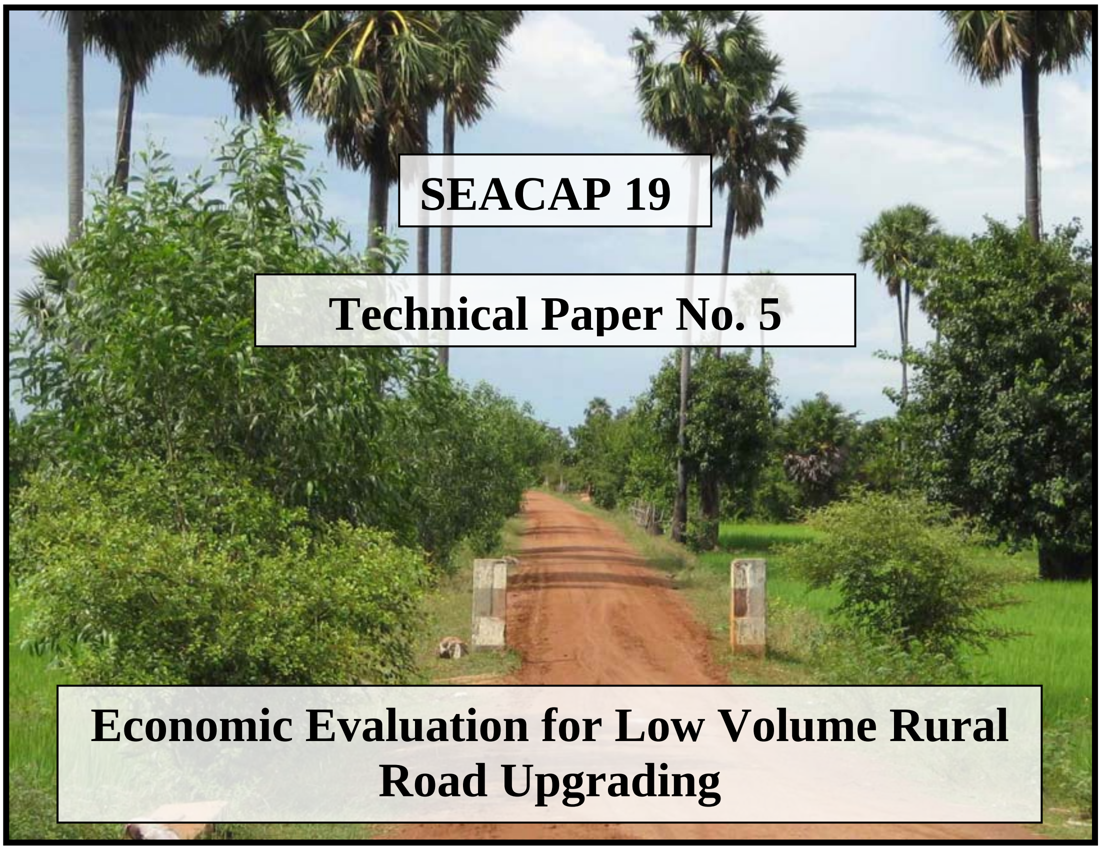
ROYAL GOVERNMENT OF CAMBODIA

SOUTH EAST ASIA COMMUNITY ACCESS PROGRAMME

DEVELOPMENT OF LOCAL RESOURCE BASED STANDARDS



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UNPUBLISHED PROJECT REPORT

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DEVELOPMENT OF LOCAL RESOURCE BASED STANDARDS

Economic Evaluation for Low Volume Rural Road Upgrading

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CONTENTS

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ADT	Average Daily Traffic
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Agency for International Aid
CBR	California Bearing Ratio
CNCTP	Cambodia National Community of Transport Practitioners
DBM	Dry Bound Macadam
DBST	Double Bitumen Surface Treatment (two layers of SBST)
DFID	Department for International Development
EOD	Environmentally Optimised Design
GMSARN	Greater Mekong Sub-region Academic & Research Network
IFRTD	International Forum for Rural Transport Development
ILO	International Labour Organisation
IRAP	Integrated Rural Accessibility Planning
IRD	Integrated Rural Development
IRI	International Roughness Index
ITC	Institute of Technology Cambodia
KaR	Knowledge and Research
km	kilometre
kW	kilowatt
LBAT	Labour-Based Appropriate Technology
LCS	Low Cost Surfacing
LVRR	Low Volume Rural Road
m	metre
MPW&T	Ministry of Public Works and Transport (Cambodia)
MRD	Ministry of Rural Development (Cambodia)
NGOs	Non-Governmental Organisations
NPA	Norwegian People’s Aid
NRDP	North-western Rural Development Project
ORN	Overseas Road Note
PDRD	Provincial Department of Rural Development
PIARC	World Road Association
PRDC	Provincial Rural Development Committee
PRIP	Provincial and Rural Infrastructure Programme
RGC	Royal Government of Cambodia

RIIP	Rural Infrastructure Improvement Project
SEACAP	South East Asia Community Access Programme
SEILA	Multilateral donors - Government Rural Infrastructure Development Programme
SIDA	Swedish International Development Agency
gTKP	Transport Knowledge Partnership
TRIP	Tertiary Roads Improvement Project
TRL	Transport Research Laboratory
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
WB	World Bank
WBM	Water Bound Macadam

EXECUTIVE SUMMARY

This document aims to identify the way forward for developing practical procedures to evaluate and justify the upgrading of unsealed LVRRs in Cambodia. The role of economic evaluation is summarised and existing procedures are briefly reviewed as to their usefulness within the Cambodian rural infrastructure environment. Knowledge gaps are identified and a Concept Note for taking the research forward is attached as an Appendix.

There are serious challenges to be met in Cambodia in terms of identifying appropriate road-engineering solutions; managing the maintenance requirements; and securing suitable funding. Planning techniques that are often applied in Cambodia generally do not consider whole life costing and draw little distinction between low-volume rural roads and busy national or provincial roads. Hence the economic evaluation and technical sustainability of upgrading low volume roads in Cambodia have rarely been adequately addressed.

In traditional approaches to undertaking an economic analysis, the basic objective is to determine the optimum mix between the costs of the project (related to the design standard) and the benefits from the project in terms of transport cost savings and other secondary benefits such as social and environmental benefits. The purpose is to find the investment option that minimises life cycle costs.

Various economic models have been developed to help decision makers assess the balance of road construction and maintenance investments and road user costs, including HDM-4 and the World Bank's RED model. On the LVRRs in Cambodia, the levels of motorised traffic are low (with the exception of motorcycles) with a substantial amount of non motorised traffic (primarily bicycles). On these types of road, significant benefits are accrued from items such as social and environmental related aspects, with traffic related benefits possibly being less important.

In general terms there are two key decision-requiring steps in rural road upgrading where economic assessment tools have a significant input:

I. Establish the requirement for upgrading
II. Selection of the most appropriate engineering option(s) from an identified short list

This area of general economic justification has not to date been part of the SEACAP initiative, where the focus of the current research has been on differentiating between pavement or surfacing options rather than on the justification for upgrading.

The economic justification evaluation calculates and compares the economic benefits and costs with the proposed paving against leaving it as an unpaved road. This latter 'do-nothing' option is often a valid and acceptable option. The "do nothing" option may be interpreted in fact as a "maintaining status quo", which in countries such as Cambodia is certainly not the same as "do nothing". The latter option will almost certainly lead to decline in asset value and increasing user costs due to an almost complete lack of effective maintenance.

Full economic analysis, even with tools such as HDM-4 or the World Bank's RED model, requires substantial amounts of data that may not be readily available in Cambodia, would be costly to collect, would be difficult to analyze with confidence, and may not be justified at the levels of investment funding available, especially for small projects.

A recent World Bank review "Surfacing Alternatives for Unsealed Roads" suggests the use of a "scoring system" to use in the evaluation of the need for unsealed road upgrading. The score sheet assesses both the environmental (climate/soil type and topography) and the socio-economic considerations affecting the decision to invest in the upgrading of the road. Minimum scores are suggested for different funding regimes.

A decision-supported cost model has been designed under SEACAP 1 to provide rural road authorities and design consultants with a supportive tool for their road surface and pavement selection process. This Cost Model and has since also been adapted on a trial basis as part of the

SEACAP 3 contract in Lao. Further work would be required to fully develop the model for surfacing options and environments encountered in Cambodia. The development of a VOC cost sub-model is also recommended to achieve a total transport whole life cost model.

So far most of the recovered information has been from the SEACAP 1 trials in Vietnam and this has been analysed principally in terms of engineering performance. A more limited amount of information has been recovered and analysed form the Puok Trials in Cambodia. Little or no relevant information has been made available from the other Cambodian trials other than some data on construction costs. Similarly, the SEACAP 17 trials in Lao have yet to yield data other than costs associated with construction.

The data sets required to apply this model in Cambodia are reviewed and information gaps are identified.

The SEACAP 19 Task 5 review has indicated that no LVRR upgrading economic assessment system has been adapted for the specific conditions of Cambodia. This is a major gap that needs to be rapidly addressed given the need for rural road infrastructure development in Cambodia and the limited budgets available.

Proposals for addressing the identified knowledge and application gaps have been drawn up and are contained in a concise Concept Note attached as Appendix B to this Technical Paper.

SEACAP 19: TECHNICAL PAPER 5
Economic Justification for LVRR Upgrading

1 Introduction

1.1 Task Objectives

The South East Asia Community Access Programme (SEACAP)[1] is researching alternative options to the indiscriminate use of gravel for the surfacing of Low Volume Rural Roads (LVRR). The objective is to generate information on the use of appropriate surfacing/paving options. This information will assist LVRR managers/owners/investors to select the most appropriate pavement and surfacing options according to a range of factors and circumstances.

The SEACAP 19 ToR proposed that appropriate upgrading techniques should be identified and further mainstreaming and demonstration work defined to be carried forward in partnership with other donors.

This Task 5 was initially proposed to formulate a project document related to the upgrading of LVRR. It was anticipated that key issues to address in this task include:

- Where and when different road surface options are suitable
- What maintenance has been applied and how effective it has been
- General deterioration patterns - how relevant would spot improvement be
- Economic information to justify upgrading.

The initial inception work highlighted that Task 4 and Task 5 were closely linked. Following the inception meeting, it was decided to expand the scope of Task 4 to address the issues relating to the engineering and road environmental selection of paving options while Task 5's scope was redefined to focus on the economic evaluation of LVRR upgrading.

1.2 Task Framework

Within the framework of SEACAP, and SC19 in particular, this Technical Paper contributes to the overall development of resource-based rural road standards for Cambodia, both by reviewing currently available information and by presenting a clear way forward for relevant research, development and mainstreaming.

This document is the formal output from Task 5 and comprises one of a suite of technical papers from the SEACAP 19 project of which the following have particular relevance to this document.

TP 4: LVRR Upgrading Options
TP 9: Unit Rate Costing System Review

1.3 Document Objectives

This document aims to identify the way forward for developing practical procedures to evaluate and justify the upgrading of unsealed LVRRs in Cambodia. The role of economic evaluation is summarised and existing procedures are briefly reviewed as to their usefulness within the Cambodian rural infrastructure environment. Knowledge gaps are identified and a Concept Note for taking the research forward is attached as an Appendix.

[1] SEACAP www.seacap-info.org

2 Background

2.1 Rural Road Investment in Cambodia

It is currently assessed that there are around 28,000 km of tertiary rural roads in Cambodia, of which approximately 99% are unsealed earth or gravel roads. The use of gravel tends to be applied indiscriminately due to its relatively low initial investment cost, in an attempt to maximise the impact of limited available funds for the construction of rural roads. Unfortunately it has resulted in an unmanageable maintenance burden for the Government of Cambodia. Since the early 1990s a wide variety of rural road programmes have delivered over 10,000 km of predominantly unsealed roads. However, without adequate maintenance provisions it is likely that the total asset value of the rural network has not been increased and may have in fact diminished with valuable resources essentially being wasted on inappropriate infrastructure development.

Maintenance of gravel roads has been estimated to cost around US$2000 per kilometre per year. With a rural road network of 28,000 km to maintain, MRD needs around US$56 million assuming that all roads are in a maintainable condition.

Based on SEACAP 06 data collected as part of the preparation of a strategic plan for rural roads, about 25% of the roads were in good to fair condition while the remaining 75% were in poor to bad condition. It would require approximately S$14 million to maintain this 25% of the network in a reasonable condition. According to the rural road department, the 2009 maintenance fund is around US$7.3 million. This lack of funds for rural road investment results in a majority of the roads falling into a state of chronic disrepair.

There are therefore serious challenges to be met in terms of identifying appropriate road-engineering solutions; managing the maintenance requirements; and securing suitable funding. The application of economic appraisal framework which is capable of reviewing options and prioritising solutions within the specific rural infrastructure environment of Cambodia would be a major step forward in meeting these challenges.

MRD and other road practitioners are well aware of the problems surrounding the maintenance burden and the lack of funding. In late 2002, a trial pavement was constructed at Pouk Market in Siem Reap province of Cambodia funded by DFID’s Knowledge and Research Programme with logistical and technical support from the ILO-Upstream Project. The construction of the trial demonstrated a range of pavement alternatives for rural road development.

Following this construction trial, a number of MRD’s projects were formulated with the objective of introducing sealed options into rural road development programmes. The uptake of adopting these durable surfaces has progressed slowly and so far less than 50 kilometres of rural roads have been built or upgraded to a sealed standard. The main reasons for this slow uptake appear to be related to the limited knowledge and resources available to carry out effective project appraisals for rural road development.

2.2 Constraints to LVRR Upgrading

It is usually necessary to undertake an economic evaluation to justify the need for road investment such as an upgrade of an unsealed road. This economic evaluation normally considers costs and benefits associated with the road over the ‘life of the road’, commonly referred to as whole life costs. Whole life costs usually include construction / maintenance costs, and road user costs (vehicle operating costs, travel time, accident costs, etc).

Planning techniques that are often applied in Cambodia generally do not consider whole life costing and draw little distinction between low-volume rural roads and busy national or provincial roads. This in part is due to the absence of an economic evaluation tool that has been tailored for Cambodia conditions.

Other constraints inhibiting the upgrading of low volume roads in particular may include:

- The perceived high initial capital required for upgrading, particularly without a tool to determine benefits over the life of an upgraded road.
- Possibly inadequate technical knowledge of upgrading techniques by local contractors.
- Insufficient construction equipment.

Hence the economic evaluation and technical sustainability of upgrading low volume roads in Cambodia have rarely been adequately addressed. Failure to revise or adapt these planning approaches to cater for low volume roads leads to the adoption and implementation of sub-optimal solutions that are generally unsustainable.

Appropriate selection methods are necessary to make sure that the pavement or surfacing option with the greatest economic impact is selected. There are a number of accepted and documented techniques to assess various aspects of the costs and effectiveness of road investments.

2.3 Regional Research on Whole Life Cost of Low Volume Sealed Roads

In the SE Asian region the research into appropriate pavements and surfacings over the last 5 years has been spearheaded by the SEACAP road trials and performance data gathering programme in Vietnam, Lao and Cambodia. As part of this research a simplified whole life cost model has been developed which considers only the costs associated with the road agency; that is construction and maintenance costs.

This model entitled “Whole Life Asset Costs” was first developed in Vietnam under SEACAP 1 and later modified for use in Lao under SEACAP 3. Its application, primarily as a tool for deciding between options for road rehabilitation, is discussed more fully in following chapters.

2.4 Conflicting Nomenclature

It became apparent in reviewing the background for this Task 5 paper that there is conflicting terminology being used by different practitioner groups within the rural road sector. In particular the use of the term “Whole Life Asset Cost” has given rise to debate.

It is clear that to some practitioners this implies a cost associated with the whole road asset including road furniture, signing etc. It has been suggested that what SEACAP has hitherto referred to as Whole Life Asset Cost (WLAC) should be termed Whole Life Asset Cost for the Road Agency. While accepting the logic of this argument, the term WLAC has been retained in this document to ensure its compatibility with previous SEACAP documents.

3 Economic Appraisal of LVRR Upgrading

3.1 Optimum Design and Appraisal

The preservation and development of a road network represents a large capital investment. Inevitably there are insufficient funds to undertake all the necessary road works. This problem is especially acute for LVRRs. Decision makers need to be able to prioritise the investments within often severely constrained budgets. In traditional approaches to undertaking an economic analysis, the basic objective is to determine the optimum mix between the costs of the project (related to the design standard) and the benefits from the project in terms of transport cost savings and other secondary benefits such as social and environmental benefits. The purpose is to find the investment option that minimises life cycle costs.

Operating vehicles on poorly maintained roads such as rough unpaved roads costs a great deal more than on, say, smooth bituminous surfaced roads. These costs include the costs of fuel, tyres, spare parts, vehicle maintenance, time, reduced utilisation and much more. There may also be costs to be assessed that are associated with access disruption on unsealed roads during the wet season.

For any country, especially developing countries, there is an important and very direct economic trade-off between investing in better roads and reducing the costs of using those roads as illustrated in Figure 1.

Figure 1: Optimising Road Standards

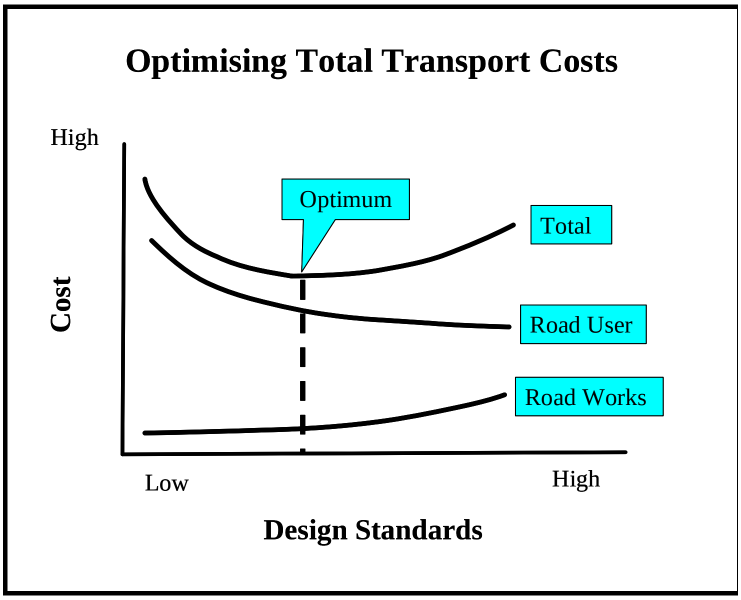

Figure 1 shows the conceptual total road transport cost curve which is made up of the construction/rehabilitation costs, maintenance costs and road user costs. It shows that as construction/rehabilitation costs increase (because of higher design standards) road user costs are typically reduced. The optimum road design standard is attained where the sum of the project costs are minimised. This optimum standard varies in relation to traffic level and the associated relative mix of construction, maintenance and user costs.

Such a trade-off includes investing in new roads and also in improving the maintenance and rehabilitation of the existing network. To identify the optimum standards and actions it is necessary to predict how roads of different designs perform (or deteriorate), to predict the effects of different types of rehabilitation and maintenance on the rates of deterioration and to calculate how the deterioration influences the costs borne by the road users. In this way optimum engineering solutions can be selected, based on economic principles, for the wide ranges of conditions encountered throughout the world.

For a given traffic level, if the road were to be constructed to a standard higher than the optimum, then the benefits derived from a reduction in road user and maintenance costs would not sufficiently offset the costs of initial construction and the resulting investment would be sub-optimal. This highlights the importance of ensuring that appropriate standards are adopted in the planning, design, construction and maintenance of roads.

Several methods exist for the economic appraisal of road investment projects for which the primary objective is to quantify and compare the costs and benefits of different options. These techniques provide guidance on the design, prioritisation and selection of candidate road projects or pavement options by addressing a wide variety of key decision-making issues.

Various economic models have been developed to help decision makers assess the balance of road construction and maintenance investments and road user costs, including HDM-4[2] and the World Bank's RED[3] model.

3.2 Life Cycle Cost Assessment

As stated previously, to assess whole life costs requires information on maintenance and road user costs. Collating information on road user items such as vehicle operating costs, value of time, accident rates and costs, etc can be an onerous task, particularly if similar studies have not been conducted in the country.

Generally, a substantial proportion of benefits from whole life cost tools tend to be generated from reductions in motorised vehicle operating costs. On the LVRR in Cambodia, the levels of motorised traffic are low (with the exception of motorcycles) with a substantial amount of non motorised traffic (primarily bicycles). On these types of road, significant benefits are accrued from items such as social and environmental related aspects, with traffic related benefits possibly being less important.

As mentioned previously, a simplified whole life cost model is being developed which considers only the costs associated with the road agency, i.e. construction and maintenance costs over the life of the road, and is referred to locally as the "Whole Life Asset Cost". It is therefore proposed that initially this road agency life cycle cost tool could be used to investigate road investment alternatives for LVRR in Cambodia. Appendix A provides details on this tool.

It is further suggested that a whole life cycle cost approach is subsequently introduced which considers road user effects, as well as possibly social and environmental aspects. This type of approach would be more in line with road investment analytical tools commonly used throughout the world.

To implement this type of whole life cycle cost approach would require the collection of more comprehensive data relating to road user effects, social and environmental aspects. Existing road investment tools, such as HDM-4, incorporate road user effects models, environmental effects (vehicle emissions) and it is understood that a social benefits module is likely to be incorporated in a future update of the software. This social benefits module will be based on a stand-alone tool that is currently available at TRL.

It should be borne in mind that to implement existing road investment tools requires significant work. This includes adapting and configuring the software to local conditions, as well as calibrating the predictive relationships to accurately reflect observed rates in the region under investigation.

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[2] more information about HDM4: http://hdmglobal.com/default.asp
[3] more information about RED: http://www.worldbank.org/html/fpd/transport/publicat/africa_tn-18.pdf

4 Economic Criteria and Decision Making

4.1 General Requirements

In general terms there are three key decision-requiring steps in rural road upgrading:

I. Establish the requirement for upgrading
II. Identify a short list of appropriate pavement and surfacing options
III. Selection of the most appropriate option(s) from (II)

Economic criteria should be involved in I and III, whilst II is essentially an engineering and road environment based process. There are, therefore, two separate but related requirements for economic input in rural road upgrading: (1) Justification for the upgrading and (2) Differentiating between options to achieve the upgrading. A third, economic and financial, input may be required to decide on the relevance or not of applying a Spot Improvement strategy.

ORN 5[4], in a review of the purpose of economic project assessment (establishing the need), states "*that estimates need to be made, not only of the costs associated with the project, but also of the benefit streams that are expected to occur as a result of the road investment*". Benefits that are normally considered are:

- Direct savings on the costs of operating vehicles
- Economies in road maintenance
- Time savings by travellers and freight
- Reduction in road accidents.

In addition there are secondary benefits which may arise at a later stage and include changes in land values or the wider economic and social development generated from the investment. ORN 5 advises that the arguments for introducing secondary benefits into the analysis are strongest in the following circumstances:

- For remote new rural transport infrastructure investment,
- Where a relatively large change in transport costs are anticipated
- Where there are unemployed resources
- The local economy is perceived to be uncompetitive and weak.

There is evidence to indicate that this scenario would apply in the development of the Cambodian rural infrastructure.

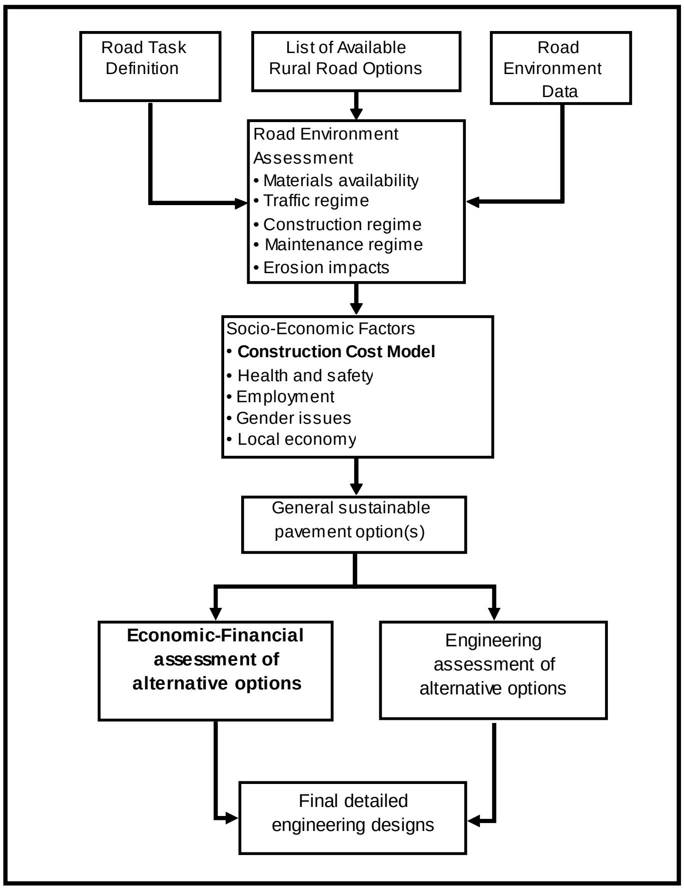
Secondary benefits, however, are very difficult to isolate and measure and may involve elements of double counting. For example, in theory, reduced transport costs will directly induce a rise in land values; to add changes in land values to transport cost savings would involve double counting.

This area of general economic justification has not to date been part of the SEACAP initiative, where the focus of the current surfacing and paving research has been on differentiating between pavement or surfacing options rather than on the justification for upgrading.

Decision making procedures developed under SEACAP have taken an established need as the starting point (Figure 2).

[4] TRL,2005. A Guide to Road Project Appraisal. Overseas Road Note 5(ORN 5)

Figure 2 Pavement Selection Flow Diagram



From the above it may be seen that the main economic inputs into pavement and surfacing selection are firstly in filtering out unsuitable options and then in the detailed assessment or ranking of the resulting short list. This detailed assessment may also include decisions on the utilisation of EOD (including Spot Improvements) and the suitability of a staged construction approach.

4.2 Justifying Upgrading and Establishing Project Priority

The resources that Cambodia has for infrastructure development are insufficient for the total needs, and an economic evaluation is a critical step in the process of determining the optimal allocation of the available resources; in other words, which of the proposed projects should qualify for the available funding, and what is their priority and the optimal timing for the work.

An economic evaluation of a proposed investment to upgrade an unpaved road to paved standard measures the worth of that investment to 'the economy', that is to the country (Archondo-Callao R S, 1999a)[5]

The economic evaluation calculates and compares the economic benefits and costs with the proposed paving against leaving it as an unpaved road. This latter so-called 'do-nothing' option is often a stated as being a valid and acceptable option. We should be clear however what is meant by the "do nothing" option as there is a danger that it can be erroneously interpreted as "maintaining status quo". In countries as Cambodia the "do nothing" option will almost certainly lead to decline in asset value and increasing user costs due to an almost complete lack of effective maintenance. It is recommended therefore that there is clear distinction made between "do

[5] Paving of unpaved roads. Economically justified paving costs. Infrastructure Notes, World Bank, Transport No, RT-3

nothing" and "maintaining status quo" and that to achieve a true assessment the negative cost of a "do nothing" option should be taken into account.

The costs of the 'with the project' option typically would include:

- The capital cost of the proposed paving
- The maintenance of the paved road
- The road user costs on the paved road.

The costs of the 'maintaining status quo" option typically would include:

- The maintenance of the 'existing' unpaved road
- The road user costs on the 'existing' unpaved road.

Traditional appraisal frameworks do not cater well for economic justification of LVRRs as poverty reduction and other social benefit issues are more difficult to quantify and tend to be ignored. (SADC, 2003)[6]. An effective LVRR assessment should ideally be capable of taking into account the following

- Benefits to non-motorised traffic (pedestrians, bicycles etc)
- Health and safety topics associated with dust from unsealed roads, particularly in village areas
- Local employment in road upgrading
- Recycling of costs within rural communities (local contractors, local manufacturers of bricks etc)
- Changes in agricultural and/or industrial output
- Changes in land values
- The use of a Spot Improvement or staged improvement strategies

Full economic analysis, even with tools such as HDM-4[7] or the World Bank's RED[8] model, requires substantial amounts of data that may not be readily available in Cambodia, and would be costly to collect and analyze with confidence, and may not be justified at the levels of investment funding available, especially for small projects. For example, ORN 5 notes that to use HDM-4 to calculate VOCs the following vehicle input data are required:

- Input prices (without tax and duties) of new vehicles, fuel, new and retreaded or remoulded tyres, oil, crew costs, passenger and freight values of time, maintenance labour costs and overhead costs

- Vehicle and load weights, vehicle and axle configuration, number of wheels, fuel type, engine power

- Vehicle utilization in terms of annual distance travelled and hours worked per day

- Average vehicle age.

These data sets are not as yet readily available in the Cambodian rural infrastructure context.

Although some concerns have been expressed with regard to the practicality of using these models for assessing LVRR upgrading, HDM-4 in particular is now a well established framework that has shown itself to be capable of regional modification and is worthy of further consideration within the Cambodian LVRR context.

The recent World Bank review "Surfacing Alternatives for Unsealed Roads"[9] acknowledges that the economic evaluation for LVRR upgrading requires special attention. In particular it notes that:

[6] SADC, 2003. Guidelines on Low-Volume Sealed roads
[7] more information about HDM4: http://hdmglobal.com/default.asp
[8] more information about RED: http://www.worldbank.org/html/fpd/transport/publicat/africa_tn-18.pdf
[9] World Bank, 2005. Surfacing Alternatives for Unsealed Rural roads, MWH

1. The immediate implications of construction cost are highly visible but other aspects such as social consequences and maintenance are equally important.
2. Upgrading of roads is often viewed purely from a technical or engineering perspective – a more holistic approach is recommended.

This review suggests the use of a "scoring system" to use in the evaluation of the need for unsealed road upgrading (Table 1).

Table 1 A Recommended Assessment Scoring System (WB, 2005)

Physical Factors			
TOPOGRAPHY	**GRADE**	**SCORE**	
Flat or Undulating area	<4%	0	
Undulating to Hilly area	4 - 8%	2	
Hilly to Mountainous	8-14%	4	
Mountainous with steep sections	>14%	5	
FACTOR SCORE			
COMBINATION OF CLIMATE AND SOIL CONDITIONS			
Soils mostly suitable for prevailing weather (e.g. most soils are suitable in arid environment, except sand) and traffic		0	
Soils suitable for prevailing weather only if treated (e.g. stabilised)		3	
Soils predominantly are unsuitable as road surfacing for given climate (e.g. clayey material in wet, or sand in arid climate)		5	
FACTOR SCORE			
Socio Economic Factors			
NON-MOTORISED TRAFFIC DEMAND FOR SURFACING			
Animal or non-motorised traffic with low volume/demand for sealed surface		1	
Non-motorised traffic with medium volume/demand for sealed surface		3	
Non-motorised traffic with high volume/demand for sealed surface		5	
FACTOR SCORE			
MOTORISED TRAFFIC VOLUME (annual average daily traffic in both directions)			
< 50		1	
50 – 200		3	
>200		5	
FACTOR SCORE			
POTENTIAL IMPACT OF DUST FORMING			
Slight – minor agricultural area with scarce population		1	
Medium – agricultural area, low – medium density population		3	
Severe - major agricultural area, densely populated		5	
FACTOR SCORE			
COMMUNITY IMPACT			
Slight – after sealing the road, trade opportunities will not change significantly or project will not create any local employment opportunities		1	
Medium – Some improvement is anticipated, some employment opportunities are created		3	
Severe – Significant improvement is anticipated or extensive employment opportunities are created		5	
FACTOR SCORE			
WILL TRAFFIC INCREASE AFTER SEALING			
Unlikely		1	
Some		3	
Likely		5	
FACTOR SCORE			
AVAILABILITY OF QUALITY MATERIAL			
Available and short hauling distance		0	
Available but hauling distance is more than 10km		3	
Suitable material is scarce or depleted		5	
FACTOR SCORE			
GRAND TOTAL			

The score sheet assesses both the environmental (climate/soil type and topography) and the socio-economic considerations affecting the decision to invest in the upgrading of the road. Overriding factors, i.e. circumstances that can override any other criteria can also be applied. For example, according to the socio-economic considerations dust on a particular road (or section of road) could be totally unacceptable (such as adjacent to hospitals or schools) and this factor on its own can sufficiently identify this road as a candidate for surfacing.

The following minimum scores for an unsealed road to be considered for surfacing are suggested as guidelines only that might be adjusted to specific local conditions

Table 2 Minimum Scores Associated with Table 1

Unsealed Road Network	**Recommended Minimum Score (Table 1)**
A. Developed countries – stable funding regimes	12-15
B. Developing countries- uncertain funding regimes	16-20
C. Severely under-funded networks	21-30

The Cambodian rural network would most likely be classified under (C).

4.3 Pavement Option Decisions- The SEACAP 1 Cost Model

Once a road upgrade is assessed as being required and the various options reviewed (as discussed in SC19 Technical Paper 4) there may well be a need to look in detail at these options. It is in this area of more detailed comparison using Whole Life Cost principles that current SEACAP research has been focussed.

A decision-supported cost model has been designed based on MS-EXCEL spreadsheets to provide rural road authorities and design consultants with a supportive tool for their road surface and pavement selection process. The Cost Model was a required output of the SEACAP 1 contract in Vietnam and has since also been adapted on a trial basis as part of the SEACAP 3 contract in Lao.

The model introduces a menu of appropriate rural road pavements with the road agency whole life cost details (construction and maintenance costs for road managers)[10] of each option, suggesting the most appropriate options for each defined local road environment. The initial menu is based on the research findings of the Vietnam RRST-1 and RRST-II trials. It is expected that further options will be added in later model versions based on other investigations.

The essential inputs for the model are

- Sub-grade geological and hydrological conditions:
    - Types of soil,
    - Strength
    - Flood regime

- Road alignment longitudinal gradient,
- Terrain (mountainous, midland, plain etc.), related to region,

[10] Intech-TRL,2006. SEACAP 1 Final Report..

- Annual rainfall, related to region,
- Material sources and haulage distances to the site.
- Traffic volume
- Axle load
- Costs associated with the above

And outputs are:

- Construction cost of the selected option **per km** (with defined surface width),
- Maintenance cost per km in terms of present cost,
- Maintenance cost per km in terms of NPV.
- Whole Life Asset Costs for the road agency

The Cost Model incorporates the logic diagram developed under the SEACAP 4 investigations on gravel road performance in Vietnam. The model suggests exclusion of the use of gravel under unsustainable circumstances, for example due to steep gradients or high rainfall, or inadequate maintenance capacity

Knowledge of the maintenance requirements of the various rural road surface options is limited. Some preliminary monitoring has been carried out on the RRST-I trial roads since their completion. Further monitoring of the performance and maintenance needs of the RRST-I and RRST-II trial roads has been recommended as an important follow up RRSR activity. In this way new and revised Maintenance Norms will be able to be developed for the range of surface options.

The Cost Model is currently complete to a functional state and can be used to analyse a range of options based on the RRST trials experiences. Further work would be required to fully develop the model for surfacing options and environments encountered in Cambodia. The development of a VOC cost sub-model is also recommended to achieve a total transport whole life cost model.

4.4 Environmentally Optimised Design Considerations

Environmentally Optimised Design (EOD) has been described elsewhere[11] as covering a spectrum of solutions for improving or creating low volume rural access – from dealing with individual critical areas on a road link (Spot Improvements) to providing a total whole rural link design (Whole Length Improvement).

The use of Spot Improvement involves the appropriate improvement of specifically identified road sections, allows the appropriate application of limited resources to be targeted at key areas on road involves economic and financial assessments within already defined projects. The use of Whole Life Costing principles and priority rating systems are an important part of this assessment as indicated in the proposed SEACAP EOD Manual[12] developed for Lao PDR. The adaptation of this manual to Cambodian road environments would be a reasonable course of action.

[11] TRL, 2008. Low Volume Rural Road Standards and Specifications for Lao PDR.(Parts I-III), SEACAP 3 for DFID and the Ministry of Public Works and Transport, GoL.
[12] TRL-OtB, 2009. An EOD Design Manual, SEACAP 3.02 for DFID and the Ministry of Public Works and Transport, GoL.

5 Economic and Whole Life Cost Databases

5.1 Regional Pavement and Surfacing Trials

A number of rural pavement trials programmes have been undertaken in the last few years in Cambodia, Vietnam and Lao. Not all these programmes have involved performance monitoring and hence they have limited usefulness as input to the development of a Life Cycle Cost assessment, Table 3.

Table 3 Summary of Regional Trials

Type of Surface/Roadbase	Cambodia			Vietnam : SEACAP 1		Laos
	Puok	ILO	NRDP	RRST-I	RRST-II	SEACAP 17
SEALS						
DBST					2006	
DBST (E)	2004**		O		2006	
SBST (E)+SS(E)				2005		
SS (E)	2004**			2005	2006	
Otta Seal		O				2008*
UNSEALED SURFACES						
Gravel Wearing Course	2004**			2005	2006	2008*
WBM				2005	2006	
Hand Packed Stone						2008*
Lime Stabilised Gravel			O			
Engineered Natural Surface						2008*
SEALED BASES & SUB-BASES						
WBM	2004**			2005	2006	2008*
DBM				2005	2006	
Emulsion Stabilised Sand				2006		
Cement Stabilised Sand				2005		
Lime Stabilised Gravel			O			
Lime Stabilised Clay				2005		
Lime & Cement Stabilised Gravel			O			
Armoured Gravel				2005	2006	
Graded Crushed Stone		O				
Sand				2005		
Sand-Aggregate Mix	2004**					
Gravel	2004**	O		2005	2006	
BLOCK SURFACES						
Stone Setts	2004**			2005		
Cobble Stone					2006	2008*
Fired Clay Brick				2005	2006	
Concrete Brick				2005	2006	2008*
CONCRETE						
Steel Reinforced				2005	2006	
Bamboo Reinforced	2004**			2005	2006	2008*
Non-Reinforced	2004**				2006	
Cast in Situ Blocks (Hysen Cells)						2008*

Notes
2005 etc Start of performance monitoring
***** Planned
****** Intertmittent only
O No monitoring
(E) Emulsion

Further details of these trials are contained in SEACAP 19 Technical Paper 4.

5.2 Regional Trials Data Sets

So far most of the recovered information has been from the SEACAP 1 trials in Vietnam and this has been analysed principally in terms of engineering performance. Some conclusions have been drawn as regards maintenance costs from road deterioration monitoring, although little or no effective maintenance has actually been undertaken.

A more limited amount of information has been recovered and analysed form the Puok Trials in Cambodia. Little or no relevant information has been made available from the other Cambodian trials other than some data on construction costs. Similarly, the SEACAP 17 trials in Lao have yet to yield data other than costs associated with construction.

5.3 Whole Life Costing Information in Cambodia

WLC analysis requires the use of a number of key data sets for unsealed roads and sealed pavement options, namely:-

- Initial construction cost (including design)
- Maintenance cost
- Relevant road environment data
- Road user costs (not included in WLAC analysis)

The following sections briefly review the availability of these key data sets based on the SEACAP 19 Task Reviews. Table 4 is a general summary of typical cost items for Cambodia based on information recovered from local authorities and other donor programmes (NRDP; JFPR-TA-90481; PRIP; TRIP IV.).

Table 4: Construction and Maintenance Cost

Cost Item	Cost in US$	Remarks
Construction of earthen road	$6000 to 8000/km	For 4m width of village roads
Upgrading from earthen to gravel standard	$15,000 -$35,000/km	Cost varies upon haulage distance of gravel, carriageway width…
Routine maintenance of gravel road	$500 - $1000/km	
Periodic maintenance of gravel road	$6000 - $8500/km	Re-gravelling at 12cm thickness
Upgrading from gravel to DBST sealed	$8 - $12/m2	
Upgrading from gravel to concrete pavement	$12 - $15/ m2	10cm of concrete laid on 6cm of compacted crushed stone

Constructions costs for unsealed roads appear to be generally available from most provincial centres although the quality of the data on the critical element of gravel cost may be suspect in some cases. Experience in Cambodia (as well as regionally) is that some actual costs are artificially low due to the use of poor quality materials in an essentially unsupervised construction regime. True costs of adequate quality, specification compliant, natural gravel could be significantly higher than is commonly quoted. There is of course a significant long term economic cost to the rural infrastructure of using sub-standard construction materials and techniques.

Actual information on the **construction cost of low volume sealed or concrete roads** is much less available and the estimates in Table 4 are general and there expected to be significant regional variations within Cambodia. This is a significant knowledge gap.

Given the lack of effective maintenance actually carried out, the information on **maintenance costs** of both unsealed and sealed is problematical, particularly for the latter. This also is a significant knowledge gap which could be addressed by indirectly by surveys of existing road condition (as is being done under SEACAP 27 in Vietnam)

The availability of **Road environment data** required as input to WLC including information on climate, terrain; hydrology; sub-grade; traffic; and axle loading is summarised in Table 5

Table 5 Data Set Availability

Data Set	Comment on Availability
Climate	Rainfall data is available from Ministry of Hydrology and in summary from "Atlas of Cambodia; National Poverty and Environment Maps, Danida, 2006"
Terrain	Reasonable quality 1: 250,000 scale down loadable topographic maps are available[13]
Hydrology	Significant areas of the Lower Mekong basin in Cambodia are subjected to serious flooding and records on this are referenced in SEACAP 19 Technical Paper 6[14].data is available in annual reports by the Mekong River Commission.
Sub-grade	There is general knowledge base on subgrade quality for Cambodia although the SEACAP 19 Task 2 assembled a database of subgrade DCP strengths from the provinces of SimReap, Kandal, Kampot and Ratanakirri.
Traffic	There is little collated information on traffic patterns in rural Cambodia.
Axle loading	Apart from isolated projects, such the Puok Trials there is little information on axle loading. Anecdotal information indicates that axle overloading is a significant problem

There is little of no specific information is available on **road user costs** for Cambodia rural roads.

[13] Old US Army topographic maps available from www.lib.utexas.edu/**maps/cambodia**.html
[14] Howell, J, 2008. Study of Road Embankment Erosion and Protection, SEACAP 19 report to DFID

6 Conclusions and Recommendations

6.1 Assessment Tools Summary

Economic criteria are an important at aspect of decision making in rural road upgrading from justifying projects in principle down to making detailed decisions within individual road links. A range of potential tools exists from the internationally established HDM4 system down to individually design scoring systems, each with its own advantages and disadvantages (Table 5)

Table 5 Comparison of Some Project Assessment Tools

Model	Advantages	Disadvantages
HDM4	Widely used model Requires initial outlay on software and professional training Extensive research on VOC & deterioration relationships Can be used for strategic planning i.e. can assess networks Now includes NMTs	High data requirements Does not include social benefits1 Cannot deal with passability and trafficability issues Road roughness is often not an appropriate measure of condition for LVRRs Not well suited for low traffic levels Not calibrated for Cambodia
RED	Has limited data requirements Readily available Can accommodate NMT and some social benefits Can be run from a spreadsheet Can accommodate impassability issues Can be used for ranking projects Well suited for traffic levels in range 50 – 200 vpd	NMT categories are limited to Four Would have to be calibrated for Low-volume sealed roads Heavy reliance on road roughness Designed for African condition and will require some adaptation for S E Asia.
SEACAP 1 Cost Model	Specifically aimed at the comparison of LVRR upgrade options Adaptable to Cambodia Uses simple spreadsheets	Not readily applicable for economic project justification Currently does take into account for VOC No social cost-benefits included
WB Scoring System	Simple approach to project justification PC system not necessary, can be used in hard copy Can be easily modified Some acknowledgment of social benefits	May over simplify some issues Does not readily differentiate between pavement options Does not help with EOD-Spot Improvement decisions

The SEACAP 19 Task 5 review has indicated that there a number of key gaps that should be addressed to take full advantage of already completed projects, namely;

- Additional research aiming at identifying appropriate holistic upgrading assessment tools suitable for Cambodia
- Collection of relevant data sets including both from of existing monitored road sections and from additional trials (see SEACAP 19 TP4)
- Analysis of data from the above monitoring
- Trialling and mainstreaming of the information at both National and Provincial/District

This work together with the other SEACAP research could then be brought together into a practical Guideline on the selection and design of LVRRs in Cambodia.

6.2 Recommendations

The SEACAP 19 Task 5 review has indicated that:

1. No LVRR upgrading economic assessment system has been adapted for the specific conditions of Cambodia. This is a major gap that needs to be rapidly addressed given the need for rural road infrastructure development in Cambodia and the limited budgets available.
2. Assessment tools are needed both to justify LVRR projects and to effectively select upgrading options once justification is established.
3. Associated with this shortfall in procedures are parallel gaps in the knowledge needed to effectively apply economic assessment tools.

Proposals for addressing the identified knowledge and application gaps have been drawn up and are contained in a concise Concept Note attached as Appendix B to this Technical Paper.

This Concept Note summarises a possible way forward through a number of Modules that could be adopted singly or in combinations. These Modules are;

I Review of Available Systems and Data Requirements

II System(s) Adaptation

III Collection of representative data

IV Trial Applications

V Training

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DEVELOPMENT OF LOCAL RESOURCE BASED STANDARDS

Appendix A

Use of Whole Life Asset Costs
for
Economic Evaluation
of
Low Volume Rural Road Upgrading

A1 Background

A Whole Life Transport Cost assessment brings in the component of user benefits, and includes saving of Vehicle Operating Costs (VOCs) and other economic or socio-economic factors (e.g. user time savings, socio-economic or environmental impact). This assessment is of more interest to, for example, national policy makers, planners and development agencies.

Economic valuation is important to make sure that only the pavement or surfacing option with the greatest economic impact is selected. There are a number of accepted and documented techniques to assess various aspects of the costs and effectiveness of road investments. Some methods require substantial amounts of data that may not be readily available, would be costly to collect, would be difficult to analyze with confidence, and may not be justified at the levels of investment funding available, especially for smaller projects.

It is noteworthy that economic evaluation technologies and techniques that are often applied in Cambodia generally draw little distinction between low-volume and high-volume roads even though these roads have quite different characteristics. As a result, many aspects of LVRR sustainability are not adequately addressed. Failure to revise or adapt these economic justification approaches to cater specifically for low-volume roads lead to the adoption and implementation of sub-optimal solutions that are unsustainable.

Any assessment will only be as good as the data and knowledge used in the relationships incorporated in the evaluation. It is very likely that the confidence in the cost data may be good for construction components. However, the knowledge and confidence may be less robust for both maintenance cost components of various road surface options and for user VOCs and other socio-economic, environmental costs.

The use of WLAC comparisons for the selection of alternative LVRR technologies is a practical, simple and transparent tool for LVRR managers to make better decisions.

Mainstreaming the use of WLAC analysis can be considered an important first step in understanding the impacts of various road management decisions. As the Road Agency develops the necessary capacities, more comprehensive analysis of the full economic implications of the decision making can be gradually introduced. Tools such as HDM4 can then be mainstreamed into the Road Agency.

A2 Introduction on Whole Life Cycle Costs

There are two approaches to the assessment of whole life costs for rural roads, which each reflect discrete objectives, and may result in different conclusions depending on the local circumstances. These can be characterized as:-

a) Whole Life Asset Costs (WLACs) for the Road Asset, and

b) Whole Life Transport Costs

A Whole Life Transport Cost assessment brings in the component of user benefits, and includes saving of Vehicle Operating Costs (VOCs) and other economic or socio-economic factors (e.g. user time savings, socio-economic or environmental impact). This assessment is of more interest to, for example, national policy makers, planners and development agencies.

A2.1 WLAC Assessment

WLAC Assessment is a process of assessing all costs associated with a road investment over its intended (initial) or design lifetime that the Agency must bear. The aim is to minimize the sum of these values to obtain the minimum overall expenditure on the asset, yet achieving a defined acceptable level of service of the asset. The principal cost components are the initial investment or construction cost and the future costs of maintaining (or rehabilitating) the asset over the assessment period selected (for example, 12 years from construction) and its residual value at the end of its design life.

Any rehabilitation costs will need to be included (for example, if maintenance is deficient and the road will need to be reconstructed during or at the end of the assessment period). Usually an assessment of the residual value of the asset at the end of the assessment period is included to incorporate the possible different consequences of construction and maintenance strategies for the pavement and surface options investigated.

From an economic evaluation viewpoint, an important decision is the reduction in value that is assigned to future costs. A discount rate is usually used to reflect future costs and benefits. In this way a dollar spent after one year is only valued at 90 cents at a discount rate of 10%. Similarly, a dollar expected to be spent after two years is valued at only 81 cents in current terms. The decision on discount rate selection is usually based on a combination of policy and economic considerations. In some industrialized countries the discount rate for public investments is 7%. Several international funding agencies use a rate of 12%. In the absence of specifications by the responsible authority, figures of around 10% are often used.

Future costs are discounted to present values using the formulas:

$$PCV = \frac{c_i}{(1+r/100)^i}$$

Future costs are discounted to present values using the formulas where:

PCV = present value of cost in year i;

c_i = sum of all costs (including construction and maintenance) in year i

i = year of analysis where, for the base year, i = 0;

r = discount rate expressed as a percentage.

Road Agency WLC is simply the different between discounted costs over the analysis period and discounted residual value of road asset at the end of the analysis period.

$$WLC = \left[\sum_{i=0}^{n} \frac{c_i}{\left(1 + (\frac{r}{100})\right)^i}\right] - \left[\frac{R_n}{\left(1 + (\frac{r}{100})\right)^n}\right]$$

where:

n = project analysis period in years

R_n = Discounted residual value of road asset at the end of analysis period (n)

A2.2 Construction Cost

Construction costs are available from previous contracts throughout the country. For Whole Life Costing purposes it would be very useful to regularly compile these costs on a regional basis, and broken down for each surface and paving option. In view of the high variability of energy/transport and materials costs the data should also be compiled by year so that any inflation cost adjustments can be made. Refinements could later be incorporated for such factors as size of contract, remoteness from main administrative centres, etc., as these aspects usually influence the overall cost of works.

A2.3 Maintenance Cost

The maintenance required on a LVRR is a function of the rate and the nature of road deterioration, and is best predicted based upon empirical knowledge developed in the unique environment in which the road is located. Once the deterioration properties are known accurate costing of the required maintenance regime can be determined. The experiences in South East Asia indicate that the capacity and delivery of LVRR maintenance is generally far from adequate.

Appropriate maintenance is fundamental to the sustainability of any road provision. Some LVRR technologies are more demanding of maintenance and more sensitive to the timing of its provision than others. Therefore before coming to a final decision on the selection of a pavement or surface type, **it is advisable to assess the future maintenance requirements** of the options being considered and to decide whether or not there is a likelihood of this level of maintenance being resourced (financially and physically) and being arranged in a timely manner.

In general earth and gravel surfaced LVRRs tend have low investment costs and have relatively high maintenance characteristics. On the other hand while their construction costs tend to be higher, bitumen seal pavements generally have more modest maintenance requirements and concrete pavements usually require the least maintenance.

It is the analysis of the trade off between initial and recurrent costs that is crucial. Both of which must fit within the resource and capacity envelopes of the road authority.

Maintenance for LVRRs can be categorised principally as Routine and Periodic.

Routine maintenance comprises a range of small scale and simple activities. Associated activities are dispersed regularly over the time. Typical activities include roadside verge clearing and cutting back encroaching vegetation, cleaning of silted ditches and culverts, repairing minor erosion, patching and pothole repair, and light grading/reshaping of unsealed surfaces. This maintenance may be able to use unskilled as well as skilled labour, or labour-based methods supported by light equipment. Conventional or community contracting may be appropriate. These regular operations are a good opportunity to identify periodic maintenance needs.

Periodic maintenance occurs less frequently – usually after a number of years. Works can include regravelling, resurfacing, resealing and repairs to structures. These works can be expected and planned. They are normally large scale and may require standard or specialist equipment and some skilled resources.

Spot Improvement, pavement strengthening overlays or pavement reconstruction is normally not considered to be ‘maintenance’ and are often funded separately under ‘development’ or ‘capital’ budgets. Rehabilitation is also not considered to be maintenance.

Occasionally urgent, unplanned, maintenance works may also be required – sometimes known as Emergency Maintenance - for example because of particularly severe weather conditions, floods, unexpected deterioration, landslips or exceptional damage caused by over-size/weight vehicles.

A pragmatic assessment of the costs of the maintenance operations and the expected maintenance resources and capacity are needed to achieve a realistic WLC assessment.

A2.4 Service Life and Residual Value

Each road investment still has an economic value to the transport network beyond the analysis period. Realistic estimation of residual value of the asset is essential for the evaluation of WLC. Certain technologies, such dressed stone paving, will have much higher residual values than wasting technologies such as gravel. Residual value can have an important influence on the analysis of technology options.

DEVELOPMENT OF LOCAL RESOURCE BASED STANDARDS

Low Volume Rural Road Upgrade Options

Economic Decision

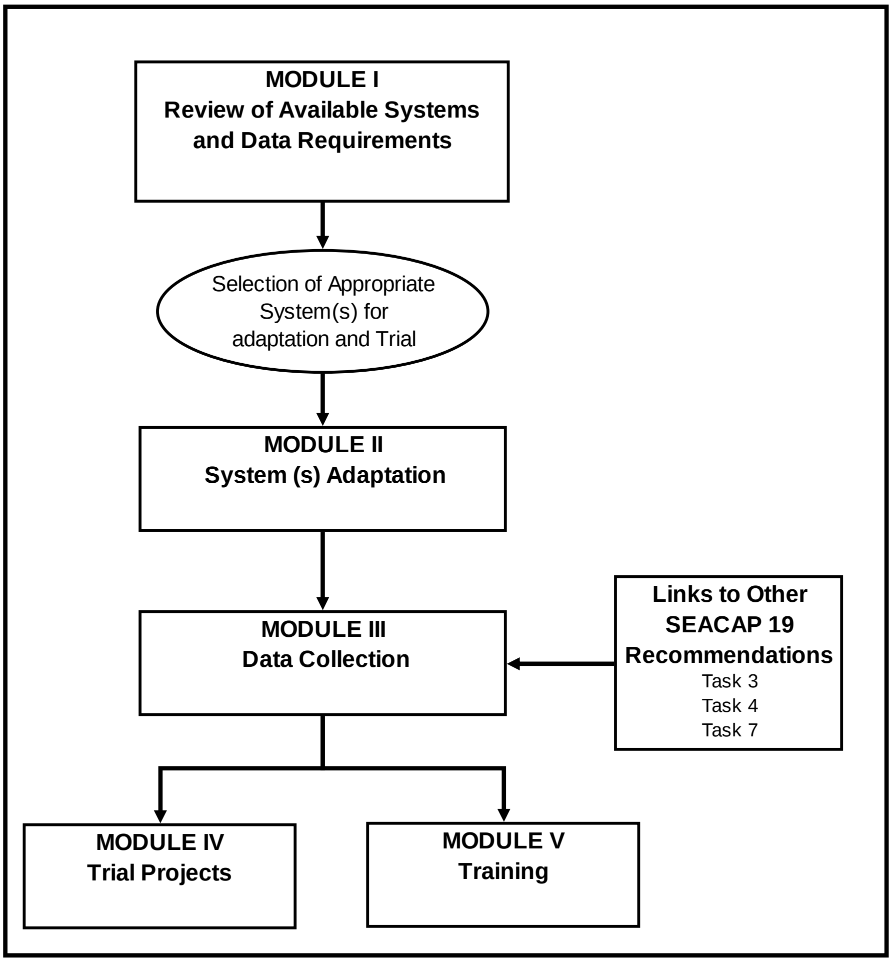
Appendix B

Further Research Concept Note

B1 Introduction

The following sections outline a modular approach to further research into the economic justification for rural road upgrading in Cambodia. This modular approached is summarised in Figure B1 below, with a preliminary outline programme presented in Figure B2

Figure B1 Further Research into Economic Assessment of Rural Road Upgrading



B2 Module I: Review

Key elements of this module are:

Review and compare various economic assessment approaches, for example:

- HDM-4
- RED Model
- SEACAP 1 Cost Model
- A typical WB-type point system

This module should also include a detailed assessment of the data requirements and the problems or difficulties in acquiring this information in Cambodia.

Key professional staff inputs would be:

- An economist with experience in rural infrastructure
- An road engineer with experience in using cost models
- A local consultant with local infrastructure knowledge

It is expected that time inputs would be of the order of 3 months and the output would be a recommendation on a system or systems to take forward into Module II

B3 Module II: Adaptation

This module should look at the modification required to apply the recommended system(s) to Cambodia. A similar team to Module I is anticipated with a 2-3 month input for each.

Following full consultation with key stakeholders the output would be a recommended modified system for the economic assessment of rural road upgrading for Cambodia together with:

- Draft guideline on use
- Recommendations how to set up a full-scale trial of the system
- National workshop

B4 Module III: Data Collection

Following-on from the previous work this Module would either identify and collate appropriate data sets or in some cases define methodologies for their collection. These data would be those required to undertake selected trials of the proposed economic assessment tools (Module IV). This module therefore has close links with Module IV, but could be largely undertaken by local Cambodian consultants.

There would also be close links with other SEACAP data sources, as shown on Figure B1.

B5 Module IV: Trial Project

This module would trial the proposed economic tools in a series of assessments that would be representative of the range of economic, social, financial and physical situations likely to occur in Cambodia. There would also be merit in "back-analysing" a number of already completed projects.

The outputs from this module would be final recommendations on the adoption, modification or rejection of the models proposed under Modules I and II.

The make up the Module IV team would be similar to that of Module I, although there probably is an argument to be made for the team to contain at least some specialists or technical reviewers who would in bring a fresh and unbiased view.

B6 Module V: Training

This module, linked closely to Module IV, would seek to train a core team of local specialist in the procedures and analytical methods associated with the proposed economic assessment models.

Figure B2 Outline programme