR from selected roads at financial and economic prices

		Financial			Economic		
		NPV (US$)	BCR	IRR (%)	NPV (US$)	BCR	IRR (%)
Dolakha							
Mude–Melung (Road 1)	LB+EB	73,183	1.83	15.9	85,712	2.27	18.9
Bhirkot–Chhaunde (Road 2)	LB	24,707	1.47	12.7	41,915	2.34	19.7
Barabise–Bigu (Road 3)	EB	1,880	1.05	9.5	7,328	1.24	14.3
Makwanpur							
Dandabas–Pakani (Road 4)	LB	18,644	1.60	14.6	29,764	2.71	24.6
Pakani–Baikuntha (Road 5)	EB	499	1.01	8.4	6,915	1.25	14.7

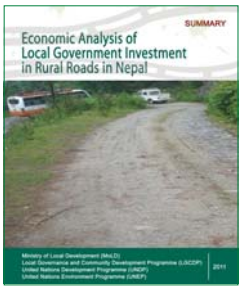
- Existing government processes, particularly budgetary processes, result in long delays in fund release, which limits the working season for road projects. This is not favourable for construction, especially with LB technology, and instead encourages or compels the choice of EB technology for 'last-minute' work.
- Current price trends (threefold increase in wages over the last 10 years and more than 50 percent reduction in heavy equipment rental rates in the same period) have increased the economic feasibility of EB technology.
- The use of EB technology has a strong correlation with the unsustainability of roads. This is caused by, amongst other things, higher risk of too-steep gradients; lack of adequate water-draining structures; an absence generally of road stabilizing and protection structures; significantly higher environmental damage which causes high environmental costs; and a high risk/occurrence (about five times higher) of landslides compared to LB roads.
- There are certain situations when EB technology can be efficient and less damaging. These situations are in (i) road widening; (ii) ridge alignments; and (iii) long alignments through unpopulated areas that require the establishment of labour camps under LB methodology. Similarly, EB technology allows for breaker attachments on excavators, which can be more efficient for breaking very hard rock than LB technology that often uses skilled labourers for tedious chisel-cutting.
- EB technology can be economical and is faster, but is still not necessarily associated with high rates of return. In contrast to this, the returns from LB methods are about 30 percent higher than for EB methods. In Nepal, most non-functioning and seasonal roads have been constructed using EB technologies.
- There are several known instances of corruption and other financial abuses, but none have been formally investigated or penalized. This indicates a clear state of impunity and lack of financial discipline. The risk of corruption is significantly higher with EB methods, since beneficiaries and communities in general have far less involvement in decision-making and in monitoring of alignment selection, tendering for work, and actual construction.
- Whenever and wherever possible, a blend of LB and EB technologies should be used for rural road construction to harness the positive features of each technology—cheaper and faster from EB technology, and sustainable and poverty-reducing from LB technology.

Recommendations

- Roads must be planned in a participatory way and should be a part of the District Transport Master Plan (DTMP). No road should be financed by local bodies, unless it is included in the DTMP. Special care should be taken that decision-making processes on road prioritization, the DTMP and road alignments are participatory and transparent. Community auditing needs to be instigated and an appeals process should be established.
- Feasibility and environmental assessments should be mandatory, and problems highlighted in environmental reports must be resolved within the road design.

- No roads should be started without sufficient funds at hand or without assured funding sources.
- Fund support from local bodies and the centre should be disbursed at the beginning of the lean season (November). For this, the following changes should be made.
  - Change the fiscal calendar in a way that allows development funds to be available for use at the local level by about the middle of November.
  - Expedite the budget release process.
  - Abolish the budget-freezing process at the financial year-end for development work.
- For road projects, an ensured multi-year budget should be allocated, so that the financial grant system does not negatively impact the capacity of local government bodies to construct roads.
- Social mobilization of communities in the influence area of roads should be mandatory for road building. This is important for developing local ownership and mitigating intentional tampering. Social mobilization messages and modes of delivery should be tailored to each community, depending on its level of social capital.
- The use of bulldozers and rock-blasting materials should be discouraged, as the tremor effect they produce impacts on surrounding geological formations and significantly increases the probability of landslides. Controlled blasting techniques, which have a higher efficiency and lower cost because of substantial savings on blasting materials, can be considered. The force of the blast should be directed outward so that remaining rock faces are stable. These techniques can also be used in combination with LB methods, if compressors and jack hammers are made available.
- LB technology should be encouraged and particularly emphasized in poverty-ridden areas. However, to harness some of the positive features of EB technology, the use of excavators and breaker attachments should be allowed in certain situations. Use of equipment should be complemented by water management structures (side and cross drains), other protection structures and bioengineering works in critical areas.
- The Department of Local Infrastructure Development and Agricultural Roads and local bodies should jointly institute a system of annual policy auditing for rural road construction by local bodies to assess policy compliance. Any failure to comply with policy should entail appropriate sanctions such as budget cuts.
- Operational guidelines need to be developed to ensure that transport does not damage roads and the maximum weight limit is enforced. This is especially relevant in relation to criteria for road closure, e.g., during the monsoon, when road surfaces are easily damaged.
- A concerted effort is needed to secure the participation of beneficiaries in all steps of the road project cycle in order to ensure ownership of the road and contributions for road maintenance. Different road maintenance models will need to be developed for different road standards and conditions to allow for communities to contribute within their capacity.

- All rural roads should have adequate operation and maintenance funds for timely maintenance. Such funds must be complemented by beneficiary contributions raised from the increased income resulting from the road. A system of reasonable taxing of vehicles and goods movement can also be developed for this purpose. The tariff fixed for such purposes should not be specified as an absolute amount in the Local Self-Governance Rules but should be left for local bodies to decide for themselves.
- Local road maintenance skills should be developed through training and work during road construction.
- Public service packages in agriculture and the social sectors (health, education, etc.) should be part of road design, so that benefits from the road are enhanced to their full potential. This is built into some projects funded by donors such the Asian Development Bank and World Bank, but not for roads built by local bodies themselves.
- Public forest and land needs to be protected from exploitation by (often) outsiders, who have easy access to natural resources through the expanding road network.
- Rent-seeking practices are anti-poor and should be strictly controlled. For this, public auditing should be mandatory.
- One of the reasons for unsustainable infrastructure at the local level is the shortage of technical manpower. Although resource availability within VDCs has increased by up to 10 times, the availability of technical manpower has remained the same. Therefore, a separate budget head for the outsourcing of technical manpower, e.g., for survey, design, construction and/or supervision, should be provided in grant funds. In addition, the possibility of using public–private partnerships for road development should be explored and tested.
- It is recommended that, in the new state structure for Nepal, the current *ilaka* are defined as the local body equivalent to the current VDC. If the *ilaka* is taken as the smallest local administrative body, then it will have adequate resources and capacity to have its own technical unit. There are currently about 700 *ilaka* compared to 3,915 VDCs.
- The foreseen transformation of democratic and public institutions in Nepal provides a good opportunity for developing clear roles and responsibilities and institutional arrangements conducive for rural road development. New guidelines for planning, design and construction as well as for operation and maintenance are needed, and beneficiary participation and monitoring and evaluation should be reinforced.
- Adequate compensation arrangements should be made for the losers of land to road alignments or of crops destroyed during construction, particularly since the losers are more often than not the poor.



INTRODUCTION

Background

Nepal is the poorest country in the South Asian region on a number of poverty measurement indices—on the Human Development Index (HDI) used by United Nations Development Programme (UNDP), by per capita income used by the World Bank, and on the Multidimensional Index of Poverty (MPI) recently introduced by Oxford University researchers, which shows nearly 65 percent of the Nepalese population fall below the absolute poverty line. A major form of poverty in Nepal is spatial—geographically concentrated poverty caused by remoteness, which leads to lack of competitiveness owing to high transaction costs both in input acquisition and output sales.

The occurrence of spatial poverty is demonstrated by the fact that 30 percent of the country's 3,915 Village Development Committees (VDCs) are yet to be linked to the road network. Hence, the development and expansion of road infrastructure in rural areas is obviously a consensus priority for local development at all levels from the centre down to VDCs and settlements. Although it has always been a major concern at the local level, it has gained added momentum since the promulgation of the Local Self-Governance Act 1999 (LSGA) and Local Self-Governance Rules 2000 (LSGR) that vested unprecedented development authority with local governments, along with the concomitant transfer of grant resources and the provision of taxing authority. This devolutionary policy intends and allows District Development Committees (DDCs) and VDCs to take charge of local development that contributes towards poverty reduction through inclusive, responsive and accountable local governance and participatory community-led development. Now, the conditional and unconditional annual budgetary grant to VDCs ranges from a minimum of NRs 1.5 million to a maximum of NRs 3 million (with an average of about NRs 2.1 million), based on 11 minimum compliance criteria.

Having recognized the importance of access to markets, services and economic opportunities, a large chunk of resources available to local governments is being used to construct rural roads. In Nepal, nearly US$ 40 million (NRs 3 billion) has been spent annually in recent years on rural roads projects and programmes. In the past, local bodies used to transfer budgets from other heads (e.g., health, education, etc.) for road construction; however, this practice has now been stopped as other sectors have become more vigilant. In total, VDCs have spent an average of over NRs 1 million each on rural roads.

Road construction technologies defined

In Nepal, there are broadly two main road construction technologies in use for rural road construction/rehabilitation, operation and maintenance: labour-based (LB) and equipment-based (EB). These technologies have their own characteristics in terms of time taken, costs incurred, benefits/losses delivered, employment, poverty impacts, sustainability, etc. The extreme of LB technology, at one end of the scale, is the 'green road' where all operations are done by organized human labour groups with the use of appropriate small tools of mostly indigenous origin. The extreme of EB technology, at the other end of the scale, is 'non-engineered' roads built solely with heavy equipment. In between, there is a continuum of combinations of LB and EB methods. These combinations come in two forms: (i) separate technologies on different sections of the same road; and (ii) the mixing or blending of technologies on a single section of the road. This latter is less common, although improvements using LB technology such as stone pitching can be seen (e.g., on the Mude–Melung road in Dolakha) particularly when EB roads precede LB roads; this is because the performance of the LB road could be jeopardized by the preceding EB road.

In Nepal, the technological development of low-cost, environment-friendly, rural roads based on people's participation has been taking place since the mid-1980s. The Local Road Improvement Programme (LRIP), supported by GTZ and Helvetas in Palpa District, implemented the environment-friendly improvement and construction of 96 km of road in 1986. GTZ supported the construction of 65 km of environment-friendly road in Dhading District in 1987. After the successful outcomes of these pilot projects, the concept was widely adopted in other districts by various donor-funded projects. The Rural Community Infrastructure Works (RCIW) programme known as Food for Work (FfW) supported by the World Food Programme (WFP), GTZ and the government through the Ministry of Local Development started in 1995 and has implemented the concept in 20 districts. Other donor projects such as the Rural Access Programme (RAP) funded by the UK's Department for International Development in seven districts, the District Road Support Project (DRSP) funded by the Swiss Agency for Development and Cooperation, the Upper Sagarmatha Agriculture Development Project (USADP), the Rural Infrastructure Development Project (RIDP) funded by the Asian Development Bank (ADB), and the Infrastructure for Income (INFRIN) project funded by the US Agency for International Development (USAID) also applied this concept. As of 2008, the length of

rural roads in Nepal totalled more than 20,000 km, of which about 3,000 km were constructed following the green roads approach.

The steps for green road construction in Nepal are presented in Box 1, and the characteristics of roads built using this technology are presented in Box 2.

In contrast to green roads, EB technology in Nepal uses only bulldozers to construct roads in an unplanned way. More advanced EB methods—e.g., using excavators and tipper trucks for transporting excavated materials to safe dumping sites, using cut-and-fill methodology with retaining walls to minimize excavation of (unstable) slopes, using compressors and jack hammers for controlled blasting, and other environmental-friendly technology—is not used for rural road construction in Nepal as yet (see Box 3).

Box 1 Steps for green road construction in Nepal

The prescribed steps for green road construction in Nepal are as follows.

Technical

- Preparation of District Transport Master Plan (DTMP)
- Road alignment selection, survey, design and report
- Preparation of training materials
- Training of user committee members, local supervisors, foremen, masons and labour groups
- Preparation of project schedule and planning
- Supervision of construction work
- Facilitation for site office and store management
- Measurement and valuation of work done by road building groups
- Quality control of work
- Progress reporting and monitoring
- Assessment and implementation of preventive maintenance on road during construction period

Social mobilization

- Dialogue and meetings with VDC and community
- Formation of user committee
- Achievement of political balance and consensus
- Training of user committee, road building groups, record-keepers, etc.
- Facilitation of user committee for mobilization of road building groups and social welfare of workers
- Facilitation of user committee for payment of workers
- Assistance to user committee for maintenance of Project Book
- Guidance of road building groups to operate group saving schemes and income-generating activities

Source: Shrestha, H.R., 2009. Harmonizing Rural Road Development with Mountain Environment: Green Roads in Nepal. In proceedings of International Conference on 'Making Globalization : Role of Consultant', 11–13 March 2009, Kathmandu, Nepal. Kathmandu: SCEAF Nepal, TCDPAP and FIDIC / ASPAC.

Box 2 Features of green roads in Nepal

The green road concept is an approach that refers to an environmentally sound, participatory, technically appropriate, labour-based rural road or trail construction/maintenance methodology. The features of green roads constructed in Nepal are as follows.

- Minimum disturbance to vegetation cover along the road corridor
- Phased construction for natural compaction (track opening of 1.25 m in first phase, widening to 3 m in second phase and final widening to 5 m in third phase; then drainage, bypasses and bioengineering works phase). The gradient is kept to less than 12 percent.
- Additional vegetation cover developed on barren earth slopes
- Outward slope to ensure water drainage and establishment of dispersed drainage system
- Local labour organization and use
- No use of heavy equipment
- Excavated material transformed into construction material
- Mass balancing and controlled tipping
- Use of public audits and cost transparency
- Other social and poverty alleviation components emphasized along the road corridor

Box 3 Features of EB roads in Nepal

The use of heavy equipment for construction of rural roads in Nepal started some 15 years ago when resources for local government bodies increased and local priorities became quick road construction. EB technology now is characterized by unplanned roads with no drains or protection structures. Road lengths are often unduly increased at the cost of forests and other resources in order to avoid agricultural land. This practice, however, has decreased in recent times as land values near operational roads have sky-rocketed. The tremor of heavy machines (particularly bulldozers) and the use of rock-blasting materials affect surrounding geological formations and hill slopes, causing destabilization. The cut–throw method is used, causing heavy mass wasting and substantial damage to slope vegetation cover, which in turn causes a significant increase in the occurrence of landslides. More advanced EB methods are used for national roads in Nepal but very seldom for rural roads construction as yet.

History of LB and EB technologies in Nepal

Excavator at work

Leveller at work

The use of labour for rural infrastructure construction including roads is historically at the core of Nepali rural communities. In the past, as in the present, community infrastructure has been constructed using voluntary and, to a certain extent, paid labour. Each community assigned a person *(urdi)* to inform everyone about the date and time for community infrastructure construction or maintenance work, and any failure to participate without an acceptable excuse was subject to a penalty. As Nepal was effectively isolated from the rest of the world, communities did not have access to heavy equipment for infrastructure construction or maintenance. Since the 1980s, they started to build green roads with support from donors in a more organized way by forming labour groups and user committees.

In contrast, the history of technology based on heavy equipment is quite short in Nepal—about 40 years for state infrastructure (national roads and others) and only about 15 years for rural roads. In the beginning, a Heavy Equipment Division was constituted within the Department of Roads (DoR). The DoR imported heavy equipment which was rented out to contractors as a package on infrastructure construction contracts. Most contractors retained the equipment for periods longer than the stipulated time and on-rented it to private individuals and communities at rates much higher than they actually had to pay to the DoR. When demand for heavy equipment for infrastructure construction began to escalate at the local level, the government allowed construction companies to import their own equipment, charging a highly subsidized customs tariff of only four percent in comparison to about 250 percent charged on private vehicle imports. Individuals were not allowed this privilege and were subjected to paying the same customs rate as for private vehicles. Hence, not a single piece of heavy

equipment has been imported to Nepal by a private individual. To import goods, the government issues a letter of credit to the exporter, which can entail a process of 4–5 months. Some contractors could not wait that long and imported equipment directly, which cost them more than when it was imported with a letter of credit, for example, an excavator costs NRs 400,000 more. The number of heavy equipment importing companies has now reached 260, and they have recently formed the Heavy Equipment Association. Most of these companies have taken up the enterprise solely for the purpose of renting out to local bodies and user committees for road construction and, to some extent, to brick kiln operators, crushing industries, etc. Initial imports were reconditioned/used equipment from Japan at about half the original price. The Heavy Equipment Association has, up till now, been opposing the import of reconditioned equipment; however, they are rethinking their stand on this because reconditioned equipment is financially more viable.

Bulldozer at work

Initially, bulldozers were imported for use in rural road construction. This has now been almost fully substituted by excavators. Other heavy equipment includes rollers, tippers, levellers, and some attachments such as breakers. Photos of heavy equipment used in road construction are shown here.


Giant tipper

Initial imports were solely from Japan, but heavy equipment supply has diversified and become fiercely competitive. Now, suppliers give incentives such as visits to selected foreign locations to encourage equipment purchase. Companies such as Hitachi, JCV (British), Caterpillar (American) and some Chinese brands have also appeared in the market. Currently, a popular brand is one that manufactures in India under a Japanese joint venture and produces an excavator with an attached loader. This is much cheaper than those imported from other countries. All heavy equipment have numbers such as PC 120 or PC 200, with these numbers representing the weight (or capacity) of the equipment, e.g., 120 means 12 t in weight. Surprisingly, however, prices are more or less the same for each weight group. Importers have to register imported equipment with the government by paying a fee of NRs 30,000. There is an annual insurance charge of NRs 50,000 per piece of equipment.

Excavator at work

The practice for renting is to charge the cost of transportation from source up to use point and back, which is about NRs 192 per km. Heavy transporters are involved in the rental chain.

Decision-making processes, unsustainable roads and implications

There are broadly two modes of decision-making as regards rural road construction in Nepal: (i) well-planned, with complete feasibility and environmental studies and with transparent participation processes; and (ii) political or elite-influenced, without serious studies and without open and transparent processes.

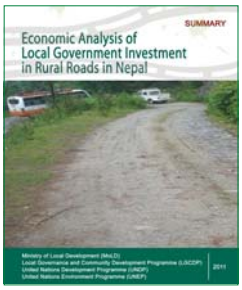
In terms of the time for road construction/rehabilitation, Nepal's budgetary process, with budget release mainly at the end of the fiscal year (June–July) and budget freezing in mid-July, often forces roads to be constructed during the monsoon period when local people are busy with agriculture. This obviously discourages the choice of LB technology. The pressure to reduce time taken for construction is also increasing the tendency to choose EB technologies.

As a consequence of inappropriate technologies and poor construction timing (whether deliberate or from necessity), not only is the sustainability of most rural transport infrastructure uncertain but the social and poverty reduction impacts of rural roads are also questionable. Some roads are constructed without adequate economic feasibility and environmental studies. Road lengths are increased unduly to avoid agricultural lands. Construction methods cause substantial damage and increase the probability of landslides estimates that 400–700 m^3 of landslide occur per km per year along mountain roads, and 3,000–9,000 m^3 occur per km during construction (Deoja, 1994)[1]. Area damaged by thrown material is about three times higher than area actually covered by road. Around the world, faulty road construction is one of the principal reasons for deforestation and forest degradation, contributing to 18 percent of total greenhouse gas (GHG) emissions in developing countries (Stern, 2006)[2].

In the context of climate change, rainfall is expected to become increasingly intense in Nepal and, hence, unsustainable and unstable roads are likely to cause increasingly greater environmental damage.

[1] Deoja, B.B., 1994. *Sustainable Approaches to the Construction of Roads and Other Infrastructure in the Hindu Kush-Himalayas.* ICIMOD Occasional Paper No. 24, Kathmandu: International Centre for Integrated Mountain Development.

[2] Stern, N., 2006. *The Economics of Climate Change.* The Stern Review. Cambridge: Cambridge University Press.



METHODOLOGY

Desk review

The study began with a review of relevant documents. These included national and international studies, progress reports, and country data collected from the centre as well as from the selected districts. District Periodic Plans and DTMPs, where available, were reviewed.

Rural road selection and field inquiry

Two districts—Dolakha and Makwanpur in the Central Development Region—were selected for field work because they have the simultaneous presence of both LB and EB technologies and processes for rural road construction in adequate numbers. Dolakha is a mountain district and Makwanpur is a hill district adjoining the Terai[3]; both districts have massive road construction activities involving LB and EB technologies, thus allowing for good comparison between the two technologies. In each district, 2–3 rural roads built by the respective local governments were studied, with at least one road using LB and/or EB technologies. Where a road has been built using different technologies in different sections, one road can provide information on both technologies. This is particularly desirable in the current study, which uses a small sample, because comparability between different technologies is better in similar settings.

The roads studied were selected in consultation with officials from the DDC and relevant institutions as well as other knowledgeable individuals in the respective district headquarters. After selecting the roads, necessary secondary data on planning aspects and costs were gathered, along with any other physical and financial progress reports related not only to the selected roads but also to the entire rural road network constructed by the local government

[3] The southern plains of Nepal, bordering India.

of each district in order to draw common conclusions about both technologies. The contractors involved in the construction of the selected roads were also approached and interviewed, where possible, to solicit their experiences, opinions and cost data. A checklist was prepared, showing information sought for analysis. Data related to costs and return also included indirect and environmental variables using appropriate valuation methods.

The selected roads were traversed for a reasonable length, interacting with respective VDC officials, user committee members and communities along the corridor.

Small focus group discussions (4–12 participants), using a semi-structured checklist of questions, were held with communities to explore average data and parameters and communities' attitudes, feelings and preferences. This was a compromise between participant observation, which is less controlled, lengthier and more in-depth, and pre-set interviews. Individual interviews were held with key informants, user committee officials, and district and VDC authorities.

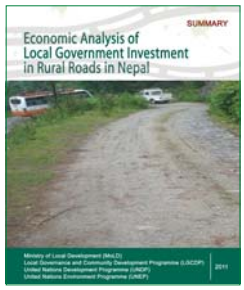
Evaluation tools

The main evaluation tool has been the comparison of financial and economic costs and benefits for the two technologies, with complete enumeration and estimations including those related to environmental and social concerns. While financial analysis used market prices for inputs and outputs, the same prices were converted to societal or country terms (shadow pricing) using standard conversion factor and unemployment-compensated labour wage rates. In both financial and economic analyses, the net present value (NPV), benefit/cost ratio (BCR) and internal rate of return (IRR) are calculated for a 30-year life of the road. Subject to availability of cost information, analysis has been done separately for all roads.

Limitations of the study

The findings of the study must be viewed in the context of the following limitations.

- The study was done during the peak monsoon season, which restricted the mobility of the study team during field visits and for taking macro pictures of features of various road alignments. However, this timing did enable the collection of accurate evidence of what can go wrong on roads built with environmentally insensitive methods. This limitation was partly overcome by extending the study period into the post-monsoon season.
- Another major limitation of the study was in the collection of data on costs and benefits, the records of which were scanty and, where available, not sufficiently disaggregated by appropriate cost heads. So, crude estimates had to be made in several cases.
- The third limitation was the small sample—six roads in two hill districts—which may have implications for the representativeness of study findings. This study must, therefore, be considered as a preparatory pilot for a larger study of rural roads in Nepal.



CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions have emerged from the study.

- Roads are the number one priority for local communities and, rightly so, considering the spatial nature of poverty in rural areas. However, if roads cannot be plied or the poor do not adequately benefit from them (because the roads are not developed properly), the present high priority allocated to them can itself become a source of problems. LB roads are more pro-poor than EB roads and can provide employment to the poor. Hence, rural road construction can be made into a pro-poor initiative with the use of LB technology.
- Existing government processes, particularly budgetary processes, result in long delays in fund release, which limits the working season for road projects. This is not favourable for construction, especially with LB technology, and instead encourages or compels the choice of EB technology for 'last-minute' work.
- Current price trends (threefold increase in wages over the last 10 years and more than 50 percent reduction in heavy equipment rental rates in the same period) have increased the economic feasibility of EB technology.
- The use of EB technology has a strong correlation with the unsustainability of roads. This is caused by, amongst other things, higher risk of too-steep gradients; lack of adequate water-draining structures; an absence generally of road stabilizing and protection structures; significantly higher environmental damage which causes high environmental costs; and a high risk/occurrence (about five times higher) of landslides compared to LB roads.

- There are certain situations when EB technology can be efficient and less damaging. These situations are in (i) road widening; (ii) ridge alignments; and (iii) long alignments through unpopulated areas that require the establishment of labour camps under LB methodology. Similarly, EB technology allows for breaker attachments on excavators, which can be more efficient for breaking very hard rock than LB technology that often uses skilled labourers for tedious chisel-cutting.
- EB technology can be economical and is faster, but is still not necessarily associated with high rates of return. In contrast to this, the returns from LB methods are about 30 percent higher than for EB methods. In Nepal, most non-functioning and seasonal roads have been constructed using EB technologies.
- There are several known instances of corruption and other financial abuses, but none have been formally investigated or penalized. This indicates a clear state of impunity and lack of financial discipline. The risk of corruption is significantly higher with EB methods, since beneficiaries and communities in general have far less involvement in decision-making and in monitoring of alignment selection, tendering for work, and actual construction.
- Whenever and wherever possible, a blend of LB and EB technologies should be used for rural road construction to harness the positive features of each technology—cheaper and faster from EB technology, and sustainable and poverty-reducing from LB technology.

Policy recommendations

Road planning

- The road to be built must be planned in a participatory way and should be a part of the DTMP. No road should be financed by local bodies, unless it is included in the DTMP. Special care should be taken that decision-making processes on road prioritization, the DTMP and road alignments are participatory and transparent. Community auditing needs to be included and an appeals process should be established.
- Feasibility and environmental assessments should be mandatory, and problems highlighted in environmental reports must be resolved within the road design.

Fund management

- No roads should be started without sufficient funds at hand or without assured funding sources.
- Fund support from local bodies and the centre should be disbursed at the beginning of the lean season (November). For this, the following changes should be made.
  - Change the fiscal calendar in a way that allows development funds to be available for use at the local level by about the middle of November.
  - Expedite the budget release process.
  - Abolish the budget-freezing process at the financial year-end for development work.

- For road projects, an ensured multi-year budget should be allocated, so that the financial grant system does not negatively impact the capacity of local government bodies to construct roads.

Preparing the community

- Social mobilization of communities in the influence area of roads should be mandatory for road building. This is important for developing local ownership and mitigating intentional tampering. Social mobilization messages and modes of delivery should be tailored to each community, depending on its level of social capital.

Road construction

- The use of bulldozers and rock-blasting materials should be discouraged, as the tremor effect they produce impacts on surrounding geological formations and significantly increases the probability of landslides. Controlled blasting techniques, which have a higher efficiency and lower cost because of substantial savings on blasting materials, can be considered. The force of the blast should be directed outward so that remaining rock faces are stable. These techniques can also be used in combination with LB methods, if compressors and jack hammers are made available.
- LB technology should be encouraged and particularly emphasized in poverty-ridden areas. However, to harness some of the positive features of EB technology, the use of excavators should be allowed for (i) road widening; (ii) ridge alignments (see photo below); and (iii) long alignments that require labour camps under LB methodology. Similarly, breaker attachments can be time- and cost-efficient for breaking rocks over long spells of very hard rock that require tedious chisel-cutting under LB methodology. However, equipment use should be duly complemented by water management structures (side and cross drains), other protection structures and bioengineering works in critical areas.
- The Department of Local Infrastructure Development and Agricultural Roads and local bodies should jointly institute a system of annual policy auditing for rural road construction by local bodies to assess policy compliance. Any failure to comply with policy should entail appropriate sanctions such as budget cuts.

Road operation and maintenance

- Operational guidelines need to be developed to ensure that transport does not damage roads and the maximum weight limit is enforced. This is especially relevant in relation to criteria for road closure, e.g., during the monsoon, when road surfaces are easily damaged.
- A concerted effort is needed to secure the participation of beneficiaries in all steps of the road project cycle in order to ensure ownership of the road and contributions for road maintenance. Different road maintenance models will need to be developed for different road standards and conditions to allow for communities to contribute within their capacity.

A ridge alignment in Dolakha that may be ideal for EB technology to expedite road construction

- All rural roads should have adequate operation and maintenance funds for timely maintenance. Such funds must be complemented by beneficiary contributions raised from the increased income resulting from the road. A system of reasonable taxing of vehicles and goods movement can also be developed for this purpose. The tariff fixed for such purposes should not be specified as an absolute amount in the Local Self-Governance Rules but should be left for local bodies to decide for themselves.
- Local road maintenance skills should be developed through training and work during road construction.

Enhancing benefits from the road

- Public service packages in agriculture and the social sectors (health, education, etc.) should be part of road design, so that benefits from the road are enhanced to their full potential. This is built into some projects funded by donors such the ADB and World Bank, but not for roads built by local bodies themselves.
- Public forest and land needs to be protected from exploitation by (often) outsiders, who have easy access to natural resources through the expanding road network.

Other issues

- Rent-seeking practices are anti-poor and should be strictly controlled. For this, public auditing should be mandatory.
- One of the reasons for unsustainable infrastructure at the local level is the shortage of technical manpower. Although resource availability within VDCs has increased by up to 10 times, the availability of technical manpower has remained the same. Therefore, a separate budget head for the outsourcing of technical manpower, e.g., for survey, design, construction and/or supervision, should be provided in grant funds. In addition, the possibility of using public–private partnerships for road development should be explored and tested.
- It is recommended that, in the new state structure for Nepal, the current *ilaka* are defined as the local body equivalent to the current VDC. If the *ilaka* is taken as the smallest local administrative body, then it will have adequate resources and capacity to have its own technical unit. There are currently about 700 *ilaka* compared to 3,915 VDCs.
- The foreseen transformation of democratic and public institutions in Nepal provides a good opportunity for developing clear roles and responsibilities and institutional arrangements conducive for rural road development. New guidelines for planning, design and construction as well as for operation and maintenance are needed, and beneficiary participation and monitoring and evaluation should be reinforced.
- Adequate compensation arrangements should be made for the losers of land to road alignments or of crops destroyed during construction, particularly since the losers are more often than not the poor.

FINANCIAL STREAM OF COSTS AND BENEFITS AND FINANCIAL RETURNS FROM EQUIPMENT RENTING

Year	Capital cost	Insurance	Driver cost	Repair and maintenance	Total cost	Rental charge	Net benefit
1	9,200,000	50,000	90,000	75,000	9,415,000	540,000	-8,875,000
2	—	50,000	180,000	75,000	305,000	1,080,000	775,000
3	—	50,000	180,000	75,000	305,000	2,160,000	1,855,000
4	—	50,000	180,000	75,000	305,000	2,160,000	1,855,000
5	—	50,000	180,000	75,000	305,000	2,160,000	1,855,000
6	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
7	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
8	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
9	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
10	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
11	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
12	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
13	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
14	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
15	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
16	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
17	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
18	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
19	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
20	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
21	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
22	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
23	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
24	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
25	—	50,000	180,000	150,000	380,000	2,160,000	1,780,000
NPV	**$8,518,519**	**$533,739**	**$1,838,126**	**$1,301,763**	**$12,192,147**	**$20,631,591**	**$8,439,444**
BCR							**1.69**
IRR							**18%**

ECONOMIC STREAM OF COSTS AND BENEFITS AND ECONOMIC RETURNS FROM EQUIPMENT RENTING

Year	Capital cost	Insurance	Driver cost	Repair and maintenance	Total cost	Rental charge	Net benefit
1	8,390,400	47,500	90,000	71,250	8,599,150	513,000	-8,086,150
2	—	47,500	180,000	71,250	298,750	1,026,000	727,250
3	—	47,500	180,000	71,250	298,750	2,052,000	1,753,250
4	—	47,500	180,000	71,250	298,750	2,052,000	1,753,250
5	—	47,500	180,000	71,250	298,750	2,052,000	1,753,250
6	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
7	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
8	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
9	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
10	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
11	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
12	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
13	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
14	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
15	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
16	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
17	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
18	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
19	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
20	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
21	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
22	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
23	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
24	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
25	—	47,500	180,000	142,500	370,000	2,052,000	1,682,000
NPV	**$7,768,889**	**$507,052**	**$1,838,126**	**$1,236,675**	**$11,350,742**	**$19,600,011**	**$8,249,269**
BCR							**1.73**
IRR							**19%**

FINANCIAL STREAM OF COSTS AND BENEFITS

Road 1 (Mude–Melung, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	8,795	—	—	1,019	9,814	—	—	—	—	—	—	-9,814
2	8,492	—	—	1,019	9,511	—	—	—	—	16	16	-9,495
3	20,525	64	342	955	21,885	—	—	—	—	41	41	-21,845
4	11,847	128	683	955	13,613	—	—	—	—	81	81	-13,531
5	35,456	191	1,025	955	37,627	—	—	—	—	122	122	-37,505
6	—	255	1,366	955	2,576	9,810	835	605	500	163	11,913	9,337
7	—	255	1,366	955	2,576	14,715	1,253	908	750	163	17,788	15,212
8	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
9	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
10	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
11	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
12	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
13	—	255	1,366	955	2,576	19,620	1,671	1,210	1,000	163	23,663	21,087
14	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
15	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
16	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
17	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
18	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
19	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
20	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
21	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
22	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
23	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
24	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
25	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
26	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
27	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
28	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
29	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
30	—	255	1,366	700	2,321	19,620	1,671	1,210	1,000	163	23,663	21,342
NPV (8% DR)				**$88,088**						**$161,271**	**$73,183**	
BCR												**1.83**
IRR												**15.9%**

Road 2 (Bhirkot–Chhaude, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	5,603	—	—	740	6,343	—	—	—	—	—	—	-6,343
2	5,405	20	—	740	6,165	—	—	—	—	22	22	-6,143
3	12,629	50	100	712	13,491	—	—	—	—	55	55	-13,437
4	11,289	100	200	712	12,301	—	—	—	—	109	109	-12,192
5	16,715	150	300	712	17,877	—	—	—	—	164	164	-17,713
6	—	200	400	712	1,312	4,740	396	234	149	219	5,737	4,425
7	—	200	400	712	1,312	7,110	594	351	223	219	8,496	7,184
8	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
9	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
10	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
11	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
12	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
13	—	200	400	712	1,312	9,480	792	468	298	219	11,256	9,944
14	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
15	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
16	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
17	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
18	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
19	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
20	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
21	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
22	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
23	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
24	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
25	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
26	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
27	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
28	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
29	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
30	—	200	400	600	1,200	9,480	792	468	298	219	11,256	10,056
NPV (8% DR)					**$52,233**						**$76,940**	**$24,707**
BCR												**1.47**
IRR												**12.7%**

Road 3 (Barabise–Bigu, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	4,499	—	—	729	5,228	—	—	—	—	—	—	-5,228
2	5,091	147	1,071	729	7,038	—	—	—	—	12	12	-7,027
3	—	294	2,143	427	2,864	1,868	149	151	90	12	2,269	-595
4	—	294	2,143	427	2,864	2,801	223	227	135	12	3,397	534
5	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
6	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
7	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
8	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
9	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
10	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
11	—	294	2,143	427	2,864	3,735	297	303	180	12	4,526	1,662
12	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
13	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
14	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
15	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
16	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
17	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
18	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
19	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
20	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
21	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
22	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
23	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
24	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
25	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
26	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
27	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
28	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
29	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
30	—	294	2,143	520	2,957	3,735	297	303	180	12	4,526	1,569
NPV (8% DR)					**$38,391**						**$40,271**	**$1,880**
BCR												**1.05**
IRR												**9.5%**

Road 4 (Dandabas–Pakani, Makwanpur)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	3,304	—	—	303	3,607	—	—	—	—	—	—	-3,607
2	3,079	60	109	303	3,550	—	—	—	—	99	99	-3,451
3	6,583	120	218	362	7,283	—	—	—	—	99	99	-7,184
4	14,360	180	327	362	15,228	—	—	—	—	99	99	-15,129
5	—	240	436	362	1,038	1,890	1,152	155	71	99	3,367	2,330
6	—	240	436	362	1,038	2,835	1,728	233	106	99	5,001	3,964
7	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
8	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
9	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
10	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
11	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
12	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
13	—	240	436	362	1,038	3,780	2,304	311	141	99	6,635	5,598
14	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
15	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
16	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
17	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
18	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
19	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
20	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
21	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
22	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
23	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
24	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
25	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
26	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
27	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
28	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
29	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
30	—	240	436	200	876	3,780	2,304	311	141	99	6,635	5,760
NPV (8% DR)					**$31,058**						**$49,703**	**$18,644**
BCR												**1.60**
IRR												**14.6%**

Road 5 (Pakani–Baikuntha, Makwanpur)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	3,728	—	—	480	4,208	—	—	—	—	—	—	-4,208
2	4,327	148	2,161	48	6,683	—	—	—	—	43	43	-6,640
3	—	295	2,161	420	2,876	1,640	300	41	11	43	2,036	-840
4	—	295	2,161	420	2,876	2,460	450	62	17	43	3,032	156
5	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
6	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
7	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
8	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
9	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
10	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
11	—	295	2,161	420	2,876	3,280	600	83	23	43	4,028	1,153
12	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
13	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
14	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
15	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
16	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
17	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
18	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
19	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
20	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
21	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
22	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
23	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
24	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
25	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
26	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
27	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
28	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
29	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
30	—	295	2,161	60	2,516	3,280	600	83	23	43	4,028	1,513
NPV (8% DR)					**$35,389**						**$35,888**	**$499**
BCR												**1.01**
IRR												**8.4%**

ECONOMIC STREAM OF COSTS AND BENEFITS

Road: Road 1 (Mude–Melung, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	6,984	—	—	968	7,952	—	—	—	—	—	—	-7,952
2	6,743	—	—	968	7,711	—	—	—	—	15	15	-7,695
3	16,297	32	170	907	17,406	—	—	—	—	39	39	-17,368
4	9,407	63	340	907	10,717	—	—	—	—	77	77	-10,640
5	28,153	95	510	907	29,665	—	—	—	—	116	116	-29,549
6	—	127	680	907	1,714	9,320	794	575	475	154	11,317	9,604
7	—	127	680	907	1,714	13,979	1,190	862	713	154	16,899	15,185
8	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
9	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
10	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
11	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
12	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
13	—	127	680	907	1,714	18,639	1,587	1,150	950	154	22,480	20,766
14	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
15	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
16	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
17	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
18	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
19	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
20	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
21	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
22	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
23	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
24	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
25	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
26	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
27	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
28	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
29	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
30	—	127	680	665	1,472	18,639	1,587	1,150	950	154	22,480	21,009
NPV (8% DR)					**$67,496**						**$153,208**	**$85,712**
BCR												**2.27**
IRR												**18.9%**

Road 2 (Bhirkot–Chhaude, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	3,031	—	—	703	3,734	—	—	—	—	—	—	-3,734
2	2,924	—	—	703	3,627	—	—	—	—	21	21	-3,607
3	6,833	25	50	676	7,584	—	—	—	—	52	52	-7,532
4	6,108	50	100	676	6,934	—	—	—	—	104	104	-6,830
5	9,044	75	149	676	9,944	—	—	—	—	156	156	-9,788
6	—	100	199	676	975	4,503	376	222	141	208	5,450	4,475
7	—	100	199	676	975	6,755	564	333	212	208	8,072	7,097
8	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
9	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
10	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
11	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
12	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
13	—	100	199	676	975	9,006	752	444	283	208	10,693	9,718
14	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
15	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
16	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
17	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
18	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
19	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
20	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
21	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
22	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
23	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
24	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
25	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
26	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
27	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
28	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
29	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
30	—	100	199	570	869	9,006	752	444	283	208	10,693	9,824
NPV (8% DR)					**$31,178**						**$73,093**	**$41,915**
BCR												**2.34**
IRR												**19.7%**

Road 3 (Barabise–Bigu, Dolakha)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	3,923	—	—	692	4,615	—	—	—	—	—	—	-4,615
2	4,439	63	849	692	6,043	—	—	—	—	11	11	-6,032
3	—	125	1,697	406	2,228	1,774	141	144	86	11	2,155	-73
4	—	125	1,697	406	2,228	2,661	212	216	128	11	3,228	999
5	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
6	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
7	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
8	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
9	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
10	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
11	—	125	1,697	406	2,228	3,548	282	287	171	11	4,300	2,072
12	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
13	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
14	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
15	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
16	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
17	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
18	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
19	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
20	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
21	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
22	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
23	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
24	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
25	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
26	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
27	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
28	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
29	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
30	—	125	1,697	494	2,317	3,548	282	287	171	11	4,300	1,983
NPV (8% DR)					**$30,930**						**$38,258**	**$7,328**
BCR												**1.24**
IRR												**14%**

Road 4 (Dandabas–Pakani, Makwanpur)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	1,701	—	—	287	1,989	—	—	—	—	—	—	-1,989
2	1,585	—	—	287	1,873	—	—	—	—	94	94	-1,779
3	3,390	86	91	344	3,910	—	—	—	—	94	94	-3,816
4	7,393	129	136	344	8,002	—	—	—	—	94	94	-7,908
5	—	172	181	344	697	1,796	1,094	148	67	94	3,199	2,502
6	—	172	181	344	697	2,693	1,642	221	101	94	4,751	4,054
7	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
8	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
9	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
10	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
11	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
12	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
13	—	172	181	344	697	3,591	2,189	295	134	94	6,303	5,606
14	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
15	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
16	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
17	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
18	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
19	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
20	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
21	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
22	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
23	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
24	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
25	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
26	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
27	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
28	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
29	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
30	—	172	181	190	543	3,591	2,189	295	134	94	6,303	5,760
NPV (8% DR)					**$17,453**						**$47,218**	**$29,764**
BCR												**2.71**
IRR												**24.6%**

Road 5 (Pakani–Baikuntha, Makwanpur)

Year	Investment stream (NRs '000)	Routine maintenance (NRs '000)	Periodic maintenance (NRs '000)	Environmental losses (NRs '000)	Total cost (NRs '000)	Benefit from export (NRs '000)	Benefit from people's movement (NRs '000)	Cost savings in rice export (NRs '000)	Benefits from merchandise import (NRs '000)	Return from income from road works (NRs '000)	Total benefits (NRs '000)	Net incremental benefit (NRs '000)
1	3,247	—	—	456	3,703	—	—	—	—	—	—	-3,703
2	3,769	61	853	46	4,729	—	—	—	—	41	41	-4,688
3	—	123	1,706	399	2,228	1,558	285	39	11	41	1,934	-294
4	—	123	1,706	399	2,228	2,337	428	59	16	41	2,880	653
5	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
6	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
7	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
8	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
9	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
10	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
11	—	123	1,706	399	2,228	3,116	570	78	21	41	3,827	1,599
12	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
13	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
14	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
15	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
16	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
17	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
18	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
19	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
20	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
21	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
22	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
23	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
24	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
25	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
26	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
27	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
28	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
29	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
30	—	123	1,706	57	1,886	3,116	570	78	21	41	3,827	1,941
NPV (8% DR)					**$27,179**						**$34,094**	**$6,915**
BCR												**1.25**
IRR												**15%**

MAP OF NEPAL SHOWING STUDY AREAS