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ENHANCING THE USE OF LOCALLY MADE, LOW COST EQUIPMENT FOR THE ROAD SECTOR (SEACAP 020)

COMBINED MODULE REPORT (FINAL)

AUGUST 2008

BY

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This document is an output from a DFID financed project. The project has been implemented by IT Transport Ltd with assistance from Khmer Consultant Engineering Corporation (KCEC) of Cambodia and Institute of Science, Transport & Technology (ITST) of Vietnam. The report has been prepared by a team consisting of Messrs Masam Abedin, Farhad Ahmed, Gary Taylor of IT Transport Ltd, and Ron Dennis of the Developing Technologies at the Imperial College London. The views expressed are those of the author(s) and not necessarily those of the funding agency.

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ABBREVIATIONS

DFID	Department for International Development (UK)
DPWT	Department of Public Works and Transport (Laos)
DTW	Development Technology Workshop (Cambodia)
HP	Horse Power
ILO	International Labour Organization
ITST	Institute of Science, Transport & Technology
ITT	I.T. Transport Ltd.
KCEC	Khmer Consultant Engineering Corporation
KII	Key Informant Interview
LAK	Laotian Kips
Laos	Lao People's Democratic Republic
MCTPC	Ministry for Communications, Transport, Post and Construction (Laos)
MRD	Ministry of Rural Development (Cambodia)
NCDD	National Committee for Management of the Decentralization and Deconcentration Reform
NDE	New Dawn Engineering
NGO	Non Governmental Organisation
PDRD	Provincial Department of Rural Development (Cambodia)
RT2	Second Rural Transport Project (Vietnam)
RT2/RT3	Second/Third Rural Transport Project
SEACAP	South East Asia Community Access Programme
SIDA	Swedish International Development Agency
SSC	Small Scale Contactor
TOR	Terms of Reference
TRIP	Tertiary Rural Infrastructure Programme (Cambodia)
TRL	Transport Research Laboratory (UK)
VND	Vietnamese Dong
WB	World Bank
2WD	Two Wheel Drive
4WD	Four Wheel Drive

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Approximate Currency Equivalents (as of April 30, 2008)

CAMBODIA	VIETNAM	LAOS
1 US$ = 3,920 Riels	1 US$ = 16,100 VND	1 US$ = 8,700 LAK
1 € = 6,140 Riels	1 € = 25,200 VND	1 € = 13,700 LAK
1 UK£ = 7,800 Riels	1 UK£ = 32,000 VND	1 UK£ = 17,300 LAK

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EXECUTIVE SUMMARY

1. This report presents the findings of a study entitled "Enhancing the Use of Locally Made, Low Cost Equipment for the Road Sector" undertaken in three countries in South East Asia: Cambodia, Vietnam and Laos. The project is financed by the Department for International Development (DFID), UK under its South East Asia Community Access Programme (SEACAP). The main objective of the project (SEACAP 020) was to identify "*ways to improve the availability and accessibility of equipment that is necessary and appropriate for the rural road technologies that are emerging from SEACAP projects"*.
2. The project has four main modules. This report is concerned with three of them: (i) the survey module (which focuses on the identification of necessary equipment, the assessment of their demand and supply and the estimation of their performance and costs); (ii) the towed grader module (which focuses on towed graders and considers their suitability and cost effectiveness compared to other grader types); and (iii) the mobile small-scale stone crusher module (examines the suitability of mobile crushers in the production of quality and economical crushed aggregate). The study findings are drawn mainly from the evidence generated through interviews with small-scale contractors in Cambodia and Vietnam and with Key Informants in Vietnam, Cambodia and Laos.

Survey module

3. Equipment ownership among the contractors was found to be high. In general, Vietnamese contractors owned more equipment than Cambodian contractors. The contractors also hired in equipment. The main source of equipment hire was other contractors.
4. Evidence suggests that there is an occasional surge in demand for certain equipment (mainly haulage, compaction and grading equipment). The potential demand linked to the rural road related roadworks for the conventional equipment (e.g. trucks and compaction equipment) is estimated to be substantial. The demand for tractor-towed based technology has been estimated to be moderate.
5. In general there are no significant equipment supply constraints in Cambodia and Vietnam. The supply meets the demand. There exists a spatial aspect to supply constraint of relatively sophisticated equipment (e.g. motor graders) as they are only available for sale in large cities. No evidence is available that suggest a temporal aspect to supply constraint.
6. Among the study countries only Vietnam has a substantial manufacturing potential. However, evidence suggests that Vietnam is facing stiff competition from Chinese manufacturers at the higher end of the market (e.g. motor graders) and there is evidence that suggest some manufacturers have ceased the production of some equipment as a result of this.
7. Contractors in the region do not import equipment directly; they usually depend on dedicated importers for equipment importation.
8. The overwhelmingly main source of equipment finance by contractors is the private capital; only a small minority of them financed equipment purchase using formal credit. Only a few contractors reported having problems in obtaining formal credit. The main problem cited by the contractors in obtaining formal credit were the strict terms and conditions (e.g. high interest rate, large deposits etc.) linked to credit services.

9. No evidence from Cambodia and Vietnam suggests that potential SSCs face problems in entering the rural road sub-sector market. However, there is a cause for concern in Laos as there is evidence to suggest that an unfavourable climate for existing small-scale contractors and for market entrants. It is advised that the Government of Laos eases some of the constraints facing SSCs.

Towed Grader Module

10. Large and medium sized motor graders were widely available and used for roadworks in the region. Small motor graders (less than 120 HP) were rare. Only two types of towed grader were available (mainly in Cambodia): the CamGrader and the Simba. Most interviewed contractors, however, were unaware of towed graders. Key informants and contractors felt that large motor graders (more than 180 HP) were not suitable for use on small rural roads due to their excessive weight. However, smaller motor graders (less than 180 HP) are lighter as well as having adequate power and versatility of functions and are therefore regarded as suitable equipment for grading rural roads.
11. A cost-effectiveness analysis, that used empirical data in combination with a number of assumptions, suggests that the Cam Grader is the most cost-effective equipment for grading earth roads, whether purchased new or second hand, at low utilisation rates (less than 2,000 hrs/year). The same analysis also suggests that at low utilisation rates and gravel roads, the small-motor grader is the most cost-effective if purchased new and the Simba grader if purchased second hand. At higher utilisation rates and if equipment is hired, the small grader is the most cost effective equipment.
12. The study estimated the potential demand of graders linked to the planned rural road development in the three countries. The number of graders that will be required per year to implement the planned roadworks in Cambodia and Laos is estimated to be low (10 and 8 units, respectively). The grader demand is higher in Vietnam (approximately 180 motor graders and 270 towed graders will be required per year). There appears to be little difficulty amongst contractors in the region in hiring or acquiring tractors, which opens the possibility of the use of towed graders. Many contractors in Vietnam were interested in the possibility of purchasing a towed grader. However, the amount that they would be willing to pay appears to be significantly below the market price. Less than a third of contractors interviewed in Cambodia were interested in purchasing a towed grader. Analysis suggests that the existing stock of motor graders appears adequate to meet the likely future demand that will originate from the rural roads sub-sector in the next five years.
13. The overall conclusion is that there may be only limited opportunities for marketing towed graders in the region, given the adequate availability of the grading equipment. Therefore, there is no cause for concern on the shortage of grading equipment, at least in the near future.

Small-Scale Mobile Stone Crusher Module

14. Mobile crushers owned by the contractors in the region were of the jaw crusher variety. They are lighter and have a simple crushing mechanism.
15. Among the three viable alternative options (hand knapping, using a mobile crusher and purchasing from a commercial quarry), mobile crushers are found to be the most cost-effective. However, hand knapping is the best option in a case when the required volume of broken stone is low or if the construction site is remotely located. When the quality of required crushed material is high and/or there is a special technical requirement,

purchasing from a commercial quarry may become the only option available to the contractor.

16. The current demand for mobile crushers is high in Vietnam but low in Cambodia and Laos. The potential demand for mobile crushers linked to the rural roads sub-sector in Cambodia and Laos (combined) is relatively low (approximately 250 units per year are estimated to be required over the next 5 years). The potential demand in Vietnam is high (over 2,900 units per year). This is due to the anticipated expansion of paved rural road network in Vietnam. Evidence suggests that currently there is no crushing equipment supply constraint in the region.
17. Evidence suggests that many contractors are not aware of the usefulness of the mobile crushers (especially its cost effectiveness) in sourcing crushed stone. It is recommended that the details of the benefits offered by the mobile crushers be disseminated among contractors and equipment suppliers in the region by appropriate authorities to make them aware of their potential advantages. Currently no mobile crusher hire market exists in the study countries. An objective of this dissemination process should be to encourage equipment suppliers to make mobile crushers available for hire, particularly in Vietnam.
18. There is overwhelming evidence from the region that suggests that the market will be able to match the future demand with adequate supply of crushing equipment. Therefore, no intervention aimed at increasing supply is necessary, barring the dissemination of the usefulness of the mobile crushers in sourcing crushed stone among contractors.

PART A: INTRODUCTION AND METHODOLOGY

A1. INTRODUCTION

A1.1 Background

A series of Department for International Development (DFID), UK funded research projects are currently being implemented in Cambodia, Laos and Vietnam. They are being funded under DFID's South East Asia Community Access Programme (SEACAP). SEACAP identifies ways to improve sustainable access to rural communities to facilitate access to social and economic facilities and services, thereby creating opportunities for pro-poor growth and poverty alleviation. The objective of the Programme is *"Livelihoods of poor and vulnerable people in SE Asia improved sustainably"*. SEACAP encourages initiatives that allow roads to be constructed and maintained in a sustainable way by local people using local materials, local labour and skills, local enterprises and simple, low cost equipment.

A1.2 The Study and the Module

This report is one of the outputs from the SEACAP 020 project, Enhancing the Use of Locally Made, Low Cost Equipment for the Road Sector. The main objective of SEACAP 020 is to identify *"ways to improve the availability and accessibility of equipment that is necessary and appropriate for the rural road technologies that are emerging from SEACAP projects"* and that such *"equipment will be "appropriate in cost and size for (SSCs) small-scale contractors involved in the rural road construction and maintenance"*. SEACAP 020 activities mainly revolve around four modules: (i) Survey; (ii) Towed Grader; (iii) Mobile Small-scale Stone Crushers; and (iv) Dissemination and Mainstreaming. Although Cambodia is the main focus of SEACAP 020, some project activities are required in Vietnam and Laos. This report combines the findings linked to modules (i), (ii) and (iii) mentioned above.

The 'Survey Module', analyses the current demand and supply of equipment necessary for SSC's in relation to rural roads in the three countries. The main activities included the identification of the equipment necessary and appropriate to support various road technologies[1], the estimation of operational performances of the identified equipment, the investigation of equipment financing practices and constraints facing SSCs, the identification of potential institutions that can help SSC finance and procure equipment, development and mainstreaming of equipment, and recommendation of follow up initiatives to enable SSCs obtain needed equipment.

The 'Towed Grader Module', analyses the suitability of the towed grader for SSCs in the rural roads sub-sector. This involved a number of activities including the analysis of basic performance norms of the graders, the comparison of the cost effectiveness of towed graders over other alternative strategies and options, the review of commercial aspects of grader ownership and the formulation of strategies to integrate towed graders into national rural road programmes.

The 'Mobile Small-scale Stone Crusher Module' analyses the suitability of mobile small-scale stone crushers[2] for SSCs in relation to rural roads related roadworks. This again involved a number of activities including research of the existing knowledge base, the identification of regional mobile crusher manufacturers, the assessment of the views of existing and potential mobile crusher users, an appraisal of the short and long term market for the mobile crushers and the proposal of strategies to integrate mobile crushers into national rural road programmes.

[1] A list of road surfaces is provided in the Appendix to the SEACAP 020 Terms of Reference.
[2] Hereinafter referred as the Mobile Crushers.

A1.3 Structure of the Report

There are four parts to this report. Part A introduces the report and the methodology of the study. Parts B, C and D are the Survey, Towed Grader and Mobile Crusher modules, respectively.

A2. METHODOLOGY

This chapter describes the methodology that has been adopted to achieve the outputs linked to the three modules. A number of activities were conducted including: (i) contractor surveys; (ii) key informant interviews (KIIs); (iii) in-depth interviews/case studies; (iv) development of equipment performance and cost models; and (iv) general analysis.

A2.1 Contractor Survey

The contractor surveys provided the most important source of data for this report. The objective of the exercise was to ascertain the commercial behaviour of contractors regarding the necessary equipment. A detailed questionnaire was developed for this purpose (Appendix I). This questionnaire was administered face to face by trained surveyors.

The Terms of Reference (TOR) of the study provided a list of SSCs to be surveyed. They included 22 Cambodian trained by the International Labour Organisation (ILO) upstream project and 42 Vietnamese contractors who carried out work on the Second Rural Transport Project (RT2). From the original list, four Cambodian contractors and 33 Vietnamese contractors were successfully identified and interviewed. Where the contractors could not be interviewed from the original list (because the contractor no longer operated or was not able/willing to be interviewed), they were replaced by appropriate small-scale contractors. This involved establishing a set of criteria for each country. This was done with the help of local experts. The contractor selection criteria were:

Cambodia

- enlisted with Seila/NCDD[3]
- bid for a road project under Seila in it's final year (2006)
- not VAT registered
- has an updated trade licence

Vietnam

- have worked on a road project under RT2/RT3
- employ under 50 full time staff[4]
- total value of capital assets under $200,000[5]
- total annual turnover of under $200,000[6]

Laos

- registered and classified as Level II or Level III contractors with the Department of Public Works and Transport (DPWT)

A total of 79 contractors were surveyed (Table 1). Of them 39 were Cambodian and 40 were Vietnamese. No Laotian contractors were surveyed because none could be found that satisfied the selection criteria. A further analysis showed that this is because few SSC's are operating in the rural roads sub-sector.

[3] The Seila Program is an aid mobilization and coordination framework for support to Cambodia's decentralization and deconcentration reforms. The Seila Programme came to a close in December 2006. The activities of Seila are now being carried out by the National Committee for Management of the Decentralization and Deconcentration Reform (NCDD). Details on the Seila programme can be accessed using the following link: http://www.seila.gov.kh/indexs.asp?language=kh&pgid=1

[4] Government of Vietnam definition of small scale contractor

[5] Government of Vietnam definition of a small business is commercial entity with capital value assets of under 1 billion Vietnamese Dong (VND) (1998) (available online at www.taichinh-kinhte.com). This value equals 2.6 billion VND after applying GDP growth over the period. Vietcom Bank describes a small business with capital value assets of under 10 billion VND. The value of $200,000 (3.2 billion VND) was chosen to take a balance of these two definitions. It was also the opinion of many experts that few small scale contractors would be identified with a lower threshold capital asset value.

[6] Vietcom bank definition of small scale business.

A2.2 Key Informants Interview (KII)

A series of interviews, using a structured questionnaire, were conducted with experts in the rural road sub-sector in order to establish their views on the necessary equipment (Table 1). They were designed to complement the contractor surveys. The responses have been incorporated throughout this report. The interviews were conducted face to face. Appendix II provides the list of interviewees.

Table 1: Extent of activities in this study

Activity	Cambodia	Vietnam	Laos	Total
Contractor surveys	39	40	None	79
Key informant interviews	13	9	5	27
Equipment supplier interviews	8	7	7	22
In-depth contractor interviews	2	1	2	5

A2.3 In-depth Interviews/Case Studies

A number of in-depth interviews were carried out with contractors. The objective was to understand their views on a number of issues including the problems faced by them and details regarding the commercial environment. A total of three SSCs in the rural road sub-sector were interviewed in Cambodia and Vietnam. Two SSCs in the building construction industry were also interviewed in Laos (Table 1).

Equipment suppliers in Cambodia, Vietnam and Laos were also surveyed using a pre-defined questionnaire (Table 1). Appendix III provides the questionnaire. This provided an invaluable source of information for this study, especially in the analysis of the supply side of the equipment.

A2.4 Equipment Performance Model

A spreadsheet-based equipment cost model has been developed for this study to determine unit equipment operating costs. The model utilises a number of inputs including purchase costs, operating life, utilisation rates, interest rates, costs of different inputs (e.g. fuel, lubricants, operator wages etc.).

A2.5 General Analysis

A thorough search of relevant secondary sources was performed and the relevant documents were reviewed. Such information has complemented the information collected from primary sources.

PART B: SURVEY MODULE

B1. EQUIPMENT DEMAND

B1.1 Equipment Assessment

MART Working Paper No. 5 (MART-ASIST-DFR, 1996) provides a comprehensive list of intermediate equipment for labour-based small-scale contracting in the road sector. From the list, a total of 22 equipment (under seven categories) were short-listed for Cambodia, Vietnam and Laos to support various road technologies that have emerged from the SEACAP road surfacing research. The main document that assisted in the short-listing was a SEACAP project report (Ministry of Transport, 2007).

Appendix IV provides the details of the exercise. Where two or more competing equipment were suitable for a particular technology type, the lowest cost option was given preference. A deviation from this approach was required in the case of the haulage equipment, whereby, the appropriate equipment is dependent on the haulage distance[7].

The following list provides the equipment that was found appropriate in the context of the three countries to implement different road surfacing options:

Haulage	**Concreting**	**Compaction**
Tipper truck	Concrete mixer	Roller (ride on vibratory)
Flat truck	Concrete vibrator	Roller (pedestrian vibratory)
Tractor 2WD		Roller (towed vibratory)
Tractor 4WD	**Grading**	Roller (ride on deadweight)
Trailer	Motor grader[8]	Roller (deadweight, hand drawn)
Wheelbarrow	Towed grader	Roller (towed deadweight)
		Plate compactor
Watering	**Bitumen related**	**Crusher**
Water bowser (self-propelled)	Bitumen heater and hand sprayer	Mobile small-scale stone crusher
Water bowser (towed)		

B1.2 Unit Equipment Operating Costs

An equipment cost model was built to estimate the operating costs of different short-listed equipment. The operating cost model uses a number of inputs including:

- purchase price and salvage value;
- maintenance cost;
- tyre costs;
- fuel and lubrication costs; and
- operator wages etc.

Table 2 provides the unit financial operation costs of different equipment. Unit operating costs for graders and crusher are not included in Table 2 as they are dealt separately in Part C and Part D respectively of this report. Appendix V provides the detailed item-wise operating cost values. Information on productivity values and utilisation rates are available in Appendix

[7] Tractor/trailer combinations are appropriate for shorter haulage distances (e.g. under 10km). On the other hand Tipper/Flat Trucks are more suitable for longer haulage distances (say over 10km).

[8] Motor graders and self propelled water bowsers were not recommended for contractors because they are not intermediate items of equipment. However, their importance as a substitute to towed graders, makes analysis of this equipment a necessary requirement. For this reason, such equipment have been added to the short-list.

VI. Information linked to utilisation rates and other cost items were collected from contractors and suppliers. Productivity values were estimated using data supplied by equipment manufacturers.

Table 2: Financial operating costs of typical equipment

Equipment	Typical Model / Brand	Description	Financial operating cost (US$/hr)
Tipper Truck	Hyundai HD 72	6 cum capacity	18.5
Flat Truck	Isuzu FRR33H4	4 cum capacity	13.7
Tractor 2WD	Kobuta MX 500	53 HP	10.1
Tractor 4WD	Kobuta 9570	93 HP	12.8
Trailer	Local manufacture	3 cum capacity	0.41
Wheelbarrow	Local manufacture	0.09 cum capacity	0.31
Roller (ride on vibratory)	Komatsu 100 JVA	CE 10T	43.4
Roller (pedestrian vibratory)	Komatsu JV08HM	CE 10T	6.8
Roller (towed vibratory)	XCMG YZ12JC	12T	7.5
Roller (ride on deadweight)	Bomag BW 154AD-2	8T	15.3
Roller (deadweight, hand drawn)	Sakai TS 10 H	1T	1.9
Roller (towed deadweight)	Bitelli	1T	0.31
Vibrating Plate	Mikasa MVH-120	400x585 mm	4.0
Water Bowser (self propelled)	Unknown	5,000l capacity	45.9
Water Bowser (towed)	Herculano RT 4000	500l capacity	2.4
Concrete Mixer	Local manufacture	560l capacity	2.9
Concrete Vibrator	Mikasa MSX-28	28x1000 mm	2.2
Bitumen Heater & Hand Sprayer	Vina Bima NBT-100, PBT-100	1 cum capacity	4.1

Source: Contractor surveys; Equipment supplier surveys; IT Transport (2003); Larcher (1997)
Notes: cum – cubic metres; CE - compaction effort; T-tonnes; l - litres

Where data were not available from primary sources (e.g. information on towed water bowsers), operating cost values were derived from secondary sources, including IT Transport (2003) and Larcher (1997).

Overall the operating cost values appear to be consistent with other study findings including a study done in Mozambique in 2003 (IT Transport, 2003). Table 2 shows that, in general, towed technology is the least expensive to operate. Self propelled haulage/watering and compaction equipment have been found to be the most expensive equipment.

B1.3 Demand

This section provides an estimate for the overall demand of the identified equipment. Projected transport road work activities have been approximated from rural transport strategies in the three countries. Estimates of roadwork activities and the equipment productivity rates were used in the demand estimation.

B1.3.1 Rural road development and maintenance plans

The rural road linked roadwork volumes for three countries have been estimated using their rural roads development plans (Ministry of Rural Development, 2007; Ministry of Communication Transport Post and Construction, 2007, World Bank, 2006).

a) Current network

Table 3 presents the current length and the projected quantum of works in the rural road sub-sector. Vietnam has by far the largest network length (over 175,000 km). Cambodia's and Laos's rural road network lengths are considerably lower than Vietnam (24,000 and 17,500 km respectively). The summary rural road network characteristics are provided below:

- earth roads constitute between 60-62% in all three countries;
- gravel roads constitute between 31-39% in these countries; and
- paved roads constitute 5% and 7% in Laos and Vietnam, respectively. Cambodia has no paved rural roads.

Table 3: Rural road summaries and plans for the years 2007/08-2011/12

Variable	Surface	Cambodia	Vietnam[9]	Laos[10]
Current network size (km)	Paved	0	12,028	880
	Gravel	9,452	54,523	6,158
	Earth	14,578	109,917	10,556
Projected development (km/yr)	Paved	103	17,006	110
	Gravel	1,381	0	770
	Earth	0	0	1,320
Projected periodic maintenance (km/yr)	Paved	0	1,718	55
	Gravel	2081	3,138	388
	Earth	0	6,326	665
Projected routine maintenance (km/yr)	Paved	103	35,819	66
	Gravel	5,475	37,288	459
	Earth	0	75,173	786

b) Projected development

Vietnam will undergo a large construction programme as a result of the government's objective to pave 55% of the rural road network. However, this will not result in an overall expansion of the network but a conversion from gravel and earth surfaced roads. Cambodia's plan is to pave 50% of the tertiary road network and to improve over 6,900 km of gravel roads over the period. Laos plans to add over 500km of paved roads, 3,800km of gravel roads and 6,500km of earth roads to its network over the five year period.

c) Projected periodic and routine maintenance

Over the 5-year period, approximately 10,400 km of gravel roads will be periodically maintained in Cambodia. In the same period Laos plans to periodically maintain approximately 5,500km of rural roads. The total estimated length that Vietnam will put under periodic maintenance is 56,000 km (approximately a third of the rural road network) over the same period.

[9] For current network size refer to Vietnam Roads Administration, 2004. For projected rural road works refer to Project Appraisal Document, Third Rural Transport Project, World Bank, 2006.

[10] For current network size refer MCTPC, Provincial Road Maintenance Management System, 2007. These values are estimates; data for Lao PDR varies significantly between different sources. This depends mainly on whether special classed roads are included. These form 56% of the rural road network but are constructed and maintained by private industries not the MCTPC. See http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPREGTOPTRANSPORT/0,,contentMDK:20767668~menuPK:2069285~pagePK:34004173~piPK:34003707~theSitePK:574066,00.html. For projected rural road works refer to National Strategy on Accelerated Provision of Rural Transport Infrastructure, MCTPC, 2007.

Cambodia, Vietnam and Laos have planned to place a total 5,600km, 148,300km and 1,300km of rural roads (respectively) under annual routine maintenance operations. The summary of the strategies are provided in Appendix VII.

B1.3.2 Equipment demand

a) Assessment of current demand

It is difficult to estimate the market demand for equipment given that it is a function of a number of factors (e.g. the level of road building activities, activities in other sectors, current contractor equipment ownership etc.). The current market equipment demand for rural road related activities is a function of the small-scale contractors' equipment ownership and hiring level. Such information is available from contractor surveys and the results are presented in Table 4 (see Appendix VIII details). The ownership and level of hiring related information is used in the assessment of the current market demand.

Equipment ownership was high (ownership rates above 60%) for the following equipment in Vietnam and Cambodia:

- trucks (mostly tipper trucks)
- wheelbarrows
- compaction equipment
- water bowers (mostly self propelled versions)
- concreting equipment
- graders (motorised only)

The vast majority of contractors owned at least one truck and one compaction equipment. Such a combination is often regarded as the most necessary equipment for contractors in the rural road sub-sector.

Table 4 also shows that ownership of tractor-towed based technology was low, although slightly higher in Cambodia than in Vietnam. Less than 20% of contractors owned tractors and a slightly higher proportion owned trailers in the two countries. For every equipment type where both a motorised/towed option is available, the demand for the motorised option was higher. All the contractors that owned (hired) graders owned (hired) the motor grader. 53% (13%) of the contractors owned (hired) a self propelled water bowser, whereas, only 24% (4%) owned (hired) a towed water bowser.

Table 4: Contractors that own or have hired equipment in the last 12 months

Equipment	Percentage of contractors that own/hire[a]					
	Total		Cambodia		Vietnam	
	Own	Hire	Own	Hire	Own	Hire
Trucks	90 (5)	51 (3.5)	82 (4.2)	51 (3)	98 (5.6)	50 (4)
Tractors	16 (1.4)	10 (1)	21 (1.5)	15 (1)	13 (1.2)	5 (1)
Trailers	27 (1.3)	15 (1.1)	33 (1.3)	3 (1)	20 (1.4)	28 (1.1)
Wheelbarrows	77 (15.5)	1 (2)	67 (18.2)	0 (0)	88 (13.4)	3 (2)
Compaction	94 (5.2)	43 (1.4)	87 (3.7)	44 (1.2)	100 (6.4)	43 (1.7)
Water bowsers	70 (1.9)	16 (1.2)	59 (1.8)	18 (1)	80 (2)	15 (1.5)
Concreting equipment	81 (8)	8 (3.7)	62 (4.8)	5 (3)	100 (9.9)	10 (4)
Mobile small-scale stone crusher	16 (1.8)	3 (1)	0 (0)	0 (0)	33 (1.8)	5 (1)
Graders	61 (1.9)	37 (1.3)	44 (1.5)	51 (1.3)	78 (2.1)	23 (1.4)
Bitumen heaters and hand sprayers	43 (3.3)	14 (2.6)	13 (2)	3 (4)	73 (3.6)	25 (2.5)

Source: Contractor surveys

Note: [a] The values in brackets refer to the average number of equipment owned/hired per owning/hiring contractor

In Vietnam ownership was higher for bitumen and mobile small-scale stone crushing equipment (no Cambodian contractor owned the latter). This finding is expected considering the higher current proportion and anticipated growth of paved roads.

Ownership rates and the average number of equipment owned were higher in Vietnam than in Cambodia. One possible explanation is that the contractors surveyed in Vietnam were larger in size than the Cambodian contractors (see Appendix IX and X).

Table 4 shows that the hiring rates and the average number of equipment hired were similar in Cambodia and Vietnam. Trucks, compaction equipment and graders were the equipment most hired. This is expected given that they are the basic equipment for roadworks.

The conclusions from the above discussions are: (i) the current equipment ownership among the Cambodian and Vietnamese contractors was high; (ii) In general, the equipment ownership among Vietnamese contractors was higher than Cambodian contractors; (iii) Despite high equipment ownership, the contractors hired in equipment. This shows that there is an occasional surge in demand for such equipment.

b) Assessment of future demand

The future equipment demand has been estimated by using the projected volume of rural roads related roadworks and productivity values of the equipment (see Appendix VI). Table 5 presents the estimated future equipment demand arising from rural roadworks. Table 5 values represent the number required annually to carry out the planned roadworks. In the demand assessment the following assumptions apply: (i) where possible, the low-cost equipment was given preference over sophisticated equipment; (ii) the equipment availability and efficiency levels are 50%[11] and 80%, respectively; and (iii) the demand is only linked to the rural roadworks. The demand from other sectors was ignored.

Table 5: Annual requirement of equipment, number of units (2007/8-2011/12)

Equipment	Cambodia	Vietnam	Laos	Total Demand Level
Tipper Truck	455	11,955	208	✸✸✸
Flat Truck	89	2,532	63	✸✸✸
Tractor 2WD	162	4,242	81	✸✸✸
Tractor 4WD	93	1,705	40	✸✸✸
Trailer	279	2,139	26	✸✸✸
Wheelbarrow	327	3,798	210	✸✸✸
Roller (ride on vibratory)	6	60	4	✸
Roller (pedestrian vibratory)	18	656	3	✸✸
Roller (towed vibratory)	11	70	9	✸
Roller (ride on deadweight)	4	621	6	✸✸
Roller (deadweight, hand drawn)	4	1,120	3	✸✸
Roller (towed deadweight)	0	1,433	45	✸✸
Vibrating Plate	49	16,790	31	✸✸✸
Water Bowser (self propelled)	65	539	50	✸✸
Water Bowser (towed)	11	934	18	✸✸
Concrete Mixer	74	804	47	✸✸
Concrete Vibrator	74	804	47	✸✸
Bitumen Heater & Hand Sprayer	1	179	1	✸

Source: Consultant's estimates
Notes: ✸✸✸ - high (demand over 1,500 units) ; ✸✸ - medium (demand between 500 and 1,500); ✸ - low (demand below 500)

[11] This level of availability is assumed to factor in effects of factors linked to the delay in sourcing spares and the limited repair capacity if the equipment breaks down at the construction site, time to move equipment from one construction site to another, and the low utilisation rate in rainy season.

Table 5 shows that there will still be substantial demand for conventional equipment (e.g. tipper truck and ride on deadweight roller). The demand for low-cost equipment (particularly tractor-towed technology) is moderate.

The demand estimation utilises a model which simplifies the rural road sub-sector characteristics. Therefore, the values in Table 5 are only approximate estimates; however, the model provides a good analysis for the relative level of demand between equipment types.

B1.4 Chapter Summary

This chapter assessed the equipment necessary to support various road technologies emerging from the SEACAP road related research. A total of 22 equipment were identified and productivity norms provided. The chapter also assessed current and future equipment demand. Equipment ownership among the contractors was high. Contractors also hired in equipment, particularly haulage, compaction and grading equipment reflecting an occasional surge in demand. Potential future demand will be high for conventional equipment (e.g. trucks and compaction equipment). The demand for tractor-towed based technology has been estimated to be moderate.

B2. EQUIPMENT SUPPLY

This chapter presents the issues linked to equipment supply, in particular, the supply constraints faced by contractors, availability of suppliers and manufactures in the region, equipment available regionally and their purchase costs and importation practices.

B2.1 Equipment Supply Constraints Faced by Contractors

Contractors were asked whether they faced difficulty in obtaining the identified equipment. Table 6 presents the results of the analysis. Cambodian contractors faced no problems accessing equipment. The Vietnamese contractors faced some equipment supply constraints; however, the overwhelming majority encountered no problems. It can therefore be concluded that supply covers the level of demand and in general there are no equipment supply constraints.

Table 6: Contractors facing difficulty in equipment procurement

Equipment	Percentage of contractors that have had difficulty acquiring		
	Total	Cambodia	Vietnam
Trucks	1	0	3
Tractors	1	0	3
Trailers	1	3	0
Wheelbarrows	0	0	0
Compaction	4	0	8
Water bowsers	4	0	8
Concreting equipment	1	0	3
Mobile small-scale stone crusher	4	0	8
Graders	4	0	8
Bitumen heaters and hand sprayers	8	0	15

Source: Contractor surveys

Evidence from key informants and supplier interviews suggest that there is little overall supply for towed graders and mobile small-scale stone crusher (Cambodia and Laos only) but this being mainly due to low demand.

Most experts (and contractors) claim that equipment can only be purchased in major cities (e.g. Phnom Penh, Hanoi, Ho Chi Minh, Vientiane). It can therefore be concluded that a spatial constraint to equipment supply exist. However, this should not necessarily act as a disadvantage to contractors. The dis-benefits associated with lack of availability of equipment for purchase in local areas will be offset by lower retail prices in main cities.

Contractors and equipment suppliers were also asked about the temporal aspect of equipment demand and supply. It is evident from their response that there was no significant temporal variation of equipment demand that could not be matched by suppliers.

Appendix XI provides details on the contractors' response regarding constraints in supply.

B2.2 Existing Suppliers and Manufacturers

There are many equipment suppliers in the region, providing contractors with a huge choice of outlets. A non-exhaustive list of equipment suppliers is presented in Appendix XII for each equipment type. Contractors were asked where they acquired their equipment and their responses are presented in Figure 1. An overwhelming majority of the contractors (83%) purchased their equipment from one of the above main cities (Figure 1). Only one in six of

the equipment was purchased from local suppliers and they were mainly wheelbarrows, trailers and concrete mixers.

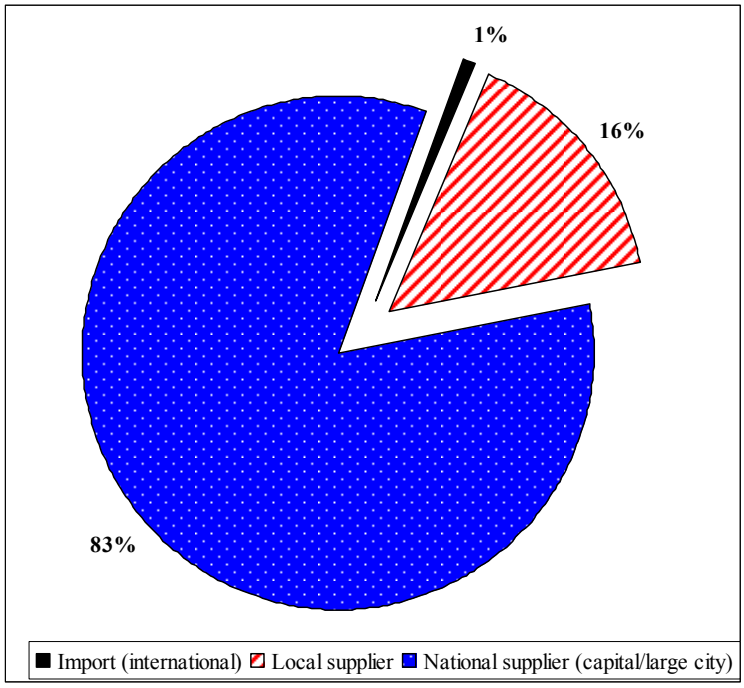
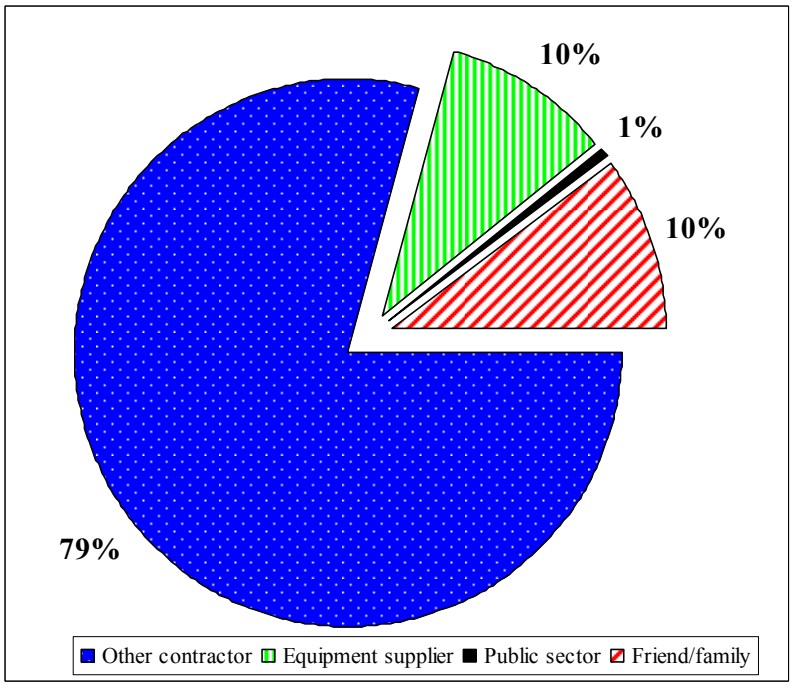


Figure 1: Source of equipment purchased

When contractors needed extra equipment an overwhelming majority (roughly 80%) rented them from other contractors (Figure 2). Renting equipment from commercial equipment suppliers was not common. Approximately 10% of contractors rented equipment from equipment suppliers; however the proportion is considerably higher in Cambodia (21%) than in Vietnam (3%) (see Appendix XIII and XIV). This means that the equipment suppliers tend not to rent equipment out. Contractors also rented equipment from friends and family (10%).



Source: Contractor survey

Figure 2: Source of equipment hire

Data on equipment hire out rates were collected in Cambodia. Table 7 presents the rates against different equipment with their brand and model. Hire out rates for different equipment range from US$ 3,800 (for motor grader) to US$ 50 per month (concrete vibrator). These rates were exclusive of driver/operator wages.

Table 7: Typical hire rates in Cambodia

Equipment	Brand & Model	Description	Hire Rate (per month, US$)
Tipper truck	HINO FD2JDBD	5 m3	3,000
Flat truck	FUSO EF639	5 tonnes	3,000
Tractor (2WD)	BELARUS 800 D-243	86 Hp	1,500
Tractor (4WD)	BELARUS 820 D-243	86 Hp	1,800
Wheelbarrow	Unknown	0.2 m^3	40 [a]
Roller (Ride on vibratory)	Komatsu JV 100A	10 tonnes	2,000
Roller (Towed deadweight)	Unknown	Unknown	300
Roller (Pedestrian vibratory)	BOMAG BW 71 E-2	0.5 tonnes	500
Roller (Deadweight)	CAT CB 214 C	2.4 tonnes	1,200
Roller (Hand drawn)	BOMAG BW 75 S	1 ton	700
Plate compactor	Mikasa MT-52FW	3 Hp	250
Concrete mixer	Unknown	0.2 m^3	350
Concrete vibrator	Mikasa MSX 28	35*1000mm	50
Motor grader	CAT 14G	180 HP	3,800

Note: [a] estimated from the daily hire out rate

B2.3 Equipment Models and Costs

The equipment supplier survey has provided a large database of information on brands and models of the equipment being used by the contractors. Such models vary greatly in price and specifications. Table 8 provides a summary of the most typical brands and models available in the region with their purchasing costs. There also exists an active second-hand equipment market in the region. Anecdotal evidence suggests that most of the second-hand equipment comes from the neighbouring countries (Thailand and China).

Table 8: Typical equipment models & purchase costs

Equipment	Brand / Model	Description	Cost (US$)	
			New	2nd hand (age in yr)
Tipper Truck	Hyundai HD 72	6 m^3	35,000	25,000 (3)
Flat Truck	Isuzu FRR33H4	4 m^3	25,000	14,500 (3)
Tractor 2WD	Kobuta MX 500	53 HP	25,000	16000 (2)
Tractor 4WD	Kobuta 9570	95 HP	42,000	20,000 (4)
Trailer	Unknown	3 m^3	1,500	500 (5)
Wheelbarrow	Unknown	0.09 m^3	30	Unknown
Roller (ride on vibratory)	Komatsu JV 100A	(CE[12]) 10 tonnes	130,000	90,000 (6)
Roller (pedestrian vibratory)	Komatsu JV08HM	0.73 tonnes (CE, 5 tonnes)	12,500	5,000 (5)
Roller (towed vibratory)	XCMG YZ12JC	12 tonnes	29,500	Unknown
Roller (ride on deadweight)	Bomag BW 154AD-2	8 tonnes	Unknown	12,000 (8)
Roller (deadweight, hand drawn)	Sakai TS 10 H	1 ton	Unknown	3,500 (9)
Roller (towed deadweight)	Bitelli	1 ton	1,000	Unknown
Vibrating Plate	Mikasa MVH-120	400*585 mm	2,545	Unknown
Concrete Mixer	Hoa Phat JZC-350	560 L	2,920	Unknown
Concrete Vibrator	Mikasa MSX-28	28*1000 mm	305	Unknown
Mobile Small-Scale Stone Crusher	Hoa Phat NHHP-PEX215 (diesel)	215*300 mm stone capacity	4,145	Unknown
Motor Grader	CAT 120H	140 HP	150,000	110,000 (5)
Towed Grader	Cam Grader	0.88 tonnes	2,500	Unknown
Bitumen Heater & Hand Sprayer	Vina Bima NBT-100, PBT-100	1 m^3	10,000	Unknown

Source: Equipment supplier surveys

B2.4 Equipment Importation

a) Importation practices

The early part of the chapter shows that the present equipment market appears to be functioning satisfactorily. Information on the contractor importation practices, available from contractor surveys, further corroborates such a conclusion (Table 9). Appendix XV presents detailed results. Table 9 shows that only a small minority of the contractors ever imported or considered importing equipment (the overall results range from 0% to 6% for different equipment types). From Table 9 it can also be concluded that contractors depend on dedicated importers for the importation of the equipment rather than direct importation.

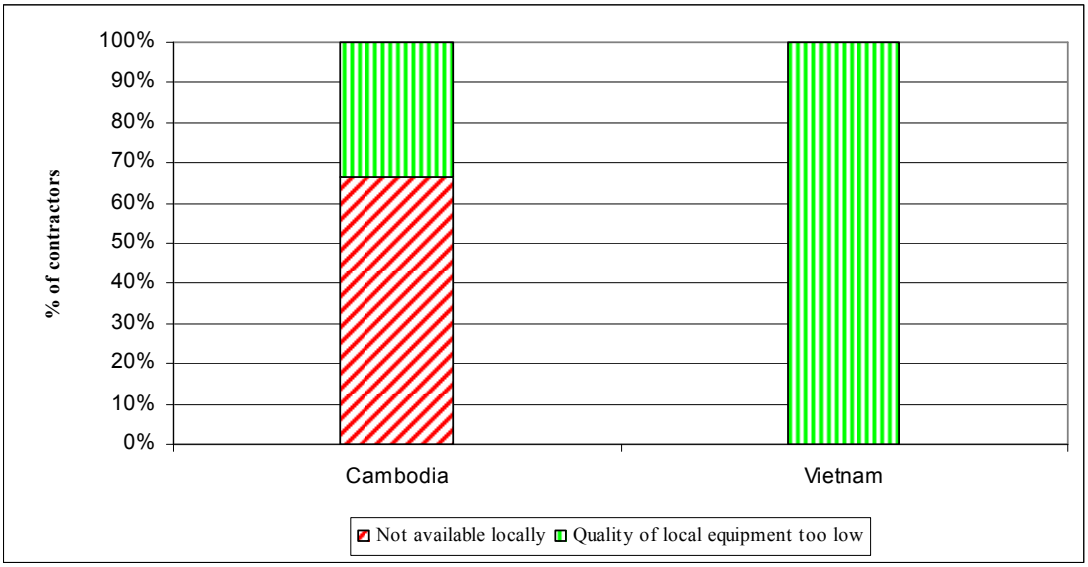
[12] Compaction effort

Table 9: Contractors that imported or considered importing equipment

Equipment	Percentage of contractors imported/considered importing		
	Overall	Cambodia	Vietnam
Trucks	4	3	5
Tractors	0	0	0
Trailers	1	0	3
Wheelbarrows	0	0	0
Compaction	6	5	8
Water bowsers	1	0	3
Concreting equipment	3	0	5
Mobile small-scale stone crusher	0	0	0
Graders	3	0	5
Bitumen heaters and hand sprayers	4	0	8

Source: Contractor surveys

Contractors, who imported or considered importing equipment, were asked questions regarding the reasons for considering the option. The only reason cited by Vietnamese contractors was the poor quality of locally available equipment (see Figure 3). The response was different in Cambodia: only a third imported or considered importation as an option due to poor equipment quality. Two thirds of the Cambodian contractors, who considered importation, did so because the equipment was not available locally.



Source: Contractor surveys

Figure 3: Reasons why importation considered

b) Common sources and practices for importation

Contractors were asked on common sources and practices for importation of equipment. Their responses show that when a contractor decides to directly import an item of equipment they would normally hire a shipping agent to conduct the necessary preparatory work. The contractors also pick up the equipment at the border/port. In northern Cambodia and Laos, contractors have been known to drive trucks across the Thai border.

Table 10 shows the typical countries from which such equipment is imported from. This information is based on the data gathered from equipment suppliers and key informant interviews. The list of equipment exporting countries is not exhaustive and it only presents the major countries that are active in the supply of equipment to these three countries. Table

10 shows that the major exporting countries include Japan, South Korea, China, Thailand and the USA.

Table 10: Equipment exporting countries to Cambodia, Vietnam and Laos

Equipment	Import from
Tipper Truck	Japan, South Korea, Thailand, USA
Flat Truck	China, Japan, South Korea, Thailand
Tractor 2WD	Belarus, China, Thailand, US
Tractor 4WD	Belarus, China, Thailand, US
Trailer	China, Thailand
Wheelbarrow	China, Thailand
Roller (ride on vibratory)	China, Japan
Roller (pedestrian vibratory)	Japan, Thailand
Roller (towed vibratory)	China, Japan
Roller (ride on deadweight)	Italy, Japan, Thailand, USA
Roller (deadweight, hand drawn)	Japan, UK
Roller (towed deadweight)	Italy
Vibrating Plate	China, Japan
Concrete Mixer	France, Italy, Thailand
Concrete Vibrator	Japan, South Korea, Thailand
Mobile Small-Scale Stone Crusher	China
Motor Grader	China, Japan, USA
Bitumen Heater & Hand Sprayers	Germany, Japan, South Korea, Thailand

Source: Equipment supplier surveys

c) Barriers to importation

Data gathered from the contractors, who considered importing equipment, show that the biggest barrier to importation is their general lack of knowledge of the required procedures. This explains the hiring of a shipping agent to conduct the necessary preparatory work.

There are also other importation barriers (as evident from key informant and equipment supplier interviews) that include:

- a requirement to hold importation licence;
- high importation tax/fee;
- long delivery time;
- inability of contractors to visit the country where the equipment is sourced in order to inspect the goods;
- lack of language skills throughout the process;
- cost of shipping agent; and
- availability of shipping agent (they tend to only exist in capital cities).

d) Feasibility of producing equipment locally

Investigation in to the equipment manufacturing potential of the countries suggests that Cambodia and Laos currently have very limited manufacturing potential. Nonetheless, they are able to manufacture smaller equipment (e.g. wheelbarrows and concrete mixers). They are also able to produce makeshift equipment with modification of some of the mainstream equipment (e.g. self propelled and towed water bowsers from trucks and trailers, see photographs below). It is common practice to operate with makeshift bitumen heaters (using an empty drum) and bitumen hand sprayers (using a watering can).


Makeshift Water Bowser in Laos

On the other hand Vietnam has a much more advanced manufacturing base. The country is able to manufacture a number of equipment including:

- tipper truck;
- flat truck;
- tractors (2WD and 4WD);
- trailers;
- wheelbarrows;
- vibrating plates;
- concrete mixers;
- concrete vibrators;
- mobile small-scale crushers;
- concrete mixers;
- bitumen heaters and hand sprayers

Contractors, key informants and equipment suppliers stated that locally produced equipment were not as cost effective as foreign ones, especially with the recent influx of modern and cheap Chinese models. For this reason equipment of foreign origin are still more popular. The cost effectiveness gap between local and foreign equipment is most stark with the more technologically advanced equipment, where some manufacturers have abandoned the manufacture of certain equipment types (e.g. the 1-5 Machinery Company based near Hanoi no longer produces motor graders and rollers).

Appendix XVI provides a non-exhaustive list of equipment manufacturers.

B2.5 Chapter Summary

Contractor survey results show that, in general, there are no equipment supply constraints. However, sophisticated equipment (e.g. motor graders) are generally only available in large cities. Therefore, there is a spatial aspect to supply constraint. Nonetheless, this is not a major issue as purchasing prices are likely to be lower than if they were available in rural areas. No evidence linked to the temporal aspect to supply constraint was found. Evidence shows that contractors frequently hire equipment from other contractors.

Only Vietnam currently has a substantial manufacturing potential. However, Vietnamese manufacturers are currently facing stiff competition from Chinese manufacturers producing low priced versions. This has resulted in some manufacturers having to stop the production of some equipment. Evidence suggests that generally the contractors do not import equipment themselves. They usually depend on dedicated importers.

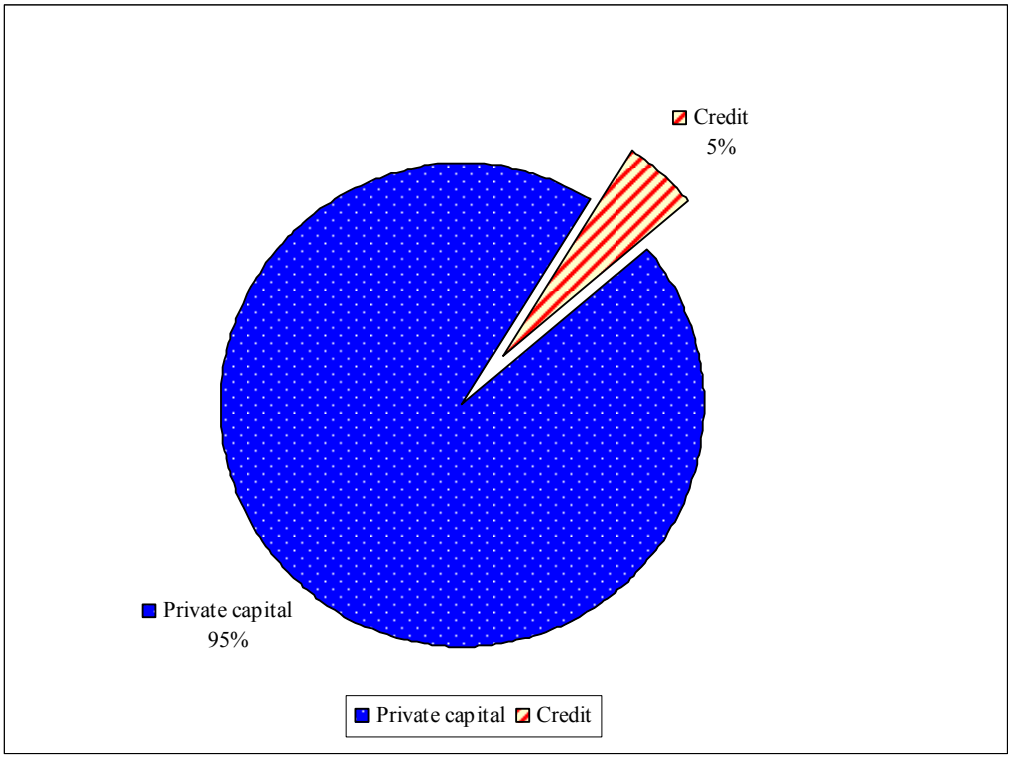
B3. EQUIPMENT FINANCING AND INSTITUTIONAL FRAMEWORK

This chapter discusses how purchase of equipment is financed by the contractors, what constraints they face and their opinions on potential solutions. Market entry into the rural road sub-sector is also discussed, as well as the potential supporting institutions.

B3.1. How are Equipment Financed

Contractor surveys collected information on financing practices of contractors. An overwhelming majority of the contractors (95%) reported that they financed equipment purchase through raising capital privately (Figure 4). The remaining 5% of contractors reported to have financed equipment purchase using formal credit. No equipment purchase was financed through grants or other methods. The results were corroborated by the key informants: they stressed that these two methods were the only modes of equipment finance. Vietnamese contractors are more likely to borrow capital from banks than Cambodian contractors. (see Appendix XVII and XVIII).

However, credit finance is becoming increasingly popular. According to key experts and contractors, credit has traditionally been accessed informally through the community (family and friends), but banks now form the main source of credit finance. A recent economic report on Vietnam concluded a similar trend across all sectors of the economy (The Economist, 2008). ACLEDA bank of Cambodia and Agri Bank of Vietnam are the only two banking institutions cited by the contractors as sources of credit.



Source: Contractor surveys

Figure 4: Method of equipment finance

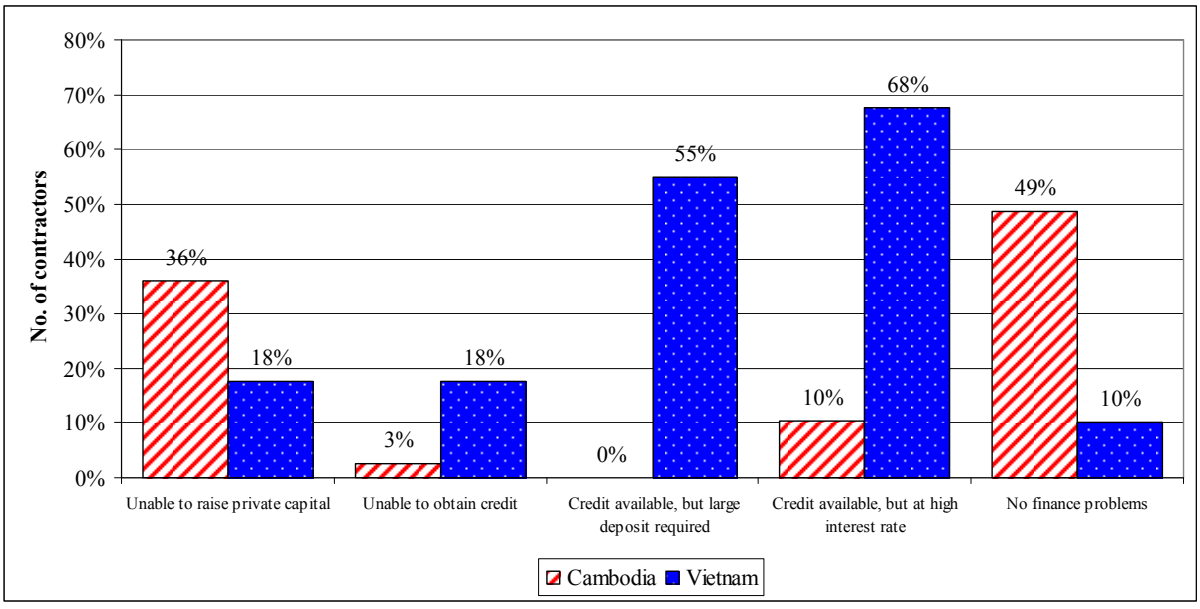
B3.2 Constraints Facing SSCs in Equipment Financing

Figure 5 shows the results of the analysis on the constraints faced by contractors in financing equipment purchase. Inability to raise private capital was the main constraint perceived by Cambodian contractors. Unfavourable conditions attached to the products/services banks provide was the main constraint for Vietnamese contractors. Research on the products that ACLEDA bank offers show that similar restrictions exist in Cambodia (see Box 1), however, these restrictions are perceived to be a greater problem in Vietnam. Box 1 shows that small scale contractors are not able to borrow amounts large enough to purchase expensive equipment (e.g. motor graders). However, they could use the loan to contribute towards the amount required (especially if purchased second hand). Loan periods of 24 months will also act as a major constraint to contractors especially if there are delays in project commencement and/or payment.

Box 1: Sample Borrowing Terms and Conditions for Small Business Loan in Cambodia

- Minimum loan of 6 million Riels (approximately US$1,500)
- Maximum loan of 40 million Riels (approximately US$10,000)
- Interest rate of 2.75% per month
- Maximum loan period of 24 months;
- Liquid deposits amounting to 100% of the loan value OR secured with property amounting to 125% of the loan value

Source: ACLEDA Bank



Source: Contractor surveys

Figure 5: Financial barriers

B3.3 Potential Financing Initiatives

Some experts expressed their opinions on various financing options ranging from establishing equipment pools to hire purchase agreements to direct supply. Many key informants preferred not to intervene in the market. However, the only option that received general acceptability from key informants was hire purchase agreements, whereby contractors receive equipment built into a contract and the value of the equipment is deducted from the work payments. Initially the equipment will be owned by the client so the equipment is essentially loaned and

therefore interest payments need to be included in the contract. Such a scheme has been implemented before in the ILO Upstream Project in Cambodia. Nonetheless, this method can run into trouble if: (i) the client is unable to pay on time; (ii) the work is not completed on time for some reasons (e.g. contractor's/client's fault, or reasons beyond the control of any of the contracting parties). These problems can be overcome by introducing clauses into the contract. For example, in the Ugandan Transport Rehabilitation Project (ILO), interest payments were frozen if the contracting agency was unable to pay the contractor on time or guarantee work (Deelen and Bonsu, 2002).

B3.4 Potential Supporting Institutions

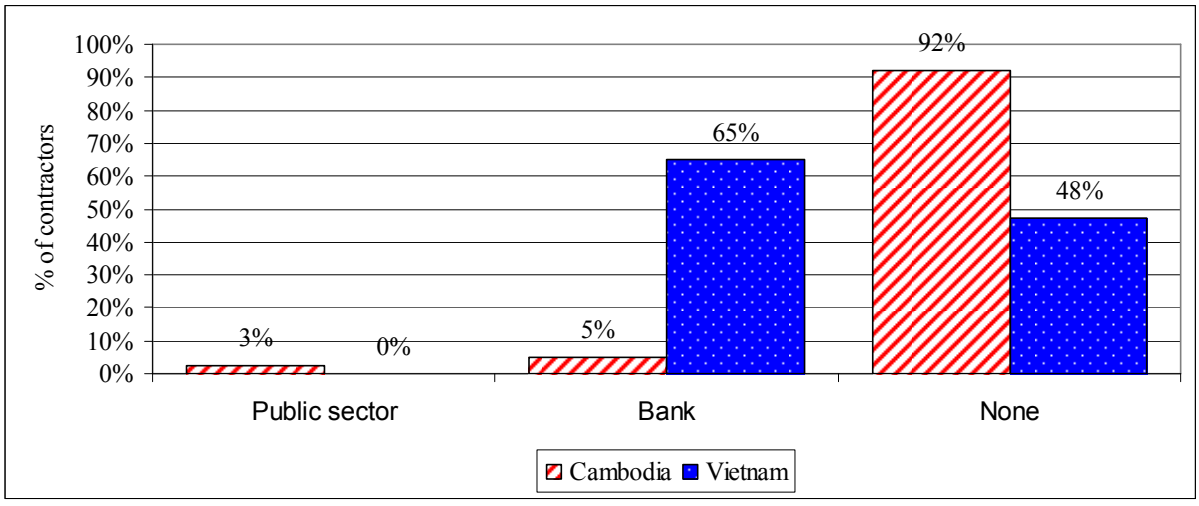
Contractors were asked which institutions could assist them to access equipment. An overwhelming majority of Cambodian contractors (92%) opined that there are no potential supporting institutions (Figure 6). The same figure for Vietnam was also considerable (42%).

Box 2: Quote from a key informant

"There are no public institutions that can currently help contractors in equipment procurement," **Mr. Ros Sar, Director of Department of Rural Development, Siem Reap, Cambodia**

Source: personal interview

58% of Vietnamese contractors cited banks as potential supporting institutions. The same figure for Cambodia was only 5%. The most likely explanation for such a difference is that the Vietnamese contractors are more familiar than their Cambodian counterparts in obtaining credit from banks. Also the business community may have more faith with banks in Vietnam than in Cambodian due to a more mature financial sector. Ministries and public sector institutions, NGOs and donors were only cited by one contractor (in Cambodia) as a potential source of support. These findings are corroborated by key informants (Box 2)



Source: Contractor surveys

Figure 6: Potential supporting institutions in equipment finance

Many key experts felt that the public sector can and should incorporate a more comprehensive capacity building service for contractors so that they can be educated on managing and conducting rural road projects. A SEACAP[13] study also recommended that capacity within the rural transport sub-sector be improved. There have been capacity building initiatives in the past, but these were mainly incorporated into individual programmes e.g. the ILO Upstream Project had a contractor development component and the SEILA programme

[13] Institutional, Incentive and Capacity Study of the Local Transport Network, SEACAP 16, July 2005

had a capacity building component called the Technical Support Unit to Commune Council. It is recommended that these initiatives be refreshed and expanded so that they are available to all contractors and applicable to all rural road works.

B3.5 Market Entry

Evidence (key informant interviews and contractor surveys) indicates that there are no market entry barriers for small scale contractors in Vietnam and Cambodia. Empirical evidence from other studies also corroborates this finding. Klerx and Lay (2001) estimated a total of approximately 500 SSCs in Cambodia in 2001. This figure might have increased substantially in the last seven years. A study in Vietnam[14] mentioned the existence of approximately 5,500 SSCs (those who have less than 50 employees) in 2002 in Vietnam. It appears from the study quoted SSC figures that the rate of growth in SSC numbers in Vietnam was very high (over 60% per year). Furthermore, a SEACAP[15] study concluded that SSCs in Vietnam were operating on a good economic and technical platform to take advantage of the opportunities available in the rural transport sub-sector.

However, small businesses have difficulty entering the rural road sub-sector in Laos and there are many reasons for this. Experts and SSCs (active in the building industry) state that the most important reasons is that a free market environment has only been functioning for the past decade and is therefore can be considered at a very early stage and the rural road sub-sector is not large enough to attract potential contractors.

Small contractors in Laos are still unlikely to enter into the market in the near future for other reasons. Mainly, large contractors are not prohibited from bidding for the smallest projects and the smallest projects are attractive enough for large contractors to consider. This problem is exemplified with an analysis of the contracts awarded on the Lao-Swedish Road Sector Project III's Basic Access Component (LSRSP III-BAC). In 2006/7, the vast majority of projects were won by a handful of contractors. The smallest project in the component was worth US$3,500 (Bokeo province) – a size and value that can be regarded as suitable for a SSC. However, this was effectively incorporated into one large project worth approximately US$100,000 and consequently awarded to a (large) contractor. The average size of rural road projects under the LSRSP III-BAC programme in the year 2006/7 was approximately US$ 60,000.

Box 3: Quotes from Laotian Building Construction Contractors

"In order to enter the rural road market you need at least one billion Kip!," **Mr Khamoune Inthisane, Inthasane Construction, Vientiane, Laos**

"I would like to work in the rural road sub-sector but the market is too small," **Mr Khounsy Thongsavath, Construction Co. Ltd., Vientiane, Laos**

Source: personal interview

Key informants also suggested that small contractors in Laos were being crowded out of the market. This is as projects are being tendered at the provincial level rather than at the community level which can be very unfavourable to small contractors who tend not have a large portfolio of work across a province. In addition, tender documents tend to disqualify small contractors based on their small equipment fleet and discourage them from bidding due to their lack of financial

[14] Vietnam: The Vital Construction Industry, July 2004
[15] Research into the Role of the Private Sector in Rural Transport, SEACAP 14, May 2005

resources. An analysis of a typical bidding document for the Lao-Swedish Road Sector Project III Maintenance Component (LSRSP III-MC) requires that contractors have access to at least one tipper truck, a bulldozer, a motor grader and a roller. This will require a significant investment for a contractor planning on entering the market.

In-depth discussions with building contractors show that there are further constraints (see Box 3). They state that they face too much competition from medium and large sized companies who can offer lower unit prices because they have the most sophisticated equipment. They claim that small companies do not have the financial resources to cover the negative cash flows often experienced during the work and sometimes even after it is completed due to late payment. They have also stated that they can't obtain access to staff appropriately skilled.

B3.6 Chapter Summary

An overwhelming majority of the contractors (95%) reported that they financed equipment purchase by raising capital privately. The remaining 5% of contractors reported to have borrowed money. Only a handful of contractors cited problems in obtaining credit. The main problems cited were unfavourable terms and conditions linked to the products being offered by banks. Contractors rated financial institutions substantially higher than public sector institutions as potential sources of help in procuring equipment.

B4. EQUIPMENT MAINSTREAMING AND CONTRACTOR DEVELOPMENT

This chapter first summarises the findings from Chapter B2 to B4. Where appropriate, recommendations have been provided.

B4.1 Demand and supply

The equipment market demand and supply mechanism is functioning correctly, therefore no major initiatives to increase the volume of supply in the market should be considered.

The current level of equipment ownership is high among the Vietnamese and Cambodian contractors. A majority of the contractors in the two countries owned the main construction equipment. In spite of high equipment ownership the contractors also rent equipment.

The potential estimated equipment demand in Cambodia, Vietnam and Laos for the years 2007/8-2011/12 is high for conventional equipment (e.g. tipper truck, ride on deadweight roller) and moderate for low-cost equipment (tractor-towed technology).

B4.2 Manufacturing Capacity

Vietnam's manufacturing capacity is broad and developing fast. There is no need to introduce any intervention that would discourage healthy market competition. Cambodia and Laos have a limited manufacturing base, but do locally modify some equipment (e.g. water bowsers). Such creative initiatives should be encouraged, but there is not need for mainstreaming interventions as such community driven initiatives tend to thrive on being able to fill a niche in the local economy.

B4.3 Barriers

There are no significant barriers for the SSCs to enter the rural roads sub-sector in Vietnam and Cambodia. However, only a few SSCs are currently operating in Laos due to a multitude of factors. It is advised that the Government of Laos eases some of the constraints facing SSCs.

Many Cambodian contractors cited the inability to raise private capital as a major barrier in financing equipment purchase. Banks have recently been offering new products in Cambodia but the uptake has been slow. The major problem cited by the Vietnamese contractors was the strict credit conditions set out by banks. However, in spite of these barriers, no intervention is recommended because the equipment market is performing satisfactorily.

Many contractors and key informants felt that hire purchase agreements be introduced where contractors receive equipment built into a contract and the value of the equipment is deducted from the works payment. Contracting agencies should consider incorporating these into their programmes, but only in special cases where it is perceived that shortage of equipment could pose a problem in smooth project implementation.

Contractors felt that were no supporting institutions (apart from banks) that could help contractors procuring equipment. Most contractors and key experts suggest that an effective contractors association be set up to support contractors. Such an initiative should be considered by the relevant ministry along with potential stakeholders.

PART C: TOWED GRADER MODULE

C1. GRADER TYPES

C1.1 Introduction to Graders

A grader is an engineering machine used in road construction to set a smooth surface and create the correct shape and camber for a road. They are commonly used in the maintenance of unsealed road surfaces to restore the correct shape and reduce surface roughness. They are also used on paved roads to shape shoulders and drains and in construction for earthwork shaping and finishing. There are two general types of graders; motor graders (which provide their own power source) and towed grader (which require an external power source).

A typical motor grader has the engine and driver's cab situated above two axles at the rear, a third axle at the front and a large blade in between (Figure 7). A towed grader performs the same basic function but unlike a motor grader it requires a tractor to pull it. The most common arrangement is one axle at the rear. The towed grader is the predecessor of the motor grader and has been used for grading operations on unsealed roads since at least 1909 (Petts and Jones, 1991).

Tractors can be used for a multitude of activities both within the rural roads sub-sector (e.g. haulage, watering, compaction etc.) as well as in other industries (e.g. agriculture). Motor graders are a highly specialised piece of equipment and have higher productivity levels than towed graders. They can also perform other activities (e.g. shaping embankments and creating drainage ditches).

C1.2 Grader Types

This section describes the most common grader technologies available in the region. Three motor graders (one small, one medium and one large sized) and two towed graders(the Simba and the DTW Cam-Grader) have been analysed.

C1.2.1 Motor Graders (Large) (more than 180 HP)

The information gathered from the equipment supplier survey indicates that large motor graders (over 180 HP engines) are available in the region. However, medium sized versions are the most common. The most typical large grader model in the region is the Komatsu 705A. The cost of new and the second-hand (5 years old) models are typically US$ 160,000 and US$ 105,000, respectively. They can be hired for approximately US$ 4,000 per month (excluding operator wages). It has a 200 HP engine and weighs approximately 18 tonnes[16].

Motor grader operators and key experts in the region have expressed their scepticism about the utility of such (heavy and large) machines for narrow rural roads. There was concern that machines of this size would not be able to turn efficiently and more importantly that the large weight may damage the roads. Overall it can be concluded that large motor graders are not suitable for rural road related roadworks.

C1.2.2 Motor Graders (Medium Sized) (120 to 180 HP)

The most common motor graders in the region are medium sized (between 120 to 180 HP). The equipment supplier survey shows that Chinese models (Changlin 165H) are the cheapest, starting at US$ 75,000. However, models from Japan and the USA dominate the market. The most common model is the CAT 120H. The costs of a new and a second hand CAT 120H are

[16] See http://www.komatsu.com/ce/products/motor_graders.html

approximately US$ 140,000 and US$ 95,000 (5 years old), respectively. It weighs approximately 13.tonnes and has a blade width of 3.66 m.

Motor grader operators in Cambodia and Vietnam unanimously stated that a motor grader of such specifications was perfectly suitable for heavy and light grading on both gravel and earth rural roads.

C1.2.3 Motor Graders (Small) (less than 120 HP)

Motor graders less than 120HP are often called 'compact graders'. A survey of equipment suppliers in the three study countries indicate that these graders are not common and subsequently no models could be identified. There are only a few manufacturers producing motor graders of this size.

Source: http://www.apellc.com/images/7222_ft.jpg

Figure 7: A Compact Motor Grader (LeeBoy 635)

A typical model is the LeeBoy 635 (Figure 7). It has a 48HP Kobuta Diesel Engine, weighs approximately 3.6 tonnes and has a mouldboard width of approximately 2.5m.[17] A new LeeBoy 635 costs approximately $60,000[18], and a 5 year and 10 year old one costs approximately $25,000 and $50,000, respectively. The potential uses of these graders in the region have been discussed with experienced motor grader operators. They stated that these models had the same versatility of functions as large/medium motor graders and they would be useful in carrying out routine maintenance work on both gravel and earth rural roads. However, they may not be suitable for heavy grading work and would be impractical for roads wider than 10 metres.

[17] Information available at: http://www.leeboy.com/uploadedFiles/635B%20Motor%20Grader.pdf
[18] Factory gate price.

C1.2.4 Towed Graders (Medium Sized) (Simba)

The SIMBA (Figure 8) is manufactured in the UK in two sizes. The standard Simba RG3 version weighs 1.35 tonnes, costs US$ 16,000[19] and requires a 70 hp tractor. There is also a heavy duty 4.4 tonne version (costs approximately US$ 35,000). Three blade sizes are available: 3m, 3.5m and 4m. A Simba grader was imported by the Tertiary Road Improvement Project (TRIP) in Cambodia for a trial. Those involved in the trial claimed that it was not compatible with a 2WD agricultural tractor, which is common in rural areas. However, it is capable of performing light grading operations on both earth and gravel roads when it is used in combination with a 4WD tractor[20].

Other towed graders of similar size include the Arthur Garden (2 tonnes) towed grader which has been produced in Zimbabwe since 1951. In the year 2000, the manufacturer produced their 2000th unit with an ex-works price of less than US$ 8,000 (Gongera and Petts, 2000). No evidence has been found that Arthur Garden towed graders were used for roadworks in the SE Asia region.

Source: www.simba.co.uk/roadgrader.php

Figure 8: The Simba Towed Grader

C1.2.5 Towed Graders (Small) (Cam-Grader)

These graders are designed and produced by DTW, an international NGO in Phnom Penh (Figure 9). They were designed and produced in DTW workshops with the transfer of skills to local manufacturers in mind. The price is $2,500 (2004 prices) and it requires a 30 hp (minimum) tractor. There are no hydraulic parts and many parts are made with spares from the locally ubiquitous Toyota Camri and therefore can be locally sourced. It has a 2.3 m blade width and is designed for a 4m carriageway to be cut in two passes. The equipment only weighs 0.88 tonnes.

Testing of the Mark I Cam-Grader was carried out in Takeo Province of Cambodia in 2003 and the findings were used to update the design for the Mark II grader. An evaluation of the Cam-Grader was carried out in Svay Rieng province in 2004. The operation of the grader was reported to be successful, produced a smooth regular camber at an estimated cost of $20 per km and was relatively easy to turn whilst being coupled to a 2WD Kobuta L2801 35HP tractor.[21] The equipment is suitable for tight turns. It is light enough for the operator to

[19] See www.simba.co.uk/roadgrader.php. c.i.f. price quoted by SIMBA in March 2007.
[20] Although the Simba did not receive a positive review by its user(s) on the TRIP trial project, the contractors did comment that it was capable of performing light grading operation on earth and gavel roads if the equipment was used properly (e.g. with a 4WD tractor)
[21] LCS Paper 19, Evaluation of Mark 2 Cambodia Light Grader, 2004

decouple the grader from the tractor, to lift the front of the equipment, to and turn the equipment on its (back) wheels.

A total of five were manufactured and operated under the TRIP 3 project. While talking to contractors on the use of these graders, it was found that they perceived the use of the graders problematic and did not expect to make further use of them. The apparent ineffectiveness of the Cam-Grader during these trials may be partly due to the contractors' use of inappropriate towing equipment (e.g. trucks instead of tractors), as well as applying the grader to an unsuitable road surface. The overwhelming consensus of the users of this equipment is that it can only satisfactorily perform light grading operations and only on earth roads.

Figure 9: Cam-Grader

C1.3 Summary Overview of Different Graders

Table 11 shows an overview of different grading options. It can be seen that the cost of a grader may range from US$ 2,500 to 160,000 (new) or US$ 1,700 to 105,000 (second-hand, five years old). Motor graders fall into three main categories: large (>180 HP), medium (120-180 HP) and small (less than 120 HP). Only two types of towed graders are available in the region: the Simba and the Cam Grader. The only locally manufactured towed grader is the Cam-Grader. All of them are suitable for the grading of rural roads except large motor graders, which are inappropriate for use on rural roads due to their size. There is also reservation about the use of the Cam-Grader in the grading of rural roads with gravel surface. The small motorised grader is not locally available.

Table 11: Overview of grading technologies

Variable		Motor Grader			Towed Grader	
		180 HP +	120-180 HP	<120 HP	>1 tonne	< 1 tonne
Typical model & brand		Komatsu 705A	CAT 120H	LeeBoy 635	Simba	Cam-Grader
Weight (tonnes)		17.62	12.65	3.5	1.35	0.88
Power (HP)		200	140	48	-	-
Blade width (m)			3.66	2.5	3 to 4	2.3
Purchase cost (US$)	New	160,000	140,000	60,200	16,000	2,500
	Second-hand[22]	105,000	95,000	40,000	10,860	1,700
Hire cost (US$/month)		4,000	3,500	1,510	400	60
Suitable for rural roads (earth)		NO	YES	YES	YES	YES
Suitable for rural roads (gravel)		NO	YES	YES	YES	NO
No. of operators required		1	1	1	2	2
Locally produced		NO	NO	NO	NO	YES
Locally available		YES	YES	NO	NO	YES (Cambodia)
Supporting equipment	Details	None	None	None	Tractor > 70HP	Tractor >35 HP
	Cost (new), (US$)	N/A	N/A	N/A	42,000	25,000
	Cost (second-hand) (US$)[23],	N/A	N/A	N/A	17,000	10,000
	Hire (US$/month)	N/A	N/A	N/A	1,800	1,500

Source: Equipment supplier interviews, Equipment manufacturers, Consultants estimates. Hire rates of the CAT 120H, Simba and Cam-Grader were derived from the Komatsu. Second-hand rates for the Simba and Cam-Grader were derived from the CAT 120H.

C1.4 Chapter Summary

This chapter discussed grader types and their characteristics. From the review of different type of graders it appears that only medium and small motor graders and the Simba towed graders are appropriate for grading work on both earth and gravel rural roads. The Cam-Grader is not suitable for heavy grading work on rural roads. Large motor graders (above 180HP) are likely to be too cumbersome to be effectively used on rural roads.

[22] 5-year old
[23] Ibid

C2. GRADER COST EFFECTIVENESS

C2.1 Introduction

This chapter presents the grader operating costs. It first introduces the productivity rates of different graders, and then compares operating costs at varying levels of utilisation and commercial options.

C2.2 Unit Grader Operating Costs

Two estimates have been made of the comparative operating costs of grading earth and gravel roads using motor graders and towed graders: one based on ownership of equipment and the other based on hire of equipment. The criterion for comparison is the cost per kilometre for each type which depends on the length and width of road graded per day. It was difficult to obtain consistent data on this from contractors as it is dependent on a number of factors including condition of the road surface, type of soil etc. The only data available for towed graders was from limited trials. However, no comparative data was available for motor graders. The comparison therefore used the data from Petts and Jones (1991) of 2km/day for a motor grader. Towed grader productivity was derived using the findings of a trial conducted by ITT in Kisii District, Kenya.[24]. This trial found the productivity of the towed grader to be 90% of the productivity of the motor grader in light grading work. Table 12 below shows the productivity levels used in this study. These grader productivity rates were verified with grader operators in the region. Only light grading work was evaluated, because trials in Cambodia have shown that the towed grader is not suitable for tasks of greater difficulty. Large motor graders (above 180 HP) were not evaluated as they were considered unsuitable for grading small rural roads (discussed in Chapter C1).

Table 12: Grader productivities (for light grading)

Variable	Motor Grader		Towed Grader	
Size	Medium (120-180 HP)	Small (<120 HP)	Medium (> 1 tonne)	Small (< 1 tonne)
Model	CAT 120H	LeeBoy 635	Simba	Cam-Grader
Productivity (Earth roads) (km/hour)	0.4	0.4	0.36	0.36
Productivity (Gravel) (km/hour)	0.4	0.4	0.36	-

Source: Petts and Jones (1991) and consultant's estimates

The cost-effectiveness of various equipment depends on the utilisation rate (number of hours used per annum). More productive and expensive equipment are more likely to be cost effective when utilisation rates are high. They are more likely to have higher utilisation capacities and will require less servicing. Jones and Robinson (1996) mentioned that in developing countries annual utilisation rates of equipment could be very low (often in the region of 200-500 hours per year). Evidence from contractor surveys has found that motor grader utilisation rates are typically 900 hours per year in Cambodia and Vietnam. The analysis below considers the cost effectiveness of the equipment for a range of utilisation levels.

[24] The trial results are unpublished. However, figures were provided by the project manager.

C2.2.1 Grader Operating Costs: Purchased Equipment

Table 13 provides the grader cost estimates when the motor grader is used for 900 hours per year for light grading on rural roads (Appendix XIX provides details). Table 13 also provides cost per km figures. This facilitates a direct comparison between the towed and motor graders. The most cost effective equipment was found to be the Cam-Grader with a 2WD tractor. This conclusion remains valid whether the graders are used in combination with a new or a second-hand 2WD tractor. A new small motor grader is more cost effective than the Simba grader and a new 4WD tractor combination. However, the Simba grader with a second-hand tractor is slightly cheaper to operate than a second-hand small motor grader. The medium sized motor grader is less economically viable, either new or second-hand, for light grading on rural roads.

Table 13: Grading costs after equipment is purchased and at a motor grader utilisation of 900 hours per year

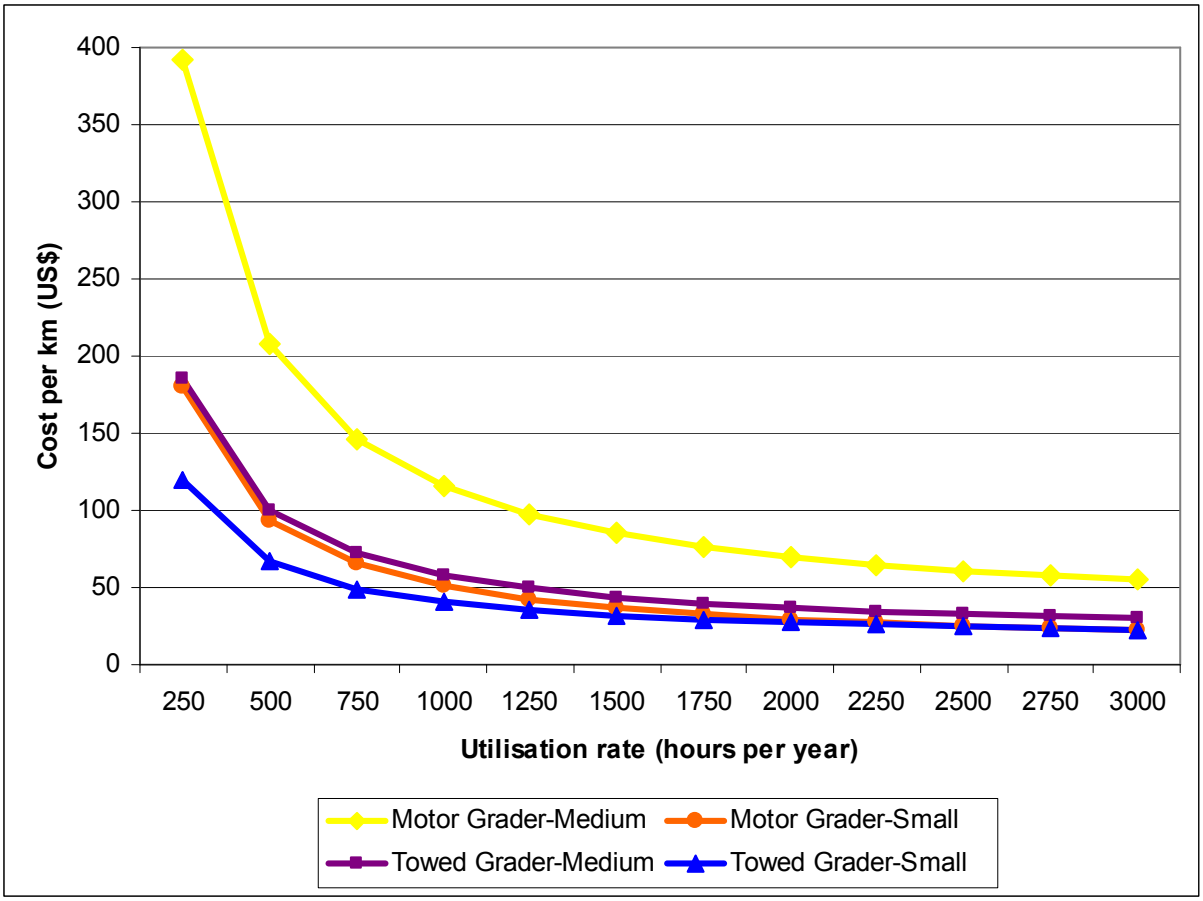
New/Second-hand	Model & Brand	Technology	Size	Operating Costs (US$/hour)	Cost per km (US$)
New	CAT 120H	Motor Grader	Medium	50.49	126.21
New	Lee Boy 635	Motor Grader	Small	22.31	55.78
New	Simba & Kobuta 9570	Towed Grader & Tractor	Medium	22.60	62.77
New	Cam-Grader & Kobuta MX500	Towed Grader & Tractor	Small	15.60	43.33
Second-hand	CAT 120H	Motor Grader	Medium	49.32	123.31
Second-hand	Lee Boy 635	Motor Grader	Small	21.49	53.73
Second-hand [a]	Simba & Kobuta 9570	Towed Grader & Tractor	Medium	18.44	51.24
Second-hand [a]	Cam-Grader & Kobuta MX500	Towed Grader & Tractor	Small	13.09	36.36

Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

[a] For second hand options, the towed graders are purchased new with a second hand tractor.

Figure 10 and Figure 11 show the costs of grading at various utilisation rates when the equipment is purchased new and second-hand, respectively.

At low utilisation levels, small towed graders (e.g. the Cam-Grader) are the most cost effective option for light grading on rural roads when all the equipment is purchased new. However, as the utilisation rate approaches 2,000 hours per year, the small motor grader is as cost effective. The medium sized motor grader is not as cost effective as the small motor grader or either of the towed graders. Therefore, in the case of purchase of new items of equipment and low utilisation rates (<2,000 hours per year), the most cost-effective options are the Cam-Grader for earth roads and the small motor grader for gravel roads. At higher utilisation rates (>2,000 hours per year), the small motor grader is the most cost-effective option for both earth and gravel roads.



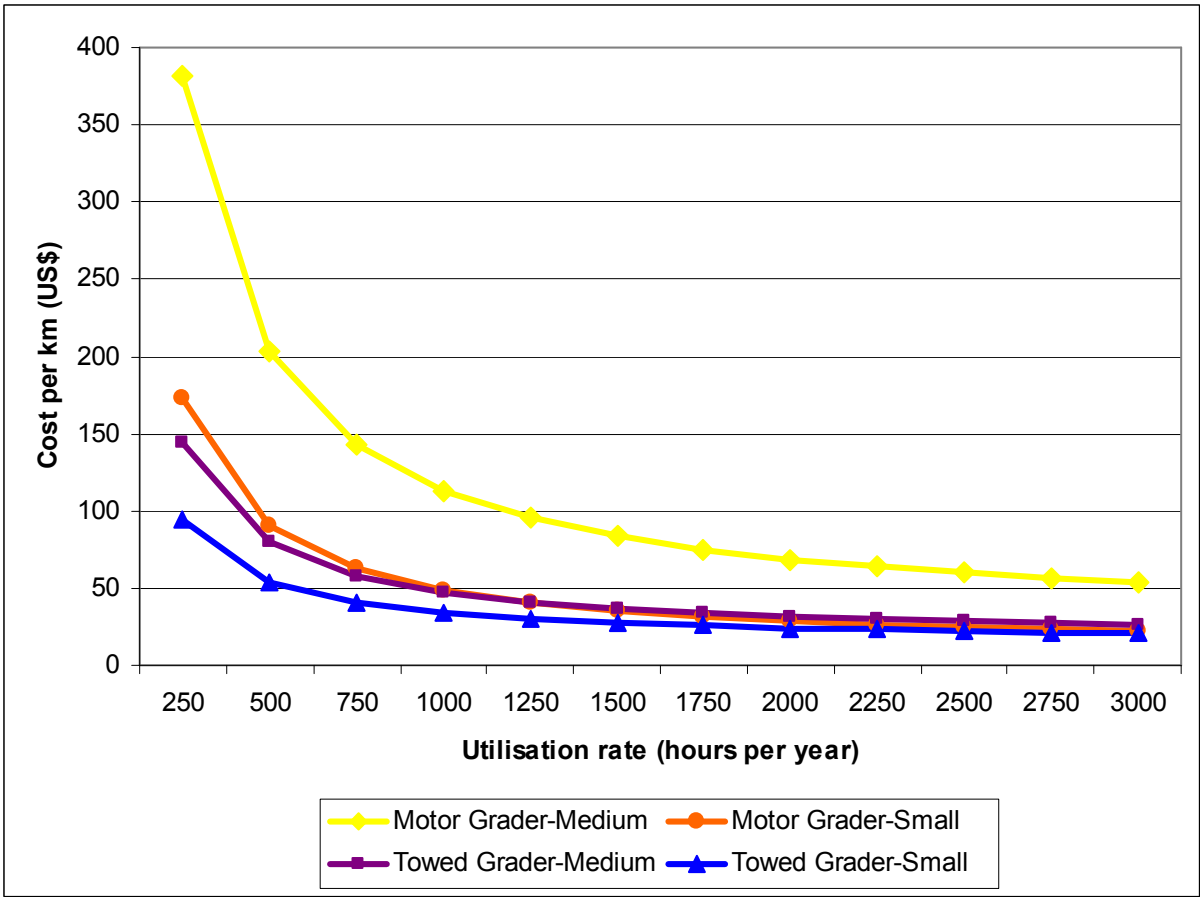
Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 10: Cost of grading (per km) when equipment is purchased new

When equipment is purchased second-hand and utilisation levels are low, the Cam-Grader is the most cost effective option. However, as utilisation approaches 2,000 hours per year the small motor grader is almost as cost effective. The Simba towed grader is more cost effective than the small motor grader at low utilisation levels. The medium sized motor grader is the least cost effective option.

Based on this analysis, the most cost effective options are to use the Cam-Grader for earth roads and the Simba grader for gravel roads when the utilisation rate is low (less than 2,000 hours per year). For higher utilisation rate (more than 2,000 hours per year), the small motor grader is the most cost effective for both earth and gravel roads.

As the equipment cost models used input data that were collected from the region. Therefore, the margin of error in the estimation of unit operating costs is expected to be low.



Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 11: Cost of grading (per km) when equipment is purchased second-hand

C2.2.2 Grader Operating Costs: Hired Equipment

Table 14 provides the grader hiring option cost estimates for utilisation rates of 2,000 hours per year (average of 170 hours per month). Appendix XX provides the detailed results. At such utilisation levels, the most cost effective equipment to hire is the small motor grader (e.g. Lee Boy 635). This analysis also holds for different utilisation rates: high as well as low (Figure 12). The Cam-Grader is more cost effective than the Simba. The medium sized motor grader is not economically viable under such circumstances.

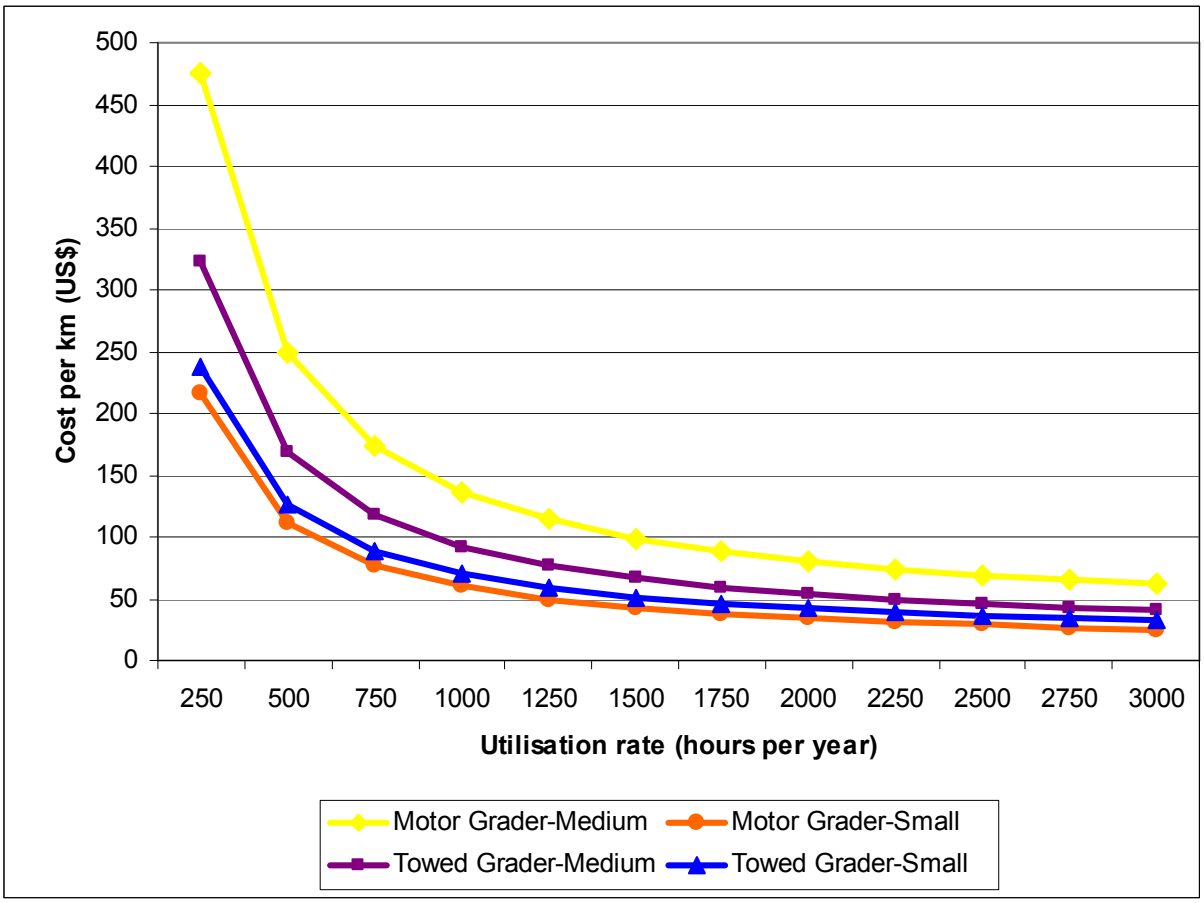
Table 14: Grading costs after equipment is hired and at a motor grader utilisation of 2,000 hours per year

Model & Brand	Technology	Size	Total Operating Costs (US$/hour)	Cost per km (US$)
CAT 120H	Motor Grader	Medium	32.1	80.4
Lee Boy 635	Motor Grader	Small	13.6	34.1
Simba & Kobuta 9570	Towed Grader & Tractor	Medium	19.4	53.9
Cam-Grader & Kobuta MX500	Towed Grader & Tractor	Small	15.1	42.0

Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

When hiring of equipment for grading (both earth and gravel roads) is considered as an option, the best strategy for the contractors is to use the small motor grader. In the absence of small motor graders the best option is to go for the Cam-Grader and the Simba for earth and

gravel roads respectively. However, because the hiring rates of some of the graders are hypothetical figures, there may be a higher margin of error associated with the results[25] when compared with the purchase option. Therefore, the results can be regarded as the best estimate based on the data available in the region.



Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 12: Cost of grading (per km) when equipment is hired

C2.3 Secondary Evidence of Grader Operating Costs

Information on the comparative costs and efficiency rates of towed and motor graders is not easy to find. Even where information is available, it is difficult to make a meaningful comparison between different studies because of varying assumptions. In many cases the assumptions are not clearly mentioned. Table 15 presents the findings on the cost of grader operations in different studies. Petts and Jones (1991) quote grading cost figures based on trials carried out in Kenya in 1987: motor grader – US$ 182/km and towed grader – US$ 97/km. Assumptions of Petts and Jones (1991) included: (i) owner-operated graders; (ii) 5 hour working day; and (iii) a working speed of 2km/hour. The towed grader that was analysed was a 2-tonne model typically used in Sub-Saharan Africa. Taking into account effects of inflation, equivalent costs at current prices would roughly be double[26]: $364/km for the motor grader and $194/km for the towed grader.

[25] It is possible that this may be larger then the difference in cost effectiveness between the small grade and the Cam Grader

[26] Assumed inflation of 4% per year

Table 15: Estimated costs of grader operations quoted in different studies

Study	Towed Grader (US$/km)		Motor Grader (US$/km)	
	Small [a]	Medium	Small	Medium
SEACAP 020 (2008) [b]	43 (36)	63 (51)	56 (54)	126 (123)
Petts and Jones (1991)	97		182	
Intech Associates (2004)	20	N/A	N/A	
Lebo and Schelling (2001)	270		N/A	
World Bank[27] (2006)	51 - 205			

Notes: [a] Within bracket figures are for second-hand grader operations
[b] 900 hours/yr operation

A more recent World Bank paper (Lebo and Schelling, 2001) quotes a figure of US$ 270 /km for Kenya at 2000 prices. This is equivalent to approximately $340/km at today's prices. Intech Associates (2004) quotes a grading cost figure of US$ 20/km (approximately US$ 24/km at current prices) for the Mark I Cam-Grader.

From the above discussions making comparisons of grader operation costs between this study and other study results is not straightforward. The calculated cost ratio of towed grader versus motor grader operations using the figures quoted by Petts and Jones (1991) is 0.53. This is similar to the ratios from the current study which were between: 0.78 (small) and 0.50 (medium). The consistent conclusion from the above is that the costs of operations of towed graders are considerably lower than that of motor graders. The World Bank estimates that the cost of light grading is between US$51 to 205 per km (average of US$110 per km) and this is consistent with the findings presented in this report for utilisation rates between 500 to 2500 hours per year.

C2.4 Grader Operating Costs Using Manual Labour

The cost of grading earth and gravel roads is approximately US$120 using manual labourers (Appendix XXI provides further details on the assumptions used to derive this figure). Therefore the use of manual labourers will only be cost effective over grader machines if grader utilisation rates are low (approximately 250 hours per year or less).

C2.5 Chapter Summary

If the annual requirement of road that requires grading is less than 100 metres, then the most cost effective option for a contractor is to use labourers, otherwise it is most cost effective to use a grading machine. The most cost-effective options of using graders are summarised in Table 16 for different utilisation rates.

Table 16: Optimum strategies for grader usage

Option	Surface	Utilisation rates (hours/year)	
		<2,000	>2,000
Purchase (New)	Gravel	Small Motor Grader	Small Motor Grader
	Earth	Cam-Grader	Small Motor Grader/Cam-Grader
Purchase (Second-hand)	Gravel	Simba	Small Motor Grader
	Earth	Cam-Grader	Small Motor Grader
Hire	Gravel	Small Motor Grader	Small Motor Grader
	Earth	Small Motor Grader	Small Motor Grader

[a] For second hand options, the towed graders are purchased new with a second hand tractor.

[27] http://siteresources.worldbank.org/INTROADSHIGHWAYS/Resources/rocks_2-3_statistics1.xls

Costs were also compared using information from other studies. Although exact comparisons are difficult due to differing data and assumptions, the consistent conclusion is that the operating costs of towed graders, in general, are lower than that of medium sized motor graders. The ratio of the cost of towed graders operations to medium sized motor grader operations can be as low as 0.5. For the light grading or rural roads, small towed graders and small motor graders appear to be the most cost-effective options in most cases.

C3. GRADER DEMAND AND SUPPLY

This chapter deals with the demand and supply situation in relation to the available graders. The evidence is mainly drawn from the contractors surveys conducted in Vietnam and Cambodia.

C3.1 Demand

C3.1.1 Assessment of Current Demand

Chapter B1 explains the difficulties associated with the estimation of equipment market demand. The study used information on the small-scale contractors' ownership and hiring level (contractor surveys generated such information) in the assessment of current market demand of graders. Table 17 summarises the ownership and hiring related information.

Motor grader ownership level was high among the Vietnamese contractors (78%) when compared with Cambodian contractors (44%). 44% and 23% of the Cambodian and Vietnamese contractors, respectively, were found to have hired motor graders in the 12 months before the survey. None of the contractors owned or hired a towed grader during the period.

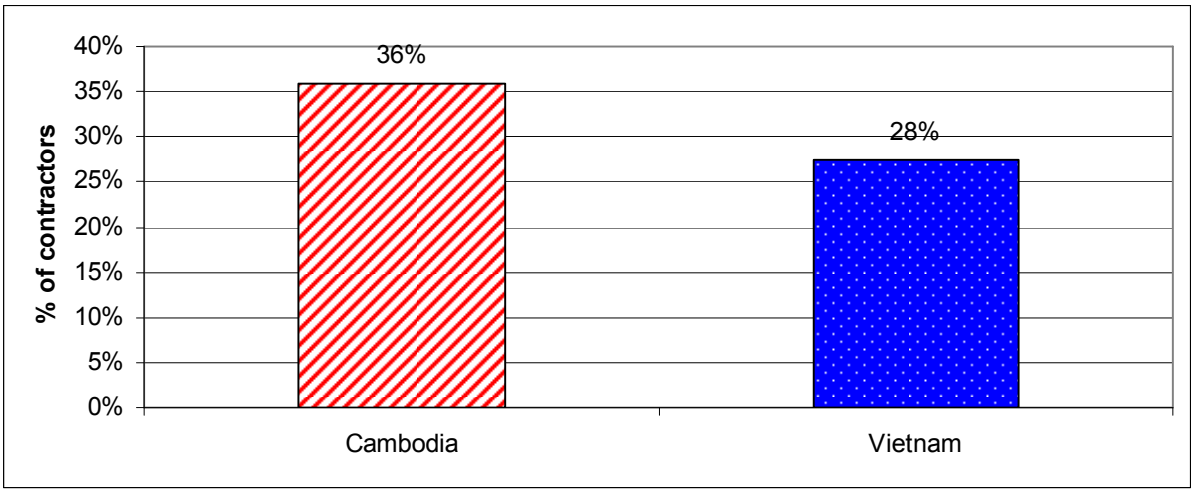
Table 17: Contractors that own or have hired grader in the last 12 months

Equipment	Percentage of contractors that own/hire[a]					
	Total		Cambodia		Vietnam	
	Own	Hire	Own	Hire	Own	Hire
Motor Grader	61 (1.9)	37 (1.3)	44 (1.5)	51 (1.3)	78 (2.1)	23 (1.4)
Towed Grader	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Source: Contractor surveys

Note: [a] The values within brackets refer to the average number of equipment owned/hired per owning/hiring contractor

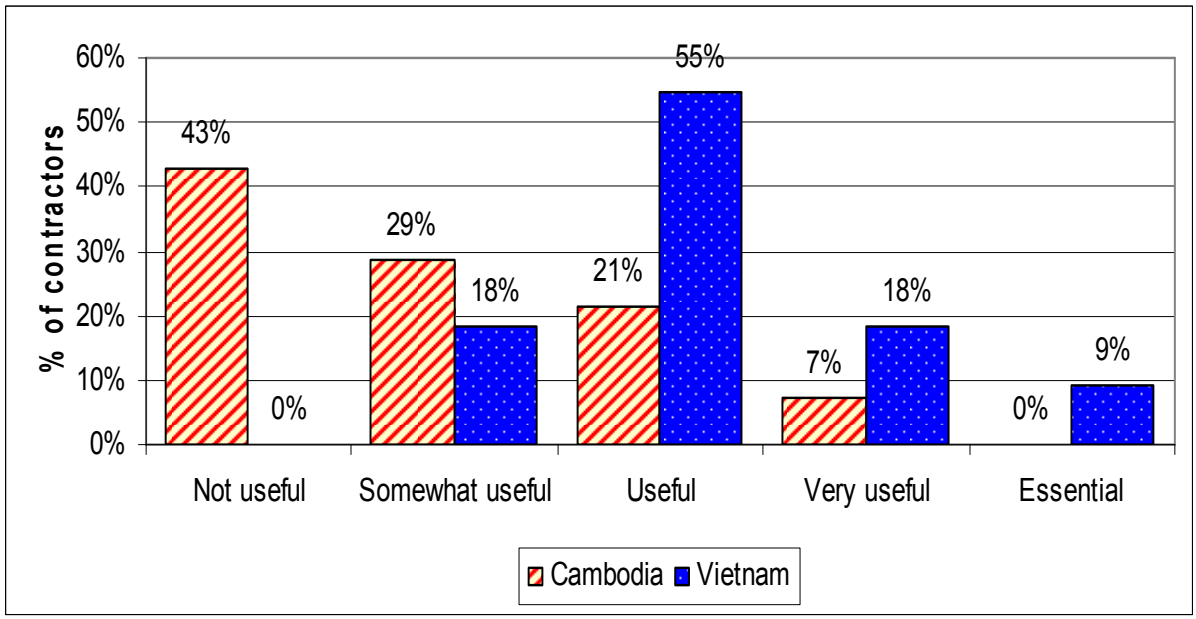
Approximately a third of Cambodian contractors and a quarter of Vietnamese contractors were aware of towed graders (Figure 13), therefore, awareness of towed graders were low. All the contractors that claimed to know about towed graders were correctly able to articulate its main functions.



Source: Contractor surveys

Figure 13: Towed grader awareness (% aware)

The Vietnamese contractors were found to be more favourable on the potential usefulness of towed grader (Figure 14). All of the Vietnamese contractors who were aware of towed graders believed that it has some level of usefulness. However, roughly 40% of the Cambodian contractors that were aware of the towed grader felt that it was not a useful item of equipment.

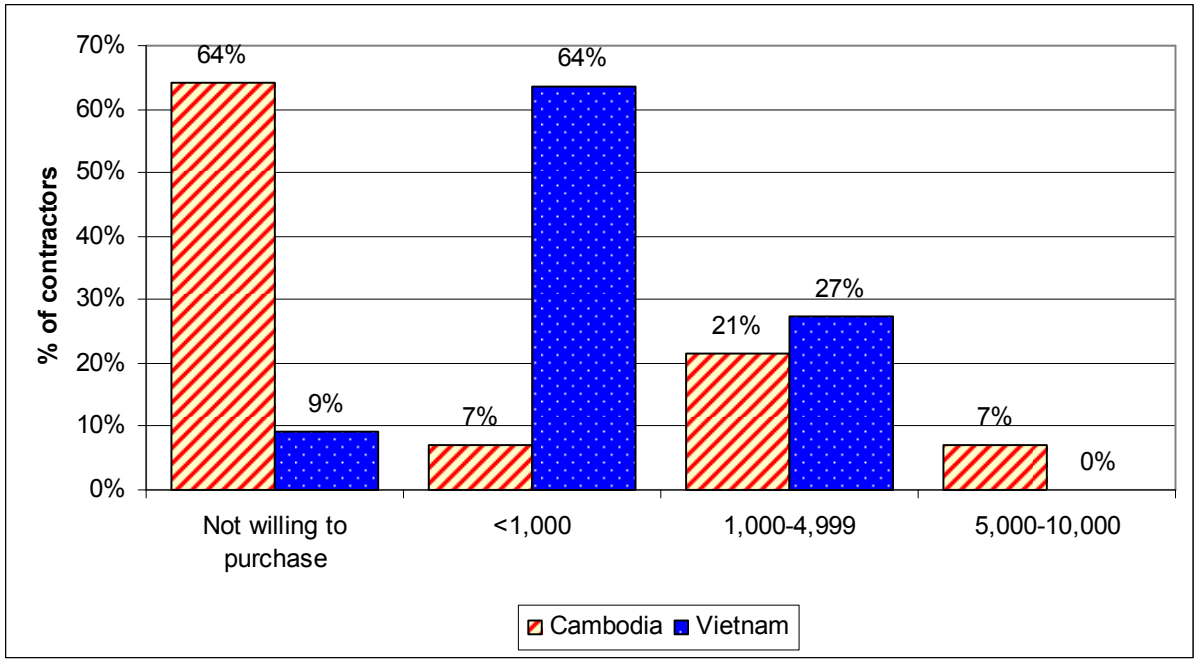


Source: Contractor surveys

Figure 14: Towed grader usefulness

Contractors who were aware of the towed grader were also asked whether they would purchase a towed grader[28] and if so how much they would be willing to pay for one (Figure 15). The majority of Cambodian contractors (roughly two thirds) would not be willing to purchase a towed grader. An overwhelming majority of the Vietnamese contractors (91%) who were aware of towed graders would be willing to buy one. However, approximately two out of three contractors, who were aware of towed graders, would only buy them if the purchase price was less than US$ 1,000. This price is way below the price of the cheapest towed grader, the Cam-Grader (approximately US$ 2,500). None of the Vietnamese contractors were willing to buy a towed grader for US$ 5,000 or more. And only 7% of the Cambodian contractors would buy a towed grader if the purchase cost was between US$ 5,000-10,000. There were no contractors who would buy a towed grader at a cost of over US$ 10,000. This means that the cost of Simba (US$ 16,000) is considerably higher than the price that any of the contractors would be willing to pay.

[28] They were not asked whether they would buy a tractor as well.



Source: Contractor's survey

Figure 15: Contractors willing to purchase a towed grader and at what price (US$)

C3.1.2 Assessment of Future Demand

The future equipment demand was again estimated using the projected rural road related roadwork volumes and productivity values of the appropriate equipment[29] (explained in Section B1.3.2). Table 18 presents the number of units that will be required to carry out the planned roadworks in the three countries. In the assessment of demand a number of assumptions apply (also explained in Section B1.3.2).

Table 18: Annual requirement of equipment, number of units (2007/8-2011/12)

Equipment	Cambodia	Vietnam	Laos
Motor Grader	17	180	8
Towed Grader	10	274	8

Source: Contractor surveys

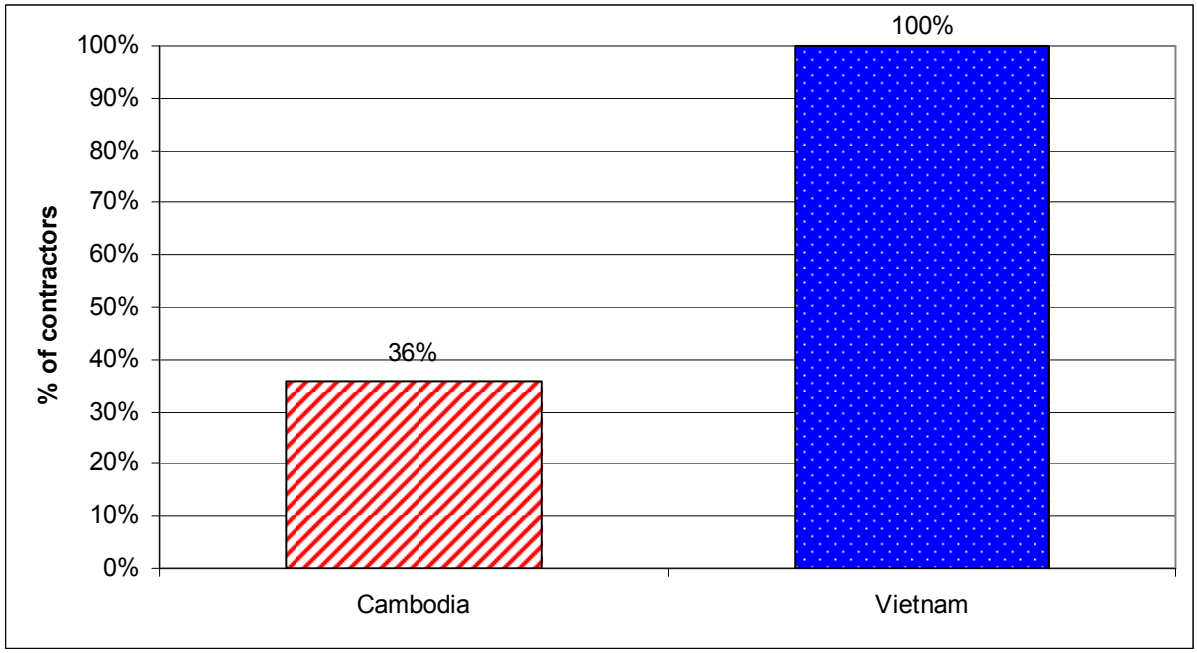
It can be seen from Table 18 that the potential future demand for towed graders is low in Cambodia and Laos, where the requirement is 10 and 8 units (respectively) per year to carry out roadworks linked to rural roads. Given the low demand for towed graders in Cambodia or Laos, it appears that any strategy that increases the supply of towed graders will not be required and would potentially be counter productive. The demand for towed graders is comparatively higher (over 270 units per annum) in Vietnam than in Cambodia and Laos, where there will be a high volume of rural road related projects. However, a total of 65 motor graders were owned by Vietnamese contractors who were interviewed in this study, and therefore, highly likely that on a national level SSCs involved in rural road related roadworks own the required number of motor graders (approximately 180 units annually). Therefore, in Vietnam strategies should not be aimed at increasing the supply of towed graders, but instead

[29] 0.4 km/hour for the motor grader. 0.36 km/hour for the towed grader. Please note that grader demand values were not subjected to an efficiency down-scale of 80%. Because the productivity values stated are regarded as being accurate. Please refer to Section B1.3.2 for further details

focused on inducing a shift in contractor demand from medium and large motor graders to small motor graders and towed graders.

C3.2 Supply

Contractors who were aware of the towed grader were asked if they had adequate access if they required one. The results are provided in Figure 16. All Vietnamese contractors believed that there would be no supply constraints. However, these figures should be treated with caution as none of the contractors actively sought to acquire a towed grader. The figures only reflect the contractors' perceptions on towed grader availability.



Source: Contractor's survey

Figure 16: Contractor's who state they have adequate access to the towed grader

Design Technology Workshop (DTW) is the only manufacturer of towed graders in Cambodia, Vietnam and Laos that the authors are aware of. DTW have manufactured a total of five units so far. None of the equipment suppliers interviewed sold a towed grader. It can be concluded that there are only a few units in Cambodia, Vietnam and Laos. Moreover, the current demand for towed graders appears to be limited (see Table 17).

This analysis has been corroborated by key informants, the vast majority of which felt that if a contractor required a towed grader they could access one, but few wish to acquire one.

Motor graders on the other hand are ubiquitous in the region. There are ample suppliers of motor graders in Cambodia, Vietnam and Laos (see Appendix XXII). Among the three countries, Vietnam has the broadest manufacturing base. However, Vietnam is facing stiff competition from China which has recently been introducing cheap equipment into the region. Many key experts and contractors claim that Vietnamese equipment is not as cost effective as the Chinese versions. This is having a negative effect on Vietnamese manufactures. For instance, 1-5 Machinery Company, a Hanoi based Vietnamese manufacturer, has stopped the production of motor graders.

C3.3 Tractor Capacity

Evidence from the contractor surveys (Table 19) shows that a very small proportion of contractors own or hire the 2WD tractor (5% and 0% of the interviewed contractors in Cambodia and Vietnam, respectively). However, over 20% of Cambodian and 8% of Vietnamese contractors own at least a 4WD tractor. Some of the contractors have also hired 4WD tractors in the 12 months previous to the interview. Overall, one in ten contractors hired 4WD tractors.

Table 19: Contractors that own or have hired tractors in the last 12 months

Equipment	Percentage of contractors that own/hire[a]					
	Total		Cambodia		Vietnam	
	Own	Hire	Own	Hire	Own	Hire
Tractor 2WD	3 (1.5)	0 (0)	0 (0)	0 (0)	5 (1.5)	0 (0)
Tractor 4WD	14 (1.4)	10 (1)	21 (1.5)	15 (1)	8 (1)	5 (1)
Tractors (All)	16 (1.4)	10 (1)	21 (1.5)	15 (1)	13 (1.2)	5 (1)

Source: Contractor surveys

Note: [a] The values in brackets refers to the average number of equipment owned/hired per owning/hiring contractor

Contractors were also asked whether they have had any difficulty acquiring tractors and the results are shown in Table 20. It is evident that contractors have not experienced major difficulties in acquiring tractors. Only a few contractors in Vietnam (3%) found it difficult to acquire 4WD tractors. It is concluded that although ownership and hiring rates of tractors are only low to moderate, there are no supply constraints of tractors in Cambodia and Vietnam. This finding is corroborated by key informants who stated that there were no constraints in tractor supply.

There are number of outlets that supply tractors in Cambodia, Vietnam and Laos (Appendix XXII presents a non-exhaustive list).

Table 20: Contractors facing difficulty in acquiring tractors

Equipment	Percentage of contractors that have had difficulty acquiring		
	Total	Cambodia	Vietnam
Tractor 2WD	0	0	0
Tractor 4WD	1	0	3
Tractors (All)	1	0	3

Source: Contractor surveys

C3.4 Chapter Summary

This chapter presents the findings of demand and supply of graders in Vietnam and Cambodia. The motor grader ownership level is high among Vietnamese contractors (78%) and Cambodian contractors (44%). None of the SSCs either owned or hired a towed grader in the 12 months prior to interviews. However, more Cambodian contractors hired motor graders (44%) than Vietnamese contractors (23%). This shows that there is considerable demand for motor graders in overall terms. Only a small proportion of the contractors in the two countries were even aware of towed graders. Cambodian contractors were found to have slightly higher level of awareness than their Vietnamese counterparts.

The potential future demand linked to the anticipated rural roadworks, for towed graders is low in Laos and Cambodia. The demand for towed graders is much higher in Vietnam. However, it appears that there is adequate equipment supply to meet the projected demand.

Therefore, no outside intervention that increases supply is warranted. Rather it is recommended that the contractors' awareness in relation to the benefits of using small motor graders and towed graders be raised. Such an action would encourage a demand shift from medium and large motor graders to small motor graders and towed graders.

C4. GRADER COMPARATIVE ASSESSMENT

C4.1 Viability

The Simba and small to medium sized motor graders are appropriate equipment for light grading on rural roads, while the Cam-Grader is only appropriate for earth surfaces. Large motor graders are generally not considered appropriate for use on small rural roads.

C4.2 Cost

The cost of purchase of the cheapest towed graders and tractors (new 2WD) is US$ 2,500 and US$25,000 respectively. The hiring cost of tractors in the study countries is approximately US$1,500 per month. The costs of motor graders start from US$ 60,000. Large and medium sized motor graders can be hired for US$ 4,000 and US$ 3,000 per month, respectively. The study found no evidence of small motor graders, the Simba or the Cam-Grader, available for hire or for purchase second-hand in the region.

At low utilisation rates (less than 2,000 hours per year) the most cost effective option is:

- the Simba for gravel roads (when equipment is purchased new);
- the small motor grader for gravel (when equipment is purchased second-hand); and
- the Cam-Grader for earth roads

At high utilisation rates (2,000 hours per year or more) the small motor grader is the most cost effective option.

If equipment is being hired, then the small motor grader is the most cost effective option at all utilisation rates.

The medium sized motor grader is not a cost effective option for light grading on rural roads.

C4.3 Demand and Supply

Motor grader ownership is high and towed grader ownership and awareness amongst contractors is low. Most contractors are not willing to pay more than US$ 1,000 for one or are not willing to purchase one at all. It can be concluded that the current demand for towed graders is low. Approximately 10 towed grader units are required annually to implement the rural roadwork requirement over the next 5 years in Cambodia and Laos. Therefore it can be concluded that future potential demand is low. Over 270 units of towed graders are required in Vietnam.

C4.4 Recommendations

The small motor grader and towed graders are viable equipment for rural roads as well as being competitive in terms of costs. However, as the anticipated rural roadworks in Cambodia and Laos require few units of towed graders, it is not recommended that any mainstreaming initiative be introduced. This can have the effect of distorting the market for grading equipment. Towed grader demand is significant in Vietnam; however, contractors are already able to meet the equivalent grading capacity using the existing stock of motor graders. It is therefore recommended that the favourable attributes of small motor graders and towed graders be disseminated between contractors and equipment suppliers so that they are aware of the potential benefits of their use. This may encourage a demand shift to smaller and intermediate equipment among contractors in the rural road sub-sector which can produce significant efficiency gains.

PART D: MOBILE SMALL-SCALE STONE CRUSHER MODULE

D1. STONE CRUSHING TECHNOLOGIES

This chapter introduces the main issues involved in crushing stone and rock. The main stone crushing technologies are also discussed. Some more details are provided in Appendix XXVI.

D1.1 Advantages and Uses of Crushed Stone and Rock

The use of crushed rock or gravel (aggregate) as a construction material has a number of advantages over naturally occurring stone and gravel including: (i) allows better packing together than the more rounded particles that tend to be found in natural materials. This results in improved strength; (ii) allows better control over aggregate mixes to meet standards and specifications; (iii) provides more surface area that improves the cement concrete strength; and (iv) crushed material is free from silts and clayey-like fines found in natural materials that are detrimental in achieving the desired construction quality. In summary, the use of crushed aggregate in construction as opposed to the uncrushed aggregate results in a much stronger final material.

There are three main uses for crushed aggregate in construction. They can be used as a base and sub-base for paved roads for improved drainage and strength. When mixed with bitumen they provide a hard-wearing surface for bituminous road. Crushed material may also be added to natural material to improve the engineering characteristics of gravel roads. Aggregate is also used extensively in the construction industry in the production of concrete that provides strength and hardness in concrete. The aggregate can also be generated by recycling construction waste material (Appendix XXIV and XXV provide more details on recycling construction rubble)

D1.2 Sources of Crushed Stone and Rock

There are a number of approaches to sourcing crushed stone and rock: they can be broken manually or using a mobile crusher and can also be purchased from a commercial quarry.

Excavating suitable stone or rock and manually breaking it to the required size is known as hand knapping. Typically a person can break approximately 0.1 tonne (0.035cu.m) of hard rock or stone per 8 hour day (Mitchell and Mwanza, 2005). For a layer thickness of 30cm this is equivalent to an area of roughly 0.12 m^2 per day per person. For a 6m wide paved road it will require 48 person days for the construction of a metre length of the road pavement. Apart from the requirement of large labour force, quality control is also a significant issue with hand knapping.

The other extreme is the purchase ready-crushed material from a commercial quarry. Commercial quarries are common in all the three study countries. However, they may not be located close to the construction site and the contractors may incur considerable costs in transporting the crushed stone or rock to the site. This however, can be the most convenient option for contractors as it does not require any investment in machines or personnel. Other advantages can be a more consistent quality and the availability of a range of stone sizes.

An intermediate solution for SSCs is to own or hire a mobile stone crusher to produce aggregate on the construction site. However, the cost-effectiveness of this option is dependent on the closeness of the stone or rock sources. Another important issue affecting the cost is whether the contractor has to pay any fee for extracting the material. Mobile crushers may also be used to produce aggregate from recyclable construction waste (e.g. concrete). This is

most likely to be feasible if construction sites that are located close to urban centres where recyclable material is most available. This process also avoids waste material disposal costs.

D1.3 Deployment of Crushers

Crushers can either be deployed at the source of the raw material or at the construction site. Both the options involve a number of steps that are listed below:

Crush at source	Crush at construction site
• Excavation of material	• Excavation of material
• Breaking material into sizes that can be fed into a crusher	• Breaking material into sizes that can be fed into a crusher
• Transportation of broken material to crusher	• Transportation of broken material to construction site
• Loading material into crusher	• Dumping broken material at construction site
• Transportation of crushed material to construction site	• Loading material into crusher
• Dumping crushed material at working area	• Dumping crushed material at working area

The identified activities may be carried out manually or using equipment (e.g. the use of a front end loader). To determine the best solution, it is necessary to evaluate both the options carefully. There are a number of operational issues involved. For example, the weight of the rocks that can be fed into the upper end of mobile crushers can only be up to 100kg.

An important issue linked to the sourcing of crushed stone is that a permit is required in order to mine natural resources in all three countries. The process of acquiring a permit can be long and difficult. Key informants in Vietnam informed that it could take 1-2 years to acquire a permit as the process involves a number of ministries (e.g. Ministries that deal with the issues of labour, finance, environment and natural resources etc.). However, most key informants stated that small scale extraction of minerals without a permit was generally tolerated by the authorities, especially when quarrying very small volumes of river or hillside gravel without intense operations such as blasting.

D1.4 Stone Crushing Technologies

D1.4.1 Crusher types

There are two basic varieties of crusher technology: (i) **impact machines** where material is broken by impact against a hard surface; and (ii) **crushing machines** where two surfaces open and close cyclically to trap and crush the material. Again there are two types of impact machines:

- **impact crushers** in which the lumps are picked up by a rotating mechanism and flung at high velocity against a fixed hard surface where they shatter; and
- **hammer mills** in which the lumps are broken up by flailing hammers.

Impact crushers are particularly suited to hard brittle materials. They are the most energy efficient type of crusher. However, the machines need to be large to absorb the impacts and vibration. They are not generally used as mobile machines.

There are two main types of crushing machines:

- **cone crushers** in which the material is fed into a conical cylinder and an eccentric mechanism rotates to crush the material against the inner face of the cone. As the material drops down inside the cone, the gap gets smaller so it is crushed into smaller

pieces. The gap at the outlet is controlled to obtain the required size of crushed material.

- **jaw crusher** in which the material is fed into the gap between a fixed jaw and an oscillating jaw. As the material drops down between the jaws the gap gets smaller. This helps in crushing the material into smaller pieces. By controlling the gap at the outlet of the jaws the required aggregate size can be obtained.

Both types of crushing machines involve considerable scraping between the movable member and the material being crushed. Therefore, the power requirements and wear of the crushing members are greater than for impact machines. The crushing machines are likely to produce material which is more uniform in size and shape than impact machines. These types are also most suitable as small-scale mobile crushers given their simple design and smoothness in operation.

Among the crushing machines, the jaw type has the simplest crushing mechanism. Cone crushers tend to be larger and heavier. Therefore, they are less suitable. The contractor survey revealed that all the mobile crushers owned by the Vietnamese contractors were of the jaw crusher variety.

D1.4.2 Jaw crushers

Figure 17 shows the details of a typical jaw crusher. It is a machine comprising a diesel engine or electric motor that drives an eccentric shaft through a belt drive. The eccentric shaft moves the reciprocating jaw backwards and forwards against the fixed jaw to crush the stone or rock. A large flywheel smoothes out the drive power. The mechanical design is simple and straightforward to maintain.

Jaw crushers are generally smaller in size than other types of crusher and this makes them the most suitable as mobile units. The typical unit, shown in Figure 17, can easily be transported to the operational site using a truck or a trailer. Usually mounting the crusher on a trailer for towing is the best option for moving a crusher to and around a site in the region.

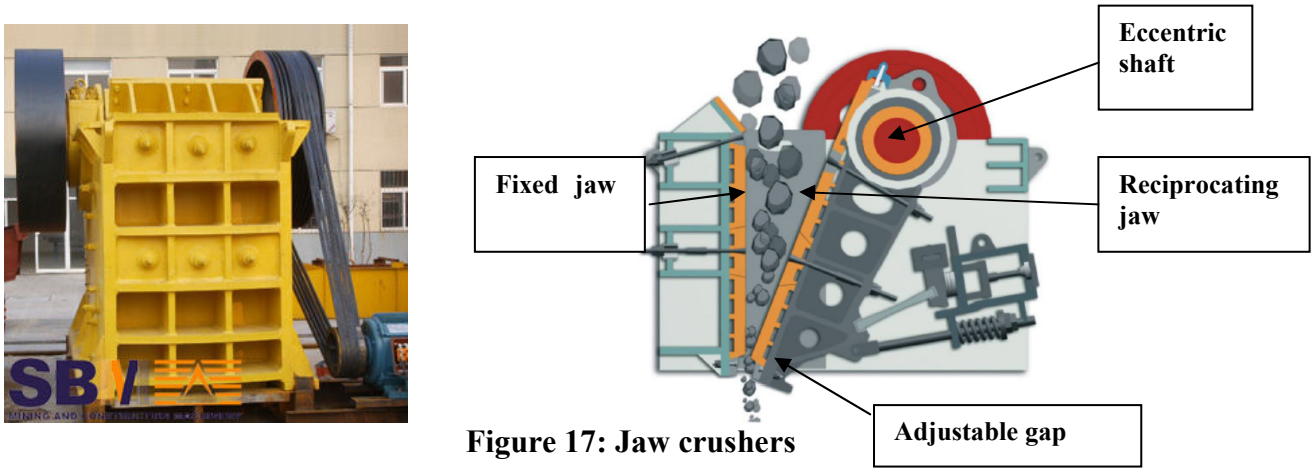


Figure 17: Jaw crushers

Table 21 provides details of typical jaw crushers. The types of small mobile stone crushers encountered in the region are manufactured by Hoa Phat and Shibang. Hoa Phat is based in Vietnam and Shibang is a Chinese based company. Approximately half of the crushers owned by the surveyed contractors are Hoa Phat models (generally purchased new) and the other half being crushers of Chinese origin (generally purchased second-hand). The most common model was Hoa Phat's NHHP-PEX215. (see Appendix XXIII). Internationally, Red Rhino, a UK based company, produces the 4000 and 5000 Series crushers. However, they are

significantly more expensive (Figure 18). New Dawn Engineering (NDE), a Swaziland based company, also produces a manually operated mobile crusher (Pemberton-Pigott, 1997). The cost of this machine, however, is more expensive than Hoa Phat's smallest model, which is diesel powered.

Table 21: Typical jaw crushers

Crusher model, Brand	Country of origin	Price (US$)	Weight (tonnes)	Size of input stones (mm)
NHHP-PEX15, Hoa Phat	Vietnam	1,420	0.4	150*250
NHHP-PEX175, Hoa Phat	Vietnam	2,560	0.9	175*300
NHHP-PEX215, Hoa Phat	Vietnam	4,245	2.0	215*300
PE150x250, Shibang	China	1,850	0.81	125*125
PE250x400, Shibang	China	5,400	2.8	210*210
PE400x600, Shibang	China	12,000	6.5	340*340
4000, Red Rhino	UK	45,000	1.5	150*400
5000, Red Rhino	UK	65,000	2.9	200*500
Rock Crusher (manual) ,NDE	Swaziland	1,650	0.2	150*150
Rock Crusher (electric) ,NDE	Swaziland	3,650	0.2	150*150

Source: Hoa Phat, Shibang, Red Rhino

Source: http://www.redrhinocrushers.com/index.aspx

Figure 18: Red Rhino 4000

The primary maintenance problem of jaw crushers is the wear of the jaws. This results from the high pressure grinding action with the stone or rock. In order to minimise this problem, the jaws need to be very hard but also adequately tough to avoid fracture. This requires a high-cost alloy steel with sophisticated heat treatment facilities. This would not be possible locally due to the high cost. However, a trade-off needs to be made between cost and life of the jaws. Table 22 compares jaws for crushers made in Vietnam and one made in the UK. Table 22 shows that the running cost of the cheaper local jaws is almost a tenth of the longer life jaws. However, contractors in Vietnam reported that the average life of the local jaws was only 215 hours. This is considerably lower than the 1,200 hours claimed by the manufacturer, (see Appendix XXIII). This increases the unit operating cost from US$13 to US$73 per 100 hours. The re-calculated unit operating cost is still approximately a half of the operating cost of longer life jaws. This means that although jaws have a short life, they are more cost-effective. Other advantages of the local jaws include their wider availability in the region and the ease with which they can be changed.

Table 22: Comparative Costs of Crusher Jaws

Brand of Crusher	Country of Origin	Stated life of Jaws (Hours)	Cost of Replacement Jaws (US$)	Cost per 100hrs of Operation (US$)
NHHP-PEX215	Vietnam	1,200	156	13
Red Rhino 4000	UK	2,000 to 2,500	3,000	133

Source: Hoa Phat, Phantom

D1.5 Chapter Summary

Crushed rock or gravel offers a number of advantages over naturally occurring stone or gravel. The main uses of crushed aggregate in the construction industry are for use in paved and gravel roads and in concrete works. Contractors can obtain the crushed materials using three different options: (i) breaking stones manually (hand knapping); (ii) purchasing from a commercial quarry; and (iii) using a mobile crusher.

There are many different types of crushing technology. Jaw crushers are the most suitable for SSC as they are smaller and lighter than other alternatives. The main producer in the region is Hoa Phat. It produces three types of mobile crushers. Their costs range between US$1,400 to US$4,300. In addition, Shibang models from China are also common. The primary maintenance problem of mobile crushers is the replacement of jaws. The local jaws seem to be more cost effective than their foreign counterparts.

D2. MOBILE CRUSHER COST EFFECTIVENESS

In this chapter the economics of mobile stone crushers are evaluated. This is done by comparing the costs of using mobile crushers against alternative methods: (i) crushing the stone manually; and (ii) purchasing aggregate from government or commercial quarries.

The evaluation is carried out for three sizes of jaw crushers produced in Vietnam by Hoa Phat. These models are similar to that shown in Figure 17. The specifications of the three crushers are provided in Appendix XXVII.

D2.1 Mobile Crushers

The cost-effectiveness of equipment depends on several factors, including utilisation rates (number of hours used per annum). More productive and expensive equipment is more likely to be cost effective when utilisation rates are high. In developing countries, annual utilisation rates of equipment can be very low (Jones and Robinson, 1996). The evidence from the contractor surveys for this study shows that average mobile crusher utilisation rates are approximately 1,000 hours per year in Vietnam. However, the analysis of the cost effectiveness of the equipment is conducted in this study for a range of utilisation levels.

D2.1.1 Equipment purchase

Table 23 provides the mobile crusher operating cost estimates for a utilisation rate of 1,000 hours per year. Appendix XXVIII provides the detailed analysis results. Table 23 also contains the cost per unit volume of output. This facilitates a direct comparison between the mobile crushers with other viable alternatives.

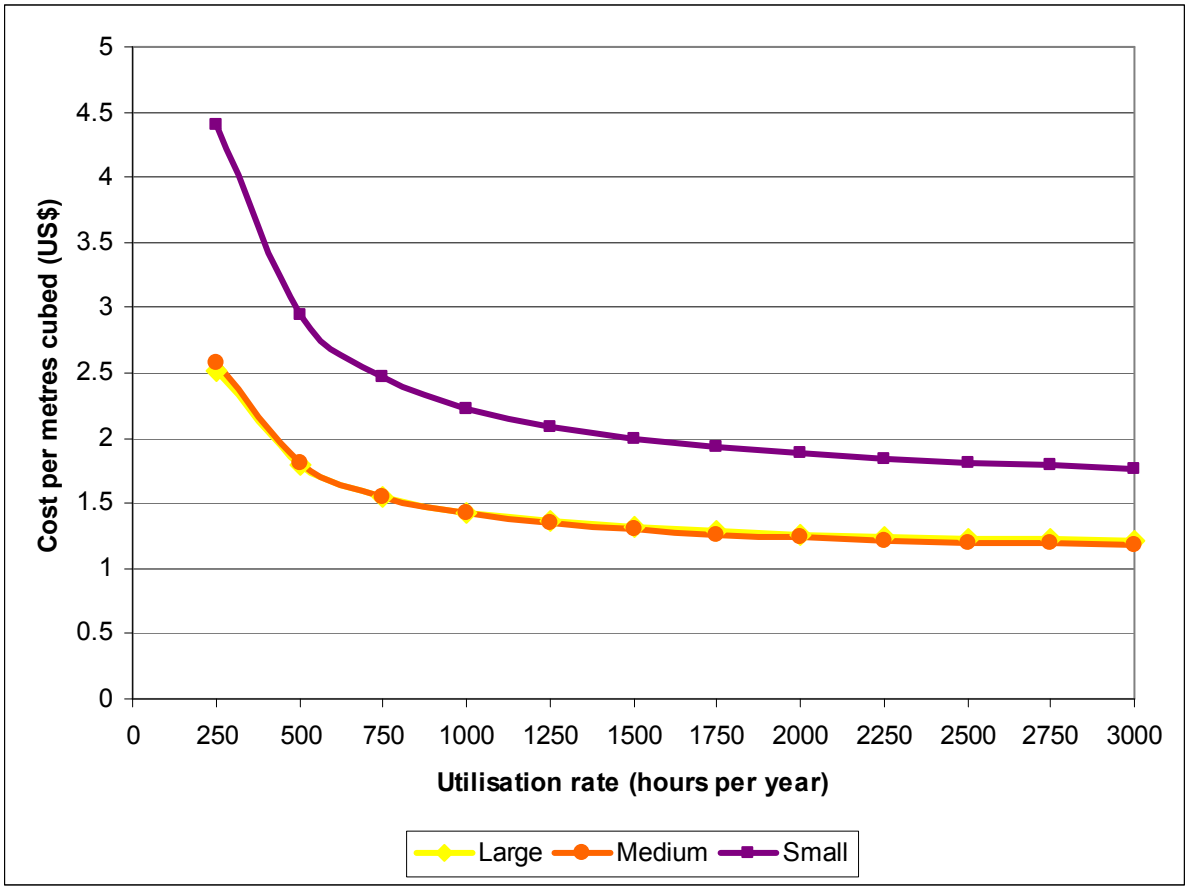
Table 23: Mobile crusher cost when utilised for 1000 hours per year (equipment purchase)

Model & Brand	Size	Total Operating Costs (US$/hour)	Cost per m^3 (US$/hr)
NHHP-PEX215, Hoa Phat	Large	8.50	1.43
NHHP-PEX175, Hoa Phat	Medium	6.39	1.42
NHHP-PEX15, Hoa Phat	Small	4.46	2.23

Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

The small mobile crusher is the cheapest to run in terms of cost per hour as the fixed (e.g. depreciation, interest etc.) and variable costs (e.g. fuel, maintenance etc.) are lower for a smaller machine.

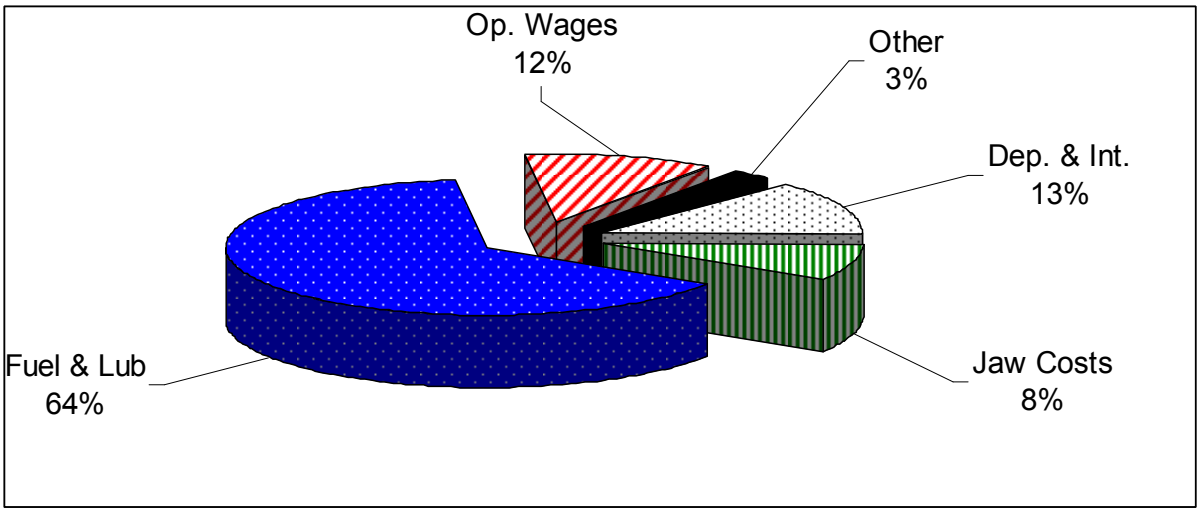
However, when the basis of comparison is the amount of output (cost per cubic metre), the small mobile crusher is found to be considerably more expensive than its larger counterparts. For utilisation rates of 1,000 hours per year, the most cost effective crushers are the large and medium sized mobile crushers. These have almost the same cost per cubic metre of crushed stone at US$1.43 and US$1.42 per cubic metre respectively. Over a range of utilisation rates, the cost effectiveness of the medium and large sized mobile crushers are virtually the same (see Figure 19).



Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 19: Mobile crusher operating costs (equipment purchase) (US$/m^3)

Figure 20 shows the proportion of different operating cost components of a large Hoa Phat mobile crusher. The fixed ownership costs (depreciation cost plus the interest payment cost) represent 13% of the total operating costs. The majority of costs are variable costs. Costs linked to fuel and lubrication comprise approximately two-third of the overall operating costs (64%). The costs of jaw replacement are also significant (8%). This illustrates an important cost difference between mobile stone crushers and other items of equipment. For most items of construction equipment, ownership costs are around 50% or more of the total operating costs. For example, a study in Mozambique calculated that the depreciation and interest costs of a motorised roller (5 tonnes) form 58% of the overall operating costs (ITT, 2003). Similarly, Petts and Jones (1991), based on evidence from Kenya, calculated the deprecation and interest costs of a motor grader at 56% of the overall operating costs.



Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 20: Mobile crusher (large, NHHP-PEX215) operating cost when utilised for 1,000 hours/year

D2.1.2 Equipment hire

Contractor survey results indicate that only two Vietnamese contractors (5% of sample) hired a mobile crusher in 12 months prior to the interview. In both cases, the contactors hired from other contractors on a basis that did not equate with normal market prices. Also this study could not identify an equipment supplier that rented mobile crushers out. For this reason hiring rates for mobile crushers could not be ascertained empirically. However, the Red Rhino 4000 and 5000 series crushers are currently being rented out in UK for approximately US$200 and $400 per day, respectively. This equals an average monthly hire to purchase ratio[30] of approximately 0.10. This evidence has been used to derive the monthly hire rates for the three Hoa Phat mobile crusher models (Table 24). Table 24 also shows the overall rental operating costs of the three mobile crushers for a utilisation rate of 2,000 hours per year (approximately 170 hours per month). Appendix XXIX provides the detailed analysis. At such utilisation rates, the medium sized crusher was calculated to be the most cost effective at US$1.39 per cubic metre crushed stone.

Table 24: Mobile crusher rental rates and operating costs for average annual utilisation rates of 2,000 hours

Model & Brand	Size	Rental rates (US$/month)	Total Operating Costs (US$/hour)	Cost per m^3 (US$)
Hoa Phat NHHP-PEX215	Large	427	8.68	1.45
Hoa Phat NHHP-PEX175	Medium	257	6.26	1.39
Hoa Phat NHHP-PEX15	Small	143	4.17	2.08

Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

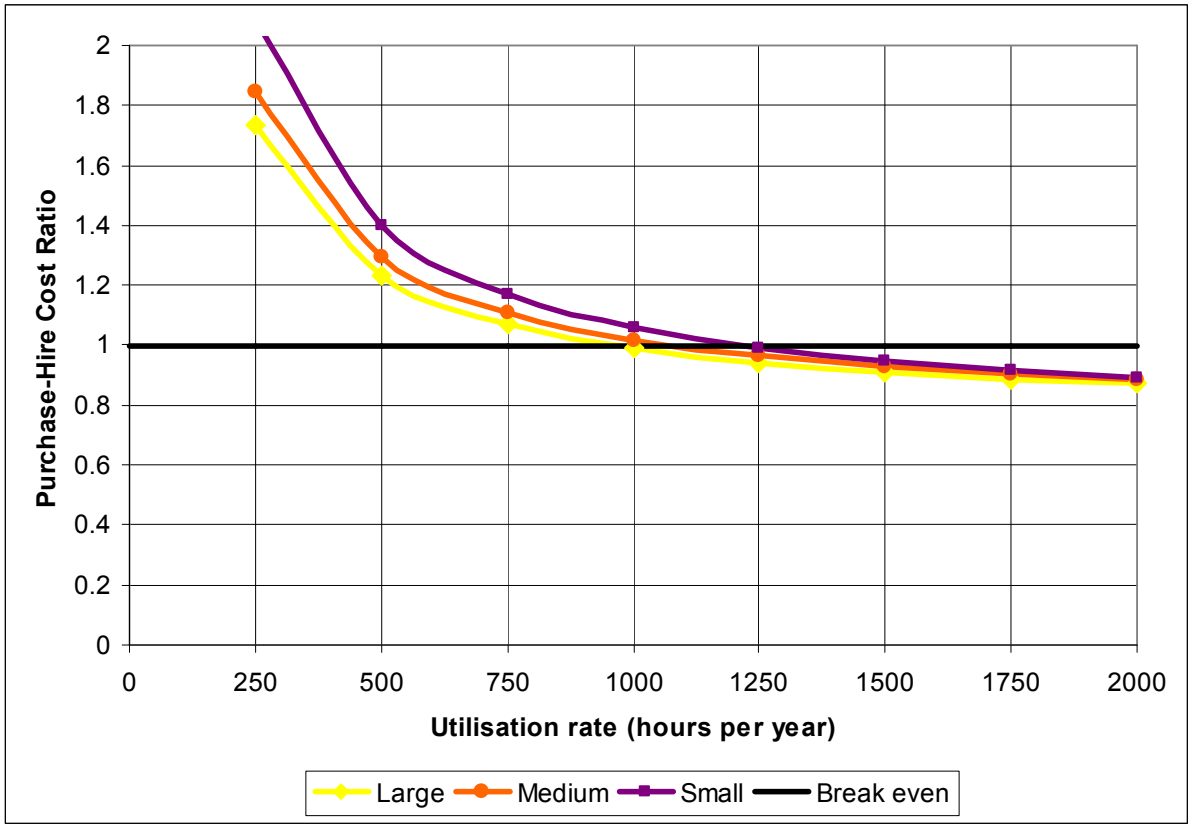
D2.1.3 Comparison between equipment purchase and hire

Figure 21 presents a comparison between the cost of purchasing and hiring a mobile crusher (in cubic metre terms). It presents the ratios of the cost of purchasing at utilisation rates varying between 250 and 2,000 hours per annum against the cost of hiring at a utilisation rate

[30] Based on 20 working days per month

of 2,000 hours per annum, a rate which reflects the approximate rate of constant annual usage[31]. The analysis assumes that the mobile crusher can be hired for short periods of time (e.g. on a daily basis).

At low utilisation rates (under 1000 hours per annum), it is cheaper to hire a mobile crusher than purchase one. At a utilisation rate between 1,000 to 1,250 hours per year there is little difference in cost between renting and purchasing (see the break even line in Figure 21). Above 1,250 hours per year, it is more cost effective to purchase a mobile crusher than to hire. This conclusion is generally consistent for all three sizes of crusher considered.



Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

Figure 21: Ratio of purchase cost (at various utilisation rates) to hire cost (utilisation rate of 2,000 hours/year)

D2.1.4 Cost of excavation

The above analysis only takes into account the cost of running the mobile crusher machines to break excavated material into the final required size. It does not take into consideration material excavation costs. In order to make a direct comparison between alternative methods, there is a need to add the costs of material excavation.

It has been estimated that a person is able to excavate 0.8 cubic metres of stone per day (Stiedl, 1998). Based on this assumption[32], the cost of excavation by hand has been estimated at US$ 1.88 per cubic metre (see Table 25).

[31] Based on 8 hours per day and 20 days per month.
[32] It is assumed that the daily wage rate for an unskilled construction labourer is US$ 1.5 per day

D2.2 Manual Crushing

Table 25 presents the estimated cost of breaking stone manually. The following major assumptions apply in the estimation of the cost: (i) the cost includes the cost of excavation and breaking of the stone (hand knapping); (ii) the productivity rates of manual stone excavation and manual stone breaking are 0.8 cubic metres and 0.036 cubic metres per labourer per day (Stiedl, 1998; Mitchell and Mwanza, 2005); (iii) the wage rate of unskilled labourer is US$ 1.5 per day; (iv) the average diameter of the broken stone is 20mm. It can be seen from Table 25 that the cost of producing crushed stone manually is approximately US$43.50 per cubic metre. This unit cost is at least 10 times higher than the cost of producing crushed stone using any of the three Hoa Phat mobile crushers (Figure 19).

Table 25: Cost of breaking stone manually

Activity	Rate (m^3/day/person)	Required person days for 1 m^3	Wage rate (US$/day)	Cost US$/$m^3$
Excavating stone	0.8	1.3	1.50	1.88
Breaking stone[33]	0.036	27.8	1.50	41.67
Total cost per m^3				43.54

Source: Mitchell and Mwanza (2005), Stiedl (1998) and consultant's estimates

Hand knapping can be more cost effective than mobile crushers when the volume of crushed stone required is low and in situations where it is difficult or costly to mobilise a mobile crusher (e.g. very remote locations). In order to estimate the approximate volume of stone below which hand knapping might be competitive, a comparative analysis of the costs between hand knapping and using a medium sized Hoa Phat mobile crusher (NHHP-PEX 175) was carried out. The results are shown in Figure 22[34]. For volumes of stone under 15 cubic metres, it was calculated to be more cost effective to crush stones manually.

D2.3 Purchasing from Commercial Quarry

The cost of purchasing crushed material from a quarry includes a fixed component (the cost of the material at the quarry gate) and a variable component (haulage distance). In Vietnam, the cost of crushed stone was found to vary from US$3.74 per cubic metre (for limestone) to US$7.16 (for "hard" stone) from an official quarry and the cost of haulage was US$6.91 per m^3/km for distances less than 30km[35]. The immediate observation is that the cost of haulage is significant.

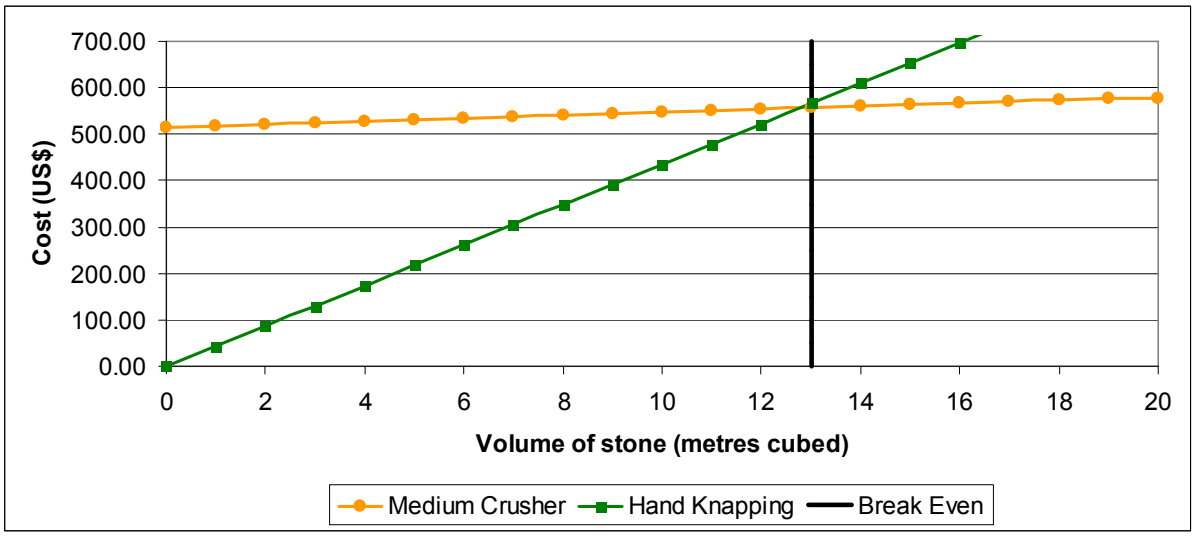
Using the lowest quarry price for stone and assuming one kilometre haulage, the total delivered cost would be US$3.74+ US$6.91 = US$10.65 per cubic metre. This is far in excess of the calculated cost per cubic metre using a mobile crusher of around US$1.4-2.2 per cubic metre (see Table 25 and the associated figure above). Further analysis was carried out to calculate the 'break-even haulage distance' for quarry stone compared to mobile crusher costs at different annual utilisation rates. This was found to vary from 300-150 metres

[33] It is assumed that stones will be broken to a diameter of 20 mm

[34] It was assumed that the cost of mobilisation (transporting the mobile crusher to the remote site) and de-mobilisation is equal to US$513. This is based on one day transportation for mobilisation and demobilisation. 5 tonne flat trucks (Fuso EF639) can be hired for US$3,000 per month and skilled construction workers are paid US$130. The cost of fuel is assumed to equal US$100 each way. Therefore, the cost of 2 days hire of a typical truck, fuel and a skilled worker costs US$513. The analysis also took into consideration the cost of excavation.

[35] US$2.16 per tonne/km, as in decision No. 89/2000/QD-VGCP by Cost Norm Office under the Government, 13 November 2000

from the quarry for mobile crusher utilisation rates between 250 and 2,000 hours per year i.e. mobile crushers are more competitive in cost than quarries for production of crushed stone.



Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers, Mitchell and Mwanza (2005), Stiedl (1998) and consultant's estimates

Figure 22: Cost of crushing stone manually and with a medium sized crusher (Hoa Phat, NHHP-PEX 175)

These costs do not take into account the fact that a contractor requires a government permit to mine natural resources. This will act as a significant cost burden to contractors, which suggests why the diffusion of mobile crushers is not as wide as the cost effectiveness benefits suggest. Also purchasing from a commercial quarry is more convenient for an SSC and the crushed product is likely to be of a higher quality and a wider range of minerals will be on offer.

D2.4 Chapter Summary

The estimated cost of producing broken stone by hand knapping was found to be approximately US$42 per cubic metre. This unit cost is substantially higher than producing crushed stone using a mobile crusher, which ranges between US$1.3 to US$4.5 per cubic metre. However, hand knapping can be cost effective where the required volume of broken stone is low (under 15 cubic metres) and in remote areas.

In general, the medium and large Hoa Phat mobile crushers are more cost effective than their smaller counterpart. If the utilisation rate of a mobile crusher is more than 1,000 hours per annum then it is more cost effective to purchase a mobile crusher. Below 1,000 hours per year, hiring was estimated to be more cost effective.

The cost of purchasing crushed material from a commercial quarry is significantly more expensive than using a mobile crusher. However, this option may be the only option available to a contractor if unable to organise the required resources (manpower or machines). Additionally, the quality of commercial quarry product is often better and there could be a wider option of material sizes available. Therefore in situations where high product quality or specific material is required, purchasing from a commercial quarry might be the optimal choice. Table 26, below, summarises the optimal crushing strategies.

Table 26: Optimum crushing strategies

Option	Hand Knapping	Mobile Crusher		Quarry Purchase
		Hire	Purchase	
Volumes of crushed material under 15 cubic metres and isolated areas	✓			
Utilisation rates below 1,000 hours per annum		✓		
Utilisation rates above 1,000 hours per annum			✓	
Unable to access resources (human and equipment) in the required time				✓
Strict requirement for good and consistent quality crushed material				✓

D3. MOBILE CRUSHER DEMAND AND SUPPLY

This chapter deals with the demand and supply situation linked to mobile crushers. The evidence is mainly drawn from the contractor surveys.

D3.1 Demand

D3.1.1 Assessment of current demand

Chapter B1 explained the difficulties linked to the estimation of current market demand. The current market demand of crushers is also assessed using the information on the contractors' ownership and hiring level (contractor surveys generated such information). Table 27 summarises the stone crusher ownership and hiring related information.

The ownership level of mobile crushers was considerable among the Vietnamese contractors – 33% owned them. However, no Cambodian contractor owned a mobile crusher. Only 5% of Vietnamese and no Cambodian contractors hired a mobile crusher in the 12 months prior to the interviews.

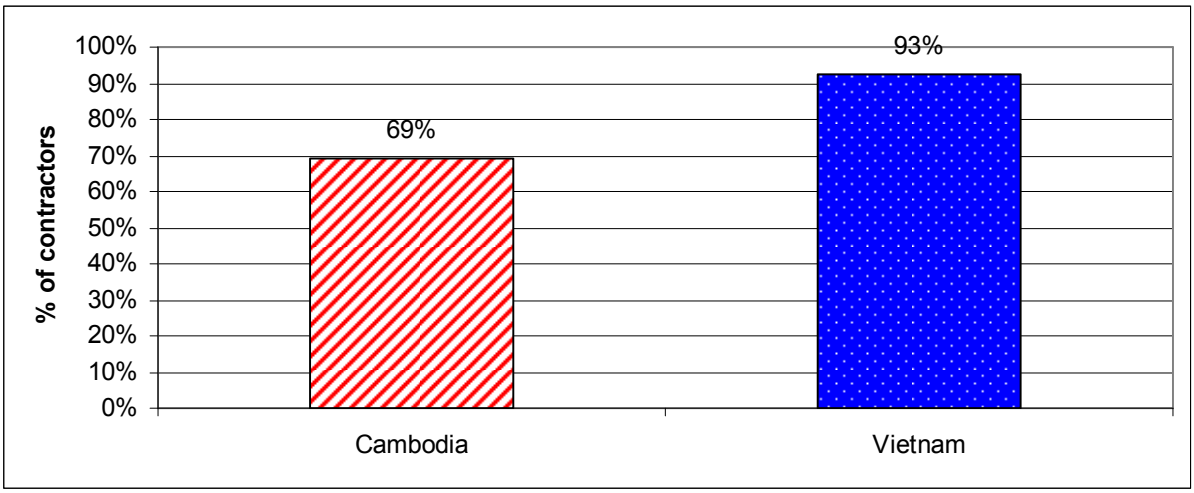
Table 27: Contractors that own or have hired a mobile crusher in the last 12 months

Equipment	Percentage of contractors that own/hire[a]					
	Total		Cambodia		Vietnam	
	Own	Hire	Own	Hire	Own	Hire
Mobile Crusher	16 (1.8)	3 (1)	0 (0)	0 (0)	33 (1.8)	5 (1)

Source: Contractor surveys

Note: [a] Within bracket values refer to the average number of equipment owned/hired per owning/hiring contractor

Most of the contractors were aware of mobile crushers: approximately 70% of the Cambodian contractors and 90% of the Vietnamese contractors were aware of the mobile crusher (Figure 23). All the contractors that claimed to know about mobile crushers were correctly able to articulate its main functions.

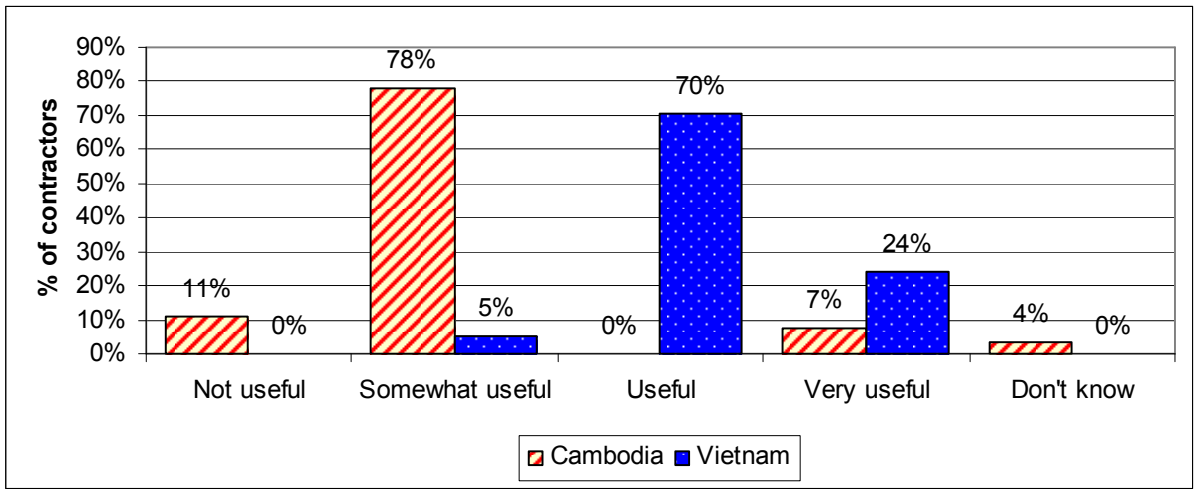


Source: Contractor surveys

Figure 23: Mobile crusher awareness (% aware)

The contractors who were aware of mobile crushers were also asked questions on their usefulness. Contractor perception regarding mobile crusher usefulness was high (Figure 24).

All of the Vietnamese contractors and 89% of Cambodian contractors thought that the mobile crusher was a useful item of equipment.



Source: Contractor surveys

Figure 24: Mobile crusher usefulness

Contractors, who were aware of the mobile crusher, were also asked whether they would purchase one and, if so, how much they would be willing to pay for one (Figure 25). 59% of the Cambodian contractors said that they would not be willing to purchase a mobile crusher. 30% of the Cambodian contractors would be willing to pay more than US$10,000 for one. This is twice the price of the largest Hoa Phat crusher. This suggests that the Cambodian contractors have little knowledge of the financial viability of mobile crushers.

An overwhelming majority of the Vietnamese contractors (95%) who were aware of mobile crushers would be willing to buy one. However, 57% of them would only buy a mobile crusher if the purchase price was less than US$ 1,000. This price is lower than the price of the cheapest Hoa Phat mobile crusher (the NHHP-PEX15 which costs approximately US$1,420). However, 35% of the Vietnamese contractors were willing to pay between US$1,000 and 4,999, the typical price of new Hoa Phat crushers.

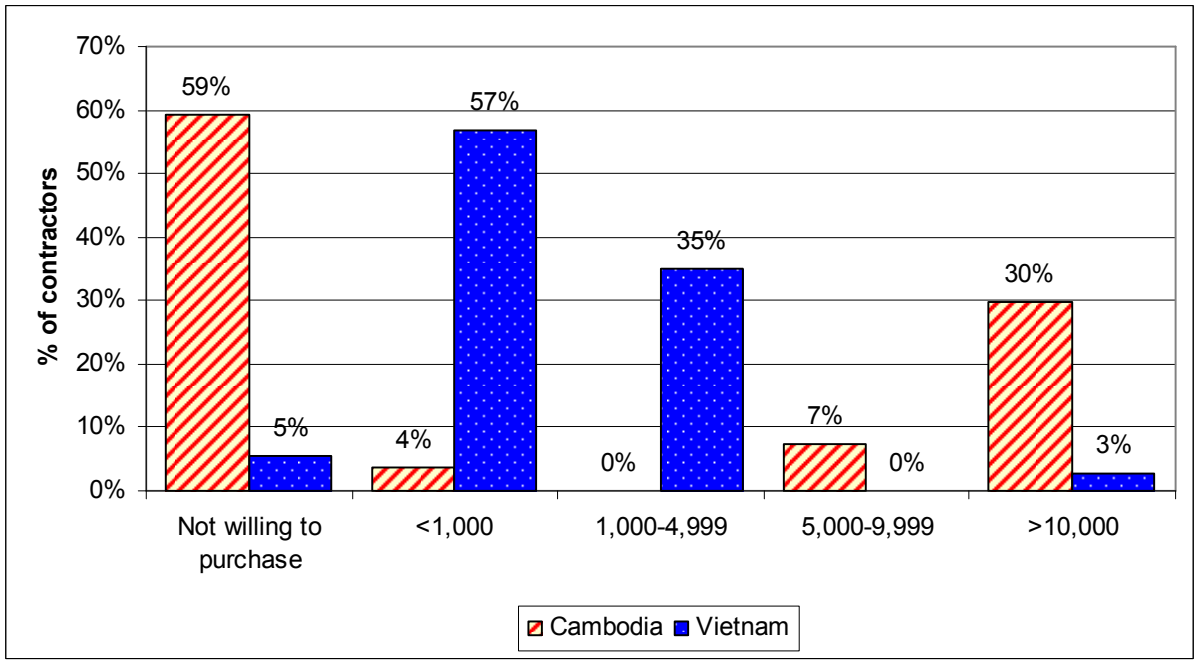


Figure 25: Contractors willing to purchase a mobile crusher and at what price (US$)

D3.1.2 Assessment of future demand

The future equipment demand was estimated using the projected amount of rural road linked roadworks in Cambodia, Vietnam and Laos and the productivity rates of the equipment[36] (details available in Section B1.3.2). Table 28 presents the projected future demand (the number that will be required to carry out the planned roadworks) for mobile crushers[37].

Table 28: Annual requirement of equipment, number of units (2007/8-2011/12)

Equipment	Cambodia	Vietnam	Laos
Small Crusher, Hoa Phat NHHP-PEX15	321	6618	222
Medium Crusher, Hoa Phat NHHP-PEX175	143	2941	99
Large Crusher, Hoa Phat NHHP-PEX215	107	2206	74

Source: Contractor surveys

Table 28 shows that the potential future demand for mobile crushers for rural roadworks is less than 200 units for Laos and Cambodia combined (for medium sized crusher) per year. Given the low demand it would not be worthwhile to pursue a mainstreaming strategy in Cambodia or Laos.

By contrast, the demand for mobile crushers is substantial in Vietnam: it is estimated that over 2,900 (for medium sized crusher) per year will be required to execute the rural road strategy. This is a significant number of units and, therefore, there is a justification for devising a mainstreaming strategy in Vietnam. The objective of the mainstreaming activity will not be to enhance the supply of mobile crushers, but instead to disseminate the information to contractors and equipment suppliers on cost advantages of mobile crushers in sourcing crushed aggregate over other alternatives. This may result in increase in demand for mobile crushers.

In general, there was a level of enthusiasm among contractors and key informants about mobile crushers. Cambodian interviewees were aware of the potential surge of paved road related roadworks, as evident from the conversations. In all three countries, many contractors were also aware that the mobile crusher could be used to recycle building construction rubble and this could also provide income outside the rural roads sub-sector. However, such enthusiasm was felt mainly in booming areas (e.g. Siem Reap). Many of the contractors stated that the requirement for a permit to extract materials was a major constraint. Many interviewees in Cambodia felt that the availability of rock and stone for crushing was far more limited in Cambodia than in Vietnam and Laos. Some of the Cambodian contractors also stated that quarry based crushers were more effective than mobile crushers and could produce higher quality products. Appendix XXX and XXXI provides further anecdotal information on contractor and key informant opinions towards mobile crusher.

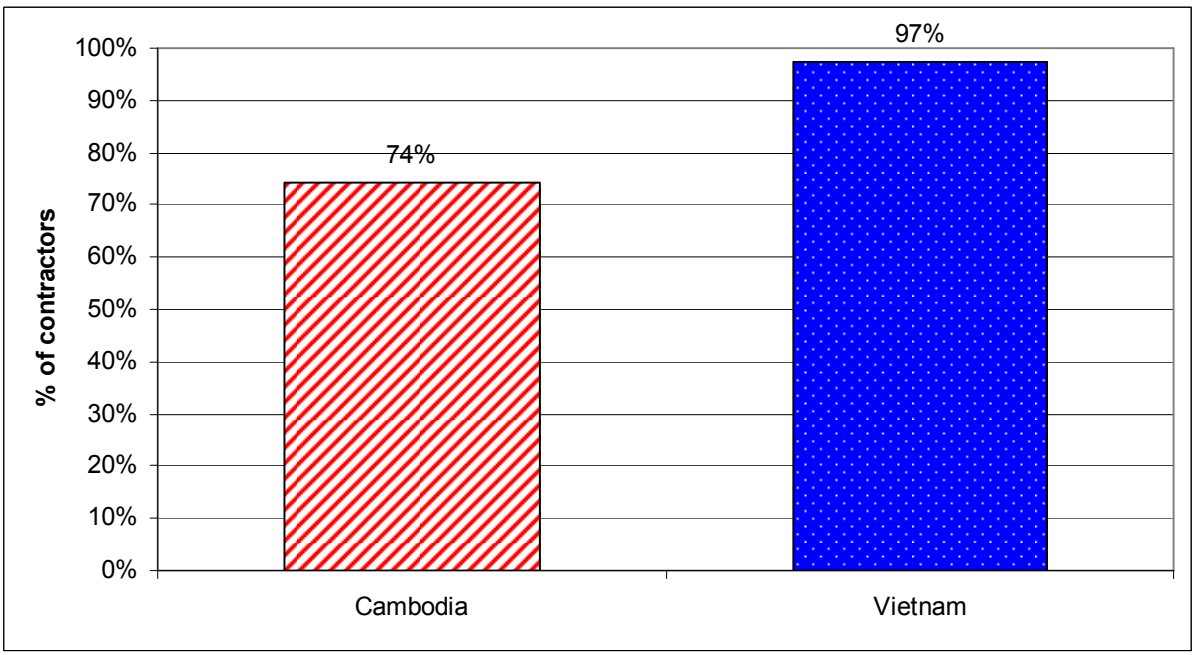
D3.2 Supply

Contractors who were aware of the mobile crusher were asked if they had adequate access if required. The results are provided in Figure 26. 97% of Vietnamese contractors and 74% of the Cambodian contractors believed that there would be no supply constraints. However, the figures for Cambodia should be treated with caution as none of the contractors actively sought

[36] Productivity rates of 6 m^3/hour, 4.5 m^3/hour, 2 m^3/hour respectively for large, medium and small Hoa Phat mobile crushers. Please note that mobile crusher demand values were not subjected to an efficiency down-scale of 80%. Because the productivity values stated are regarded as being accurate (see Appendix XXIII). Please refer to Section B1.3.2 for further details

[37] The following assumptions apply in the assessment of the demand: roadworks are timed and managed perfectly so that the equipment runs to its full potential and the demand from non-rural road sub-sector is excluded.

to acquire a mobile crusher, therefore, this only reflects the contractors' perceptions on mobile crusher availability. However, all key informants in Cambodia as well as Laos stated that there are no supply constraints to mobile crushers in their respective countries.



Source: Contractor's survey

Figure 26: Contractor's who state they have adequate access to the mobile crusher

There are no manufacturers of mobile crushers in Cambodia or Laos. The main manufacturer of crushers in Vietnam is Hoa Phat producing 200 units annually (see Figure 27). The Manager of Hoa Phat's Sales Department stated that the mobile crusher sales volume had been increasing on average 40% per annum, and this trend was expected to continue for the foreseeable future. In spite of this huge surge, the company claims to be able to meet the projected demand. Hoa Phat has also exported their mobile crushers abroad. Since the year 2000, Hoa Phat exported crushers to Sri Lanka and Ukraine. The company began exporting to Cambodia and Laos recently. It can be concluded that Hoa Phat has a strong manufacturing potential and are able to meet regional crusher demand.

Figure 27: Mobile crusher under assembly, Hoa Phat, Ho Chi Minh City

D3.3 Chapter Summary

The vast majority of contractors in Cambodia and Vietnam were aware of mobile crushers and its functions. Mobile crusher ownership level is considerable among Vietnamese contractors (33%). However, none of the Cambodia contractors interviewed owned a mobile crusher. While most Cambodian contractors, who were aware of mobile crushers, would not be willing to purchase a mobile crusher, an overwhelming majority of the Vietnamese contractors (95%) would be willing to buy one. The conclusion is that the current demand for mobile crushers is high amongst Vietnamese contractors but low among Cambodian contractors.

The potential future demand for mobile crushers is less than 250 units annually in Laos and Cambodia (combined). However, potential demand is over 2,900 units in Vietnam. This is mainly due to the anticipated high level of paved road work activities. Therefore it is concluded that a mainstreaming strategy needs to be pursued with an objective of dissemination of information on the cost advantages of mobile crushers.

There were no current constraints to mobile crusher supply in the region. Hoa Phat is currently producing approximately 200 units annually and has been exporting to Asian and European countries. No outside intervention is needed to boost Hoa Phat's production capacity as they seem to be adequately satisfying national and regional demand.

D4. MOBILE CRUSHER COMPARATIVE ASSESSMENT

D4.1 Viability

Contractors can obtain crushed/broken stone or rock by hand knapping, using a mobile crusher or purchasing from a commercial quarry. Mobile crushers appear to have a wide application in the three study countries. However, in isolated areas the only option may be to hand knap and certain contracts may require quality crushed material that may only be obtainable from a commercial quarry. In addition, contractors require a permit to extract natural resources. Without such a permit hand knapping and using a mobile crusher are technically illegal activities. However, for small scale excavation, this is often not enforced.

D4.2 Cost

Mobile crushers cost between US$1,400 (less than 0.5 tonnes) to US$12,000 (over 6 tonnes). Equipment suppliers in the region rarely hire out mobile crushers.

The most cost effective method of acquiring broken/crushed stone was calculated to be by using a mobile crusher, except in the following cases:

- when the required volume of broken stone is low (less than 15 m^3) and/or when the construction site is located in isolated areas that makes the mobilisation and demobilisation costs of the mobile crusher considerable. In such cases hand knapping is the most cost effective option; and
- when high quality of the crushed material is required and when the contractor is unable to organise the required resources (man power or machines) due to time restraints. In such cases purchasing from a commercial quarry may be the only option.

The most cost effective Hoa Phat mobile crushers are the medium (NHHP-PEX175) and large (NHHP-PEX215) models. If a contractor is able to utilise a crusher for more than 1,000 hours per year, it is more cost effective to purchase a mobile crusher. Otherwise, hiring is the more cost-effective option.

D4.3 Demand and Supply

Less than 200 units per year of the medium sized Hoa Phat crusher is estimated to be required in Cambodia and Laos (combined) in order to implement the roadworks within the rural roads sub-sector over the next 5 years. However, over 2,900 units will be required in Vietnam due to the anticipated expansion of paved road related activities. Evidence shows that there is no constraint to the supply of mobile crushers in the region.

D4.4 Recommendations

Mobile crushers provide contractors with considerable cost advantages in terms of sourcing crushed material and it is recommended that this information is disseminated by the appropriate authority in the respective countries among contractors and equipment suppliers. An objective of this dissemination process should be to encourage equipment suppliers to make mobile crushers available for hire, particularly in Vietnam.

Despite the high anticipated demand of mobile crushers in Vietnam, no external intervention is required to increase market supply as it appears that the only supplier in Vietnam, Hoa Phat, has the capacity to meet the projected demand.

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APPENDICES

APPENDIX I

Contractor Survey (FORM 1)

Company Name:		**Interviewee's Name:**	
Interviewee ID No:		**Position in the Company:**	
Address:		**Operating Region:**	
		Telephone No.:	
Name of surveyor:		**Surveyor ID No:**	
Date:		**Location:**	

SECTION 1: Company details

1.1a) What is the annual turnover of your company? (approximate average over the last 3 years, US$)

Less than 5,000	□	5,000 to 9,999	□
10,000 to 19,999	□	20,000 to 39,999	□
40,000 to 80,000	□	80,000 to 199,999	□
200,000 to 499,999	□	500,000 to 999,999	□
Over 1,000,000	□	No data available	□
Not stated			□

1.1b) What is the annual turnover of your company from rural road projects only? (approximate average over the last 3 years, US$)

Less than 5,000	□	5,000 to 9,999	□
10,000 to 19,999	□	20,000 to 39,999	□
40,000 to 80,000	□	80,000 to 199,999	□
200,000 to 499,999	□	500,000 to 999,999	□
Over 1,000,000	□	No data available	□
Not stated			□

1.2 How many permanent (full time) staff your company has?

0	□	1 – 2	□	3-5	□
6 – 10	□	11 – 15	□	16-50	□
51-100	□	More than 100	□	Not Stated	□

1.3 What organisations are the company enlisted with/ has worked for?

MOT	□	PDOT	□
Other public sector	□	Other contractor	□
Other private sector (national)	□	Other private sector (international)	□
Aid agency	□	RT2 or RT3 only	□

SECTION 2: Equipment

2.1 Has the company used any of the following equipment in the last 12 months? (Y/N)
If so, please tick (√) the appropriate box

Equipment	(√)	Type (where applicable	Equipment	(√)	Type (where applicable)
Truck (flat truck, tipper truck, itean)			Concrete Vibrator		
Tractor (type 4WD; 2WD) & Trailer			Mobile Small-Scale Stone Crusher		
Wheelbarrow			Grader (motor grader; towed grader)		
Roller/compactor [a]			Bitumen Heater		
Water Bowser (self propelled, towed)			Bitumen Hand Sprayer		
Concrete Mixer					

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

2.2 Does your company own any equipment? (Y/N)
If yes, please indicate what equipment, how many and how it was purchased

Equipment	(√)	Number (and type)	Method of Purchase (use code)	Purchase from? (use code)	Comment
Truck (flat truck, tipper truck, itean)					
Tractor (type 4WD; 2WD) & Trailer					
Wheelbarrow					
Roller/compactor [a]					
Water Bowser (self propelled, towed)					
Concrete Mixer					
Concrete Vibrator					
Mobile Small-Scale Stone Crusher					
Grader (motor grader; towed grader)					
Bitumen Heater					
Bitumen Hand Sprayer					

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

2.3 Has your company thought about purchasing any additional equipment? (Y/N)
If yes, please indicate what equipment

Equipment	(√) purchase considered	Type	Reason not purchased (use code)	Comment
Truck (flat truck, tipper truck, itean)				
Tractor (type 4WD; 2WD) & Trailer				
Wheelbarrow				
Roller/compactor [a]				
Water Bowser (self propelled, towed)				
Concrete Mixer				
Concrete Vibrator				
Mobile Small-Scale Stone Crusher				
Grader (motor grader; towed grader)				
Bitumen Heater				
Bitumen Hand Sprayer				

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

If no, please indicate why you never considered purchasing additional equipment

The reason why I have never considered purchasing additional equipment is……

2.4 Has the company ever faced any problems in financing the purchase of equipment? (Y/N)

If yes, what problems did you face?

Unable to raise private capital	□
Unable to obtain credit	□
Credit available, but large deposit required	□
Credit available, but at high interest rate	□
Other, please specify……..	

2.5a Has the company ever imported or thought about importing equipment? (Y/N)
If no, the please go to question 2.6
If yes, what equipment did you think about importing?

Equipment	(√) if considered importing	Type	Equipment	(√) if considered importing	Type
Truck (flat truck, tipper truck, itean)			Concrete Vibrator		
Tractor (type 4WD; 2WD) & Trailer			Mobile Small-Scale Stone Crusher		
Wheelbarrow			Grader (motor grader; towed grader)		
Roller/compactor [a]			Bitumen Heater		
Water Bowser (self propelled, towed)			Bitumen Hand Sprayer		
Concrete Mixer					

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

2.5b Why did you feel you needed to import such equipment?

Not available when required	☐
Not available locally	☐
Quality of local equipment too low	☐
Local equipment too expensive	☐
Other, please specify…….. ……	

2.5c Did you encounter any problems importing? (Y/N)

If yes, please specify such problems

Did not know how to import	☐
Equipment not available to import	☐
Importation tax too high	☐
Foreign equipment too expensive	☐
Lengthy/complicated process (please provide further information below)	☐
Other, please specify below……... ……	

Further information on importation…….

2.6 Has your company hired any equipment in the last 12 months? (Y/N)
If yes, please indicate what equipment, how many and from which source

Equipment	(√) if hired	Number and Type	Source (use code)	Comment
Truck (flat truck, tipper truck, itean)				
Tractor (type 4WD; 2WD) & Trailer				
Wheelbarrow				
Roller/compactor [a]				
Water Bowser (self propelled, towed)				
Concrete Mixer				
Concrete Vibrator				
Mobile Small-Scale Stone Crusher				
Grader (motor grader; towed grader)				
Bitumen Heater				
Bitumen Hand Sprayer				

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

2.7 Has your company ever had any difficulty obtaining the following equipment? (Y/N)
If yes, please indicate which equipment and why

Equipment	(√) if difficulty obtaining	Type	Reason (use code)	Comment
Truck (flat truck, tipper truck, itean)				
Tractor (type 4WD; 2WD) & Trailer				
Wheelbarrow				
Roller/compactor [a]				
Water Bowser (self propelled, towed)				
Concrete Mixer				
Concrete Vibrator				
Mobile Small-Scale Stone Crusher				
Grader (motor grader; towed grader)				
Bitumen Heater				
Bitumen Hand Sprayer				

Note: [a] type: Ride on vibratory, towed vibratory, deadweight, towed deadweight, pedestrian vibratory, plate compactor, hand drawn

2.8 Are there any potential institutions that can help your company in procuring equipment? (Y/N)

If yes, please indicate which institution(s) can help?

MOT	□	PDOT	□
Other public institution	□	Please provide example	……
Bank	□	Please provide example	……
Charity/NGO	□	Please provide example	……
Other	□	Please provide example	……

Please indicate how such institution(s) can help?

SECTION 3: Towed Grader

3.1 Are you aware of the towed grader? (Y/N)
If no, please go to question 4

3.2 Do you know what it does? (Y/N)
If yes, please state its function

3.3 Have you seen a towed grader? (Y/N)
If yes, please go to question 3.4; If no, please go to question 3.5

3.4 Has your company used a towed grader? (Y/N)

3.5 Does your company have adequate access to the towed grader when required? (Y/N)
If yes, please go to question 3.7; If no, please go to question 3.6

3.6 Why do you feel that your company has restricted access to the towed grader?

Cannot find equipment to purchase	☐
Cannot find equipment to hire	☐
Equipment too expensive	☐
Other, please specify……. ……..	

3.7 Do you own a towed grader? (Y/N)

3.8 Do you think that the towed grader is a useful item of equipment? (Y/N)

If yes, please indicate how useful

Somewhat useful	☐
Useful	☐
Very useful	☐
Essential	☐
Don't know	☐

3.9) How much are you be willing to pay for a towed grader (US$)?

less than 1,000	☐	1,000-1,999	☐
2,000-2,999	☐	3,000-3,999	☐
4,000-4,999	☐	5,000-6,999	☐
7,000-9,999	☐	10,000-20,000	☐
more than 20,000	☐	Not willing to purchase one	☐

3.10) If you had a towed grader, would you have adequate access to a tractor? (Y/N)

SECTION 4: Mobile small-scale stone crusher

4.1 Are you aware of the mobile small-scale stone crusher? (Y/N)
If no, you have now completed the questionnaire

4.2 Do you know what it does? (Y/N)
If yes, please state its function

4.3 Have you seen a mobile small-scale stone crusher? (Y/N)
If yes, please go to question 4.4; If no, please go to question 4.5

4.4 Has your company used a mobile small-scale stone crusher? (Y/N)

4.5 Does your company have adequate access to the mobile small-scale stone crusher when required? (Y/N)
If yes, please go to question 4.7; If no, please go to question 4.6

4.6 Why do you feel that your company has restricted access to the mobile small-scale stone crusher?

Cannot find equipment to purchase	☐
Cannot find equipment to hire	☐
Equipment too expensive	☐
Other, please specify……. …….	

4.7 Does your company own a mobile small-scale stone crusher? (Y/N)

4.8 Do you think that the mobile small-scale stone crusher is a useful item of equipment? (Y/N)
If yes, please indicate how useful

Somewhat useful	☐
Useful	☐
Very useful	☐
Essential	☐
Don't know	☐

4.9) How much are you be willing to pay for a mobile small-scale stone crusher (US$)?

less than 1,000	☐	1,000-1,999	☐
2,000-2,999	☐	3,000-3,999	☐
4,000-4,999	☐	5,000-6,999	☐
7,000-9,999	☐	10,000-20,000	☐
more than 20,000	☐	Not willing to purchase one	☐

Thank you! You have now completed the questionnaire! We appreciate your help

APPENDIX II

List of Key Informants

Cambodia

- HE Suos Kong, Secretary of State, MRD
- HE Yoeun Sophal, Director, Department of Rural Roads, MRD
- Ngoun Dara, Deputy Director, Department of Rural Roads, MRD
- Var Synarong, Engineer, MRD
- Sam Ny, Deputy Director, Provincial Department of Rural Roads, Kampot
- Veasna Bun, Infrastructure Operations Officer, The World Bank
- Paul Van Im, Programs Officer, Asian Development Bank
- Phibal Chao, Lecturer, Norton University, Cambodian Mekong University
- Ros Sar, Director, Department of Rural Development, MRD, Siem Reap
- Sereyreatama Dit, Director, PDWT
- Chem Salin, Engineer, Ministry of Rural Development
- Heng Kackada, Secretary, CNCTP
- Suo Sadim, Vice Chairman Undersecretary, Electric Authority of Cambodia

Vietnam

- Chun Su, Rural Transport Expert, MOT
- Choi Sun, Director of Rural Transport, Ministry of Transport
- Dr. Nguyen Huu Tri, Director General, Science and Technology Department, ITST
- Dr. Jasper Cook, Regional Manager, Intech Associates
- Simon Lucas, Infrastructure Specialist, The World Bank
- Hury Bui Ngoc, Highway Engineer, ITST
- Mr. Thang, Manager of Rural Transport Project
- Tran Quoc Thang, Deputy Director, IMUIS
- Ta Van Giang, Deputy Director of R&D Department, ITST

Laos

- Mr. Sengdarith, Director, Local Roads Division
- Mr. Somnak, Deputy Director, Local Roads Division
- Belal Hussein, Basiv Access Component, Lao-Swedish Road Sector Project III
- Per Oluf, Team Leader, Maintenance Component, Lao-Swedish Road Sector Project III
- Khamvieng Nanthalid, Deputy Director, ARI Co. Ltd.

Date	
Location	

Interview with Equipment Supplier (FORM 2)

SECTION 1: Interviewee's details

1.1) Name:

1.2) Employer:

1.3) Position:

1.4) Work address:

1.5) Telephone No:

SECTION 2) Equipment

2.1) Which of these equipment do you supply?

Equipment	Tick if supply (√)	Equipment	Tick if supply (√)
Tractor (2WD)		Roller (Hand drawn)	
Tractor (4WD)		Plate compactor	
Tipper truck		Towed bowser	
Flat truck		Concrete mixer	
Trailer		Concrete vibrator	
Wheelbarrow		Motor grader	
Roller (Ride on vibratory)		Towed Grader	
Roller (Towed vibratory)		Mobile small-scale stone crusher	
Roller (Towed deadweight)		Bitumen heater	
Roller (Pedestrian vibratory)		Bitumen hand sprayer	
Roller (Deadweight)			

2.2) What are the top 4 most typical models? How much does each model cost (new and second hand)? How many do you sell of each model?

Typical model			New		2nd Hand		
Brand	**Model**	**Power, Volume, Weight [a]**	**Price (US$)**	**Number per year**	**Av. Price (US$)**	**Av. age (yrs)**	**Number per year**

[a] For tipper trucks, flat trucks, trailer, water bowser, wheel barrow, concrete mixer, bitumen heater, bitumen hand sprayer (please provide volume, cubic metres).
For rollers please provide weight, (kg, tones)
For tractors and motor graders please provide power (e.g. 100 hp).
For concrete vibrator please provide diameter (E.g. 3 inch)

2.3) Do you hire this equipment out? (Y/N)

If yes, please provide details on the model, hire out rate and the number you hire out per year?

Typical model			Hire out rate ($/month)	Number hire out per year
Brand	**Model**	**Volume,Power, Weight [a]**		

[a] For tipper trucks, flat trucks, trailer, water bowser, wheel barrow, concrete mixer, volume, bitumen heater, bitumen hand sprayer please provide (cubic metres).
For rollers please provide weight.
For tractors and motor graders please provide power (e.g. 35 hp).

For concrete vibrator please provide diameter (E.g. 3 inch)

2.4) Do you feel that there is insufficient demand for the equipment that you sell? (Y/N)

If yes, please indicate why

2.5) Is there excess demand for the equipment you supply (i.e. cannot meet demand)? (Y/N)

If yes, which periods of the year? (E.g. throughout the year, months, wet season, dry season etc.)

2.6) Do you import the equipment? (Y/N)

If yes, from which country(s)?

2.7a) What are the typical importation procedures?

2.7b)What are common barriers to importation?

2.7c) Is there any potential for this equipment to be manufactured locally? (Y/N/Don't know)

APPENDIX IV

Required Equipment for Various Road Surfacing Technologies

Equipment	√ Engineered Natural Surface	√ Soil Stabilisation	√ Natural Gravel / Laterite	√ Water Bound Macadam	√ Dry Bound Macadam	√ Crushed Stone Macadam	√ Hand Packed Stone	√ Telford Paving	√ Cobble Stones	√ Stone Setts or Pave'	√ Dressed Stone	√ Mortared Stone	√ Stone Chippings	√ Slurry Bound Macadam	√ Bituminous Sand Seal	√ Bituminous Chip Seal	√ Slurry Seal	√ Ottaseal[38]	√ Penetration Macadam (Bitumen)	√ Pre-Mix Macadam (Bitumen)	√ Burnt Clay Brick	√ Concrete Brick	√ Un-Reinforced Concrete	√ Steel Reinforced Concrete	√ Bamboo Reinforced Concrete	√ Geo-Cell Paving	√ Stone Chipping Blinding
Tractor (2WD)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Tractor (4WD)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Tipper Truck																											
Flat Truck																											
Dumpers																											
Power Tiller																											
Itean																											
Trailer	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√				
Wheelbarrow	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Pedestrian Vibrating Roller	√						√	√	√																		
Towed Deadweight Roller				√ >6T	√ >6T	√ >6T									√ 1-3T	√ 1-3T	√ >6T	√ >6T	√ >6T	√							
Ride On Vibrating Roller																											
Towed Vibrating Roller	√	√3Tm	√3Tm	√ 3Tm	√ 3Tm	√ 3Tm	√	√	√1Tm				√3Tm	√>3T	√	√>3T	√		√	√							
Towed Bowser	√	√	√	√	√	√	√	√							√	√											
Hand Drawn Roller																											
Laden Truck / Traffic																											
Vibrating Plate									√	√>60kg	√>60kg	√>60kg		√>60kg						√ 60kg	√ 60kg						
Concrete Mixer										√ >80l	√ >80l	√ >80l					√ >80l					√ 250l	√ 250l	√ 250l			

[38] Needs pneumatic tyred roller

Equipment	Engineered Natural Surface	Soil Stabilisation	Natural Gravel / Laterite	Water Bound Macadam	Dry Bound Macadam	Crushed Stone Macadam	Hand Packed Stone	Telford Paving	Cobble Stones	Stone Setts or Pave'	Dressed Stone	Mortared Stone	Stone Chippings	Slurry Bound Macadam	Bituminous Sand Seal	Bituminous Chip Seal	Slurry Seal	Ottaseal[38]	Penetration Macadam (Bitumen)	Pre-Mix Macadam (Bitumen)	Burnt Clay Brick	Concrete Brick	Un-Reinforced Concrete	Steel Reinforced Concrete	Bamboo Reinforced Concrete	Geo-Cell Paving	Stone Chipping Blinding
Concrete Vibrator																							√	√	√		
Concrete Dumper																											
Concrete Paver Press																											
Hand Operated Mobile Crusher				√	√	√		√					√			√	√	√									
Towed Grader	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√							√
Bitumen Heater																			√	√							
Bitumen Hand Sprayer														√	√	√	√	√	√	√							
Fuel Bowser																											

Note: It is assumed that the construction would start from the re-shaping of the sub-grade. Sub-base and base (where applicable) would subsequently be constructed.

>6T – greater than 6 tonnes; 1-3T – between 1 to 3 tonnes; 3Tm – minimum 3 tonnes; >60kg –greater than 60 kg; >80l – would require greater than 80 litres

Analysis based on the minimum equipment requirements.

Main equipment from the analysis:

(i) Tractor (2WD) and Tractor (4WD) –for towing a trailer in order to transport maintenance materials and for towing grader

(ii) Trailer – for transporting construction materials (< 10km)

(iii) Tipper truck, Flat truck and Itean – for transporting construction materials (> 10km)

(iv) Wheelbarrow – for transporting construction material for a short-distance during construction and maintenance.

(v) Pedestrian vibratory roller, Towed deadweight roller (>6T and 1-3 tonnes), Towed vibratory roller (>3T, >1T), Vibrating plate (>60kg) - for compaction

(vi) Towed Bowser – watering equipment

(vii) Concreting equipment: concrete mixer (>80l and 250l) and vibrator

(viii) Hand operated mobile crusher – for crushing of rock and stone

(ix) Towed grader – to shape road surface

Bitumen related equipment: bitumen heater and bitumen hand sprayer.

APPENDIX V

Equipment Operating Costs

Equipment/Vehicle	Make	Model	Depreciation	Interest	Maintenance costs	Cost of tyres	Fuel & lub. costs	Operators wages	Overhead	Total Operating Costs
Tipper Truck	Hyundai	HD 72	2.19	2.93	0.63	0.38	11.11	1.13	0.18	18.54
Flat Truck	Isuzu	FRR33H4	1.56	2.10	0.45	0.38	7.96	1.13	0.14	13.70
Tractor (2WD)	Kobuta	MX 500	1.56	2.10	0.37	0.25	4.64	1.13	0.10	10.14
Tractor (4WD)	Kobuta	9570	2.63	3.52	0.48	0.25	4.64	1.13	0.13	12.76
Trailer	Local manufacture		0.11	0.14	0.08	0.07	-	-	0.00	0.41
Wheelbarrow	Local manufacture		0.01	0.00	-	-	-	0.30	0.00	0.31
Roller (ride on vibratory)	Komatsu	100 JVA	13.00	17.44	1.18	0.20	10.13	1.02	0.43	43.39
Roller (pedestrian vibratory)	Komatsu	JV08HM	0.78	1.05	0.11	0.13	4.02	0.64	0.07	6.79
Roller (towed vibratory)	XCMG	YZ12JC	1.84	2.47	0.27	0.25	2.54	-	0.07	7.45
Roller (deadweight)	Bomag	BW 154AD-2	2.40	3.22	0.50	0.40	7.63	1.02	0.15	15.32
Roller (hand drawn)	Sakai	TS 10 H	0.44	0.59	0.15	0.06	0.01	0.64	0.02	1.90
Roller (towed deadweight)	Bitelli		0.06	0.08	0.02	0.13	0.01	-	0.00	0.31
Plate Compactor	Mikasa	MVH-120	0.51	0.34	0.10	-	2.01	1.02	0.04	4.02
Water Bowser (self propelled)	Unkown		11.67	15.65	0.63	0.38	11.11	6.00	0.45	45.87
Water Bowser (towed)	Herculano	RT 4000	0.83	1.12	0.24	0.17	-	-	0.02	2.38
Concrete Mixer	Local manufacture		0.37	0.24	0.03	0.09	1.51	0.64	0.03	2.90
Concrete Vibrator	Mikasa	MSX-28	0.10	0.04	0.02	-	1.01	1.02	0.02	2.22
Bitumen Heater	Vina Bima	NBT-100	0.39	0.42	0.05	-	-	0.85	0.02	1.73
Bitumen Hand sprayer	Vina Bima	PBT-100	0.65	0.70	0.03	0.17	-	0.85	0.02	2.42

Source: Contractor surveys; Equipment supplier surveys; IT Transport (2003); Larcher (1997)

APPENDIX VI

Financial Operating, Productivity and Utilisation Rates of Costs of Typical Equipment

Equipment	Typical Model / Brand	Productivity			Utilisation rate (hrs/year)	Financial operating cost (US$/hr)
		Activity	Value	Unit		
Tipper Truck	Hyundai HD 72	Haulage	71.11	tonne.km/hr	1,600	18.54
Flat Truck	Isuzu FRR33H4	Haulage	30.44	tonne.km/hr	1,600	13.70
Tractor 2WD	Kobuta MX 500	Haulage	13.09	tonne.km/hr	1,600	10.14
Tractor 4WD	Kobuta 9570	Haulage	25.71	tonne.km/hr	1,600	12.76
Trailer	Local manufacture	Haulage	see tractor		1,400	0.41
Wheelbarrow	Local manufacture	Haulage	0.24	tonne.km/hr	1,200	0.31
Roller (ride on vibratory)	Komatsu 100 JVA	Compaction	1,365.00	m2/hr	1,000	43.39
Roller (pedestrian vibratory)	Komatsu JV08HM	Compaction	80.76	m2/hr	1,600	6.79
Roller (towed vibratory)	XCMG YZ12JC	Compaction	1,365.00	m2/hr	1,600	7.45
Roller (ride on deadweight)	Bomag BW 154AD-2	Compaction	270.00	m2/hr	1,000	15.32
Roller (deadweight, hand drawn)	Sakai TS 10 H	Compaction	30.00	m2/hr	1,600	1.90
Roller (towed deadweight)	Bitelli	Compaction	63.00	m2/hr	1,600	0.31
Vibrating Plate	Mikasa MVH-120	Compaction	1.73	m2/hr	1,000	4.02
Water Bowser (self-propelled)	Unknown	Watering	457.14	m2/hr	300	45.87
Water Bowser (towed)	Herculano RT 4000	Watering	194.29	m2/hr	600	2.38
Concrete Mixer	Local manufacture	Concreting	6.72	m3/hr	1,600	2.90
Concrete Vibrator	Mikasa MSX-28	Concreting	6.72	m3/hr	1,000	2.22
Bitumen Heater	Vina Bima NBT-100	Bitumen	252.95	m2/hr	1,600	1.73
Bitumen Hand Sprayer	Vina Bima PBT-100	Bitumen	252.95	m2/hr	1,600	2.42

Source: Contractor surveys, Equipment supplier surveys, Equipment manufacturers, 'Cost Comparison Study', Mozambique, ILO, 2003' and 'Tools and Equipment-Design, Development and Specifications', Regional Seminar Papers, ASIST, 1997.

APPENDIX VII

Rural Road Work Activities in Cambodia, Vietnam and Laos

Cambodia

The Cambodian Rural Road Strategic Plan (Ministry of Rural Development, 2007) was used as the main source to ascertain the programme for the rural road network.

Three scenarios are proposed (see table below), however, all three options aim to bring all Tertiary Roads to a maintainable standard in 7 years and all Sub-Tertiary 1 Roads to a maintainable standard in 10 years. The scenarios differ in their proposed strategy for Sub-Tertiary 2 and Sub-Tertiary 3 Roads. The consultant's of this report have been advised by the authors of the Cambodian Rural Transport Strategy that Scenario 3 is the most likely.

Cambodian Rural Transport Strategy (Criteria)

Criteria	Scenario 1	Scenario 2	Scenario 3
Bring all T roads to a maintainable standard (yrs)	7	7	7
Bring all ST1 roads to a maintainable standard (yrs)	10	10	10
Bring all ST2 roads to a maintainable standard (yrs)	10	10	15
Bring all ST3 roads to a maintainable standard (yrs)	10	15	20

Source: Ministry of Rural Development (2007),

The table below provides the development, periodic and routine maintenance of paved, gravel and earth roads.

Cambodian Rural Transport Strategy, Rural road work activities (km/year, 2007/8-2011/12)

Activity	Surface	Tertiary	Tertiary 1	Tertiary 2&3	Total
Construction	Paved	103	-	-	103
Construction	Gravel	103	232	1,046	1,381
Periodic Maintenance	Paved	-	-	-	-
Periodic Maintenance	Gravel	325	349	1,408	2,081
Routine Maintenance	Paved	103			103
Routine Maintenance	Gravel	933	890	3,652	5,475

Source: Ministry of Rural Development (2007),

Vietnam

Plans developed by the Ministry of Transport (MOT), Vietnam were used as the main source to obtain planned expansion and maintenance forecasts. The aim of the plans is to pave 55% of the rural network by the 2010 (World Bank, 2006). It assumes no expansion of the total rural network length, only a redistribution of the paved/gravel/earth composition. Gravel and earth roads are assumed to be periodically maintained every 5 years, and paved roads are assumed to require paving and periodic maintenance every seven years (however, newly built roads are not subject to any form of periodic maintenance). All roads are assumed to require routine maintenance once every year unless they have been constructed or are being subjected to periodic maintained, in which case they will be routinely maintained in the following year.

Laos

The National Strategy on Accelerated Provision of Rural Transport Infrastructure document was used as the main source to ascertain the panned rural road network strategy for Laos (Ministry of Communication Transport Post and Construction, 2007). It articulates that approximately 11,000 km of rural roads require construction and that 19% of the network is

open all-year round and are therefore eligible for periodic maintenance. All roads are assumed to require routine maintenance once every year unless they have been constructed or are being subjected to periodic maintained, in which case they will be routinely maintained in the following year.

Appendix VIII

Contractors that own or have hired equipment in the last 12 months

Equipment	Percentage of contractors that own/hire[a]					
	Total		Cambodia		Vietnam	
	Own	Hire	Own	Hire	Own	Hire
Tipper Truck	87 (4.5)	49 (3.3)	82 (3.6)	49 (2.6)	93 (5.2)	50 (4)
Flat Truck	23 (2.2)	1 (10)	18 (2.6)	3 (10)	28 (2)	0 (0)
Tractor 2WD	3 (1.5)	0 (0)	0 (0)	0 (0)	5 (1.5)	0 (0)
Tractor 4WD	14 (1.4)	10 (1)	21 (1.5)	15 (1)	8 (1)	5 (1)
Trailer	27 (1.3)	15 (1.1)	33 (1.3)	3 (1)	20 (1.4)	28 (1.1)
Wheelbarrow	76 (15.5)	1 (2)	67 (18.2)	0 (0)	85 (13.4)	3 (2)
Roller (ride on vibratory)	77 (1.8)	39 (1.1)	77 (1.5)	38 (1.1)	78 (2.1)	40 (1.1)
Roller (pedestrian vibratory)	9 (2)	0 (0)	18 (2)	0 (0)	0 (0)	0 (0)
Roller (towed vibratory)	1 (1)	0 (0)	3 (1)	0 (0)	0 (0)	0 (0)
Roller (ride on deadweight)	65 (2.6)	8 (1.3)	36 (1.1)	0 (0)	93 (3.2)	15 (1.3)
Roller (deadweight, hand drawn)	34 (1.6)	0 (0)	46 (1.5)	0 (0)	23 (1.9)	0 (0)
Roller (towed deadweight)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vibrating Plate	43 (2.3)	6 (1.2)	28 (2.1)	8 (1)	58 (2.4)	5 (1.5)
Water Bowser (self propelled)	53 (1.9)	13 (1.3)	38 (1.4)	15 (1)	68 (2.1)	10 (1.8)
Water Bowser (towed)	24 (1.4)	4 (1)	36 (1.4)	3 (1)	13 (1.2)	5 (1)
Concrete Mixer	77 (3.5)	8 (2.5)	56 (2.7)	5 (1)	98 (3.9)	10 (3.3)
Concrete Vibrator	75 (4.9)	5 (1.8)	54 (2.7)	5 (2)	95 (6.1)	5 (1.5)
Mobile Small-Scale Stone Crusher	16 (1.8)	3 (1)	0 (0)	0 (0)	33 (1.8)	5 (1)
Motor Grader	61 (1.9)	37 (1.3)	44 (1.5)	51 (1.3)	78 (2.1)	23 (1.4)
Towed Grader	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bitumen Heater	41 (1.6)	14 (1.4)	10 (1.8)	3 (2)	70 (1.6)	25 (1.3)
Bitumen Hand Sprayer	38 (2.1)	14 (1.3)	8 (1)	3 (2)	68 (2.2)	25 (1.2)

Source: Contractor surveys

Appendix IX

Total company annual turnover (for rural road sub-sector only) Percentages (total values in brackets)

Turnover (US$)	Total	Cambodia	Vietnam
Less than 5,000	3 (2)	5 (2)	0 (0)
5,000 to 9,999	3 (2)	5 (2)	0 (0)
10,000 to 19,999	13 (10)	23 (9)	3 (1)
20,000 to 39,999	18 (14)	21 (8)	15 (6)
40,000 to 80,000	25 (20)	23 (9)	28 (11)
80,000 to 199,999	15 (12)	13 (5)	18 (7)
200,000 to 499,999	13 (10)	0 (0)	26 (10)
500,000 to 999,999	4 (3)	0 (0)	8 (3)
more than 1,000,000	1 (1)	0 (0)	3 (1)
No data available	6 (5)	13 (5)	0 (0)
Not stated	0 (0)	0 (0)	0 (0)

Source: Contractor surveys

APPENDIX X

Total company annual turnover (for all commercial sectors). Percentages (total values in brackets)

Turnover (US$)	Total	Cambodia	Vietnam
Less than 5,000	0 (0)	0 (0)	0 (0)
5,000 to 9,999	0 (0)	0 (0)	0 (0)
10,000 to 19,999	5 (4)	10 (4)	0 (0)
20,000 to 39,999	8 (6)	15 (6)	0 (0)
40,000 to 80,000	11 (9)	23 (9)	0 (0)
80,000 to 199,999	23 (18)	38 (15)	8 (3)
200,000 to 499,999	13 (10)	0 (0)	26 (10)
500,000 to 999,999	25 (20)	0 (0)	51 (20)
more than 1,000,000	9 (7)	0 (0)	18 (7)
No data available	5 (4)	10 (4)	0 (0)
Not stated	1 (1)	3 (1)	0 (0)

Source: Contractor surveys

APPENDIX XI

Contractors facing difficulty in equipment procurement

Equipment	Percentage of contractors that have had difficulty acquiring		
	Total	Cambodia	Vietnam
Tipper Truck	1	0	3
Flat Truck	0	0	0
Tractor 2WD	0	0	0
Tractor 4WD	1	0	3
Trailer	1	3	0
Wheelbarrow	0	0	0
Roller (ride on vibratory)	3	0	5
Roller (pedestrian vibratory)	1	0	3
Roller (towed vibratory)	0	0	0
Roller (ride on deadweight)	1	0	3
Roller (deadweight, hand drawn)	0	0	0
Roller (towed deadweight)	0	0	0
Vibrating Plate	0	0	0
Water Bowser (self propelled)	4	0	8
Water Bowser (towed)	0	0	0
Concrete Mixer	1	0	3
Concrete Vibrator	1	0	3
Mobile Small-Scale Stone Crusher	4	0	8
Motor Grader	3	0	5
Towed Grader	1	0	3
Bitumen Heater	6	0	13
Bitumen Hand Sprayer	5	0	10

Source: Contractor surveys

APPENDIX XII

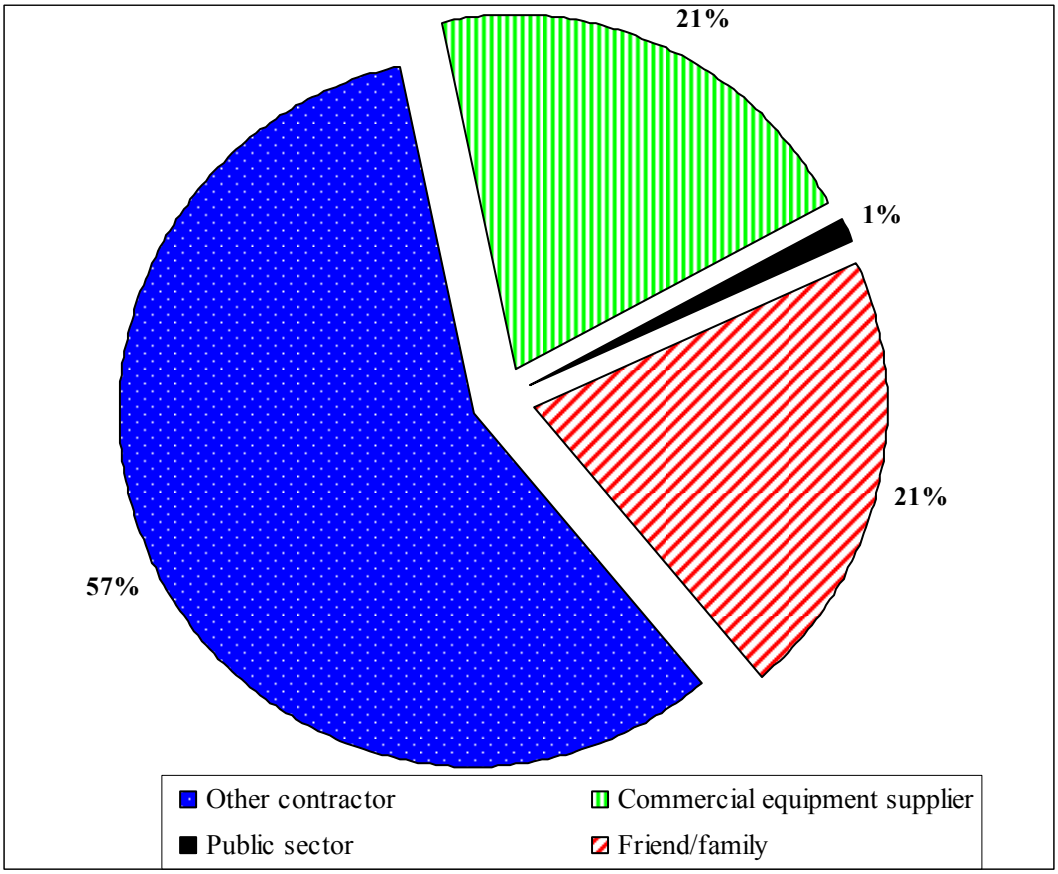
Equipment suppliers

Equipment	Equipment Supplier	Address	Country
Tipper truck	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Vehicle Assemble Factory Company	Donekoy, T 4 Road, Hatsayphong District, Vientiane	Laos
	Sovann Yaun Company	#271 E0, St Tep Phan, Phnom Penh	Cambodia
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
	Komatsu Vietnam JSC	K2 Office - 14 Thuy Khue Street, Tay Ho District, Hanoi	Vietnam
Flat truck	Vehicle Assemble Factory Company	Donekoy, T 4 Road, Hatsayphong District, Vientiane	Laos
	Sovann Yaun Company	#271 E0, St Tep Phan, Phnom Penh	Cambodia
	Xuan Kien Automobile Factory	2 Trieu Quoc Dat Street, Hanoi	Vietnam
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
Tractor 2WD	Insithong Motor Company	Ban Nongdouang Neau, Samsenethai Road, Sikhottabong District, Vientiane	Laos
	Agriculture Development Co. Ltd.	# 117, St 126, Phnom Penh	Cambodia
	Vietnam Engine and Agricultural Machinerary Corp.	2 Trieu Quoc Dat Street, Hanoi	Vietnam
Tractor 4WD	Insithong Motor Company	Ban Nongdouang Neau, Samsenethai Road, Sikhottabong District, Vientiane	Laos
	Agriculture Development Co. Ltd.	# 117, St 126, Phnom Penh	Cambodia
	Vietnam Engine and Agricultural Machinerary Corp.	2 Trieu Quoc Dat Street, Hanoi	Vietnam
Trailer	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
Wheelbarrow	Hol Korb Lathes	#66S2, St.163, Toul Tumpoung I, Khan Chamcarmon, Phnom Penh	Cambodia
	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Roller (ride on vibratory)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Dong Loi Joint Stock Machinary Company	G7, Lang Quoc te Thang Long – Cau Giay Dist, Hanoi	Vietnam
	KLC Ltd Company	A22-Lot 9 – Dinh Cong, Hanoi	Vietnam
Roller (pedestrian vibratory)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Seak Ly Co. Ltd.	#286, St 182, Phnom Penh	Cambodia

Equipment	Equipment Supplier	Address	Country
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Roller (towed vibratory)	Tu Chau Construction Equipment Cooperation (XCMG)	24 T2 Building, Trung Hoa-Nhan Chinh New Urban Area, The 17 Floor, Hanoi	Vietnam
Roller (ride on deadweight)	Seak Ly Co. Ltd.	#286, St 182, Phnom Penh	Cambodia
	Transport Material and Equipment Sharehold Company	Khuat Duy Tien Road - Thanh Xuan Dist, Hanoi	Vietnam
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
Roller (deadweight, hand drawn)	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Chhim Chiv	#2100A, St 68, Phnom Penh	Cambodia
Roller (towed deadweight)	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
Vibrating Plate	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Sam Sokhom	#2058 E0, St 68, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Water Bowser (towed)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
Concrete Mixer	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Hol Korb Lathes	# 66S2, St 163, Phnom Penh	Cambodia
Concrete Vibrator	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Mobile Small-Scale Stone Crusher	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
	Thien Hoa An	146 Truong Chinh Str., Dong Da, Hanoi	Vietnam
Motor Grader	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos

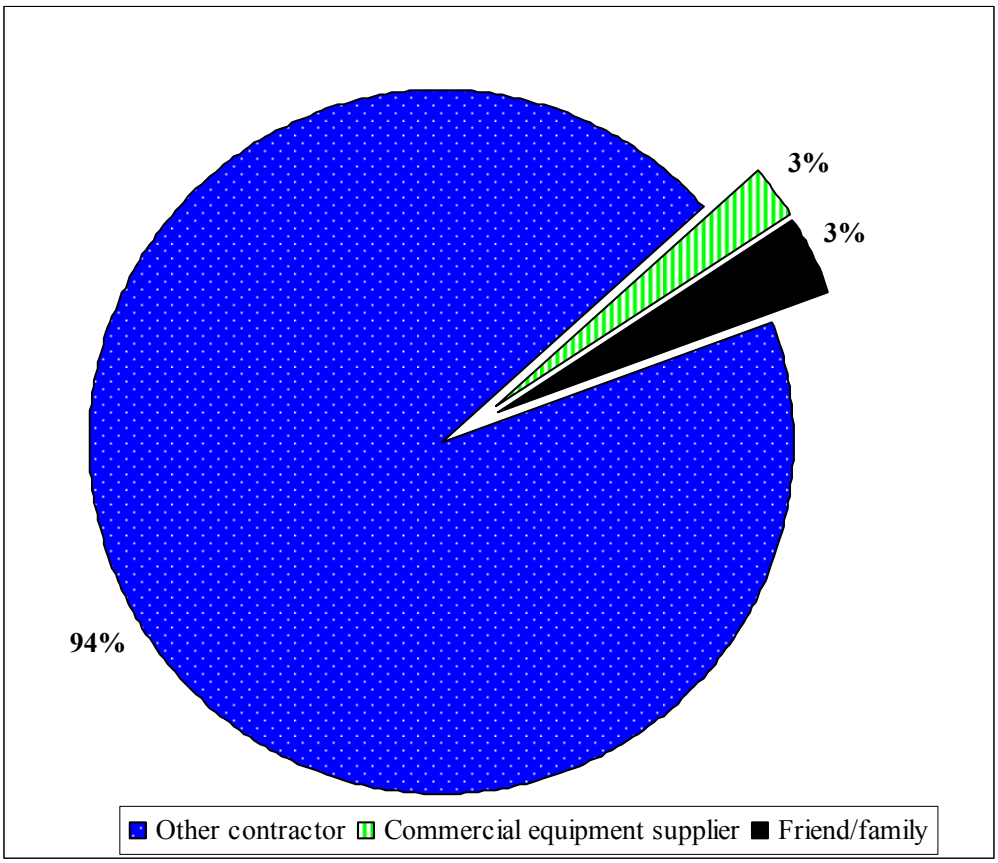
Equipment	Equipment Supplier	Address	Country
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Metro Group Fo Cambodia Co Ltd.	#1778, St 5, Phnom Penh	Cambodia
	Dong Loi Joint Stock Machinary Company	G7, Lang Quoc te Thang Long – Cau Giay Dist, Hanoi	Vietnam
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
	Komatsu Vietnam JSC	K2 Office - 14 Thuy Khue Street, Tay Ho District, Hanoi	Vietnam
Towed Grader	DTW	Unit 17ab&c, Street 528, Phnom Penh	Cambodia
Bitumen Heater	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Bitumen Hand Sprayer	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam

Source of equipment hire (Cambodia)



Source: Contractor surveys

Source of equipment hire (Vietnam)



Source: Contractor surveys

APPENDIX XV

Contractors that imported or considered importing equipment

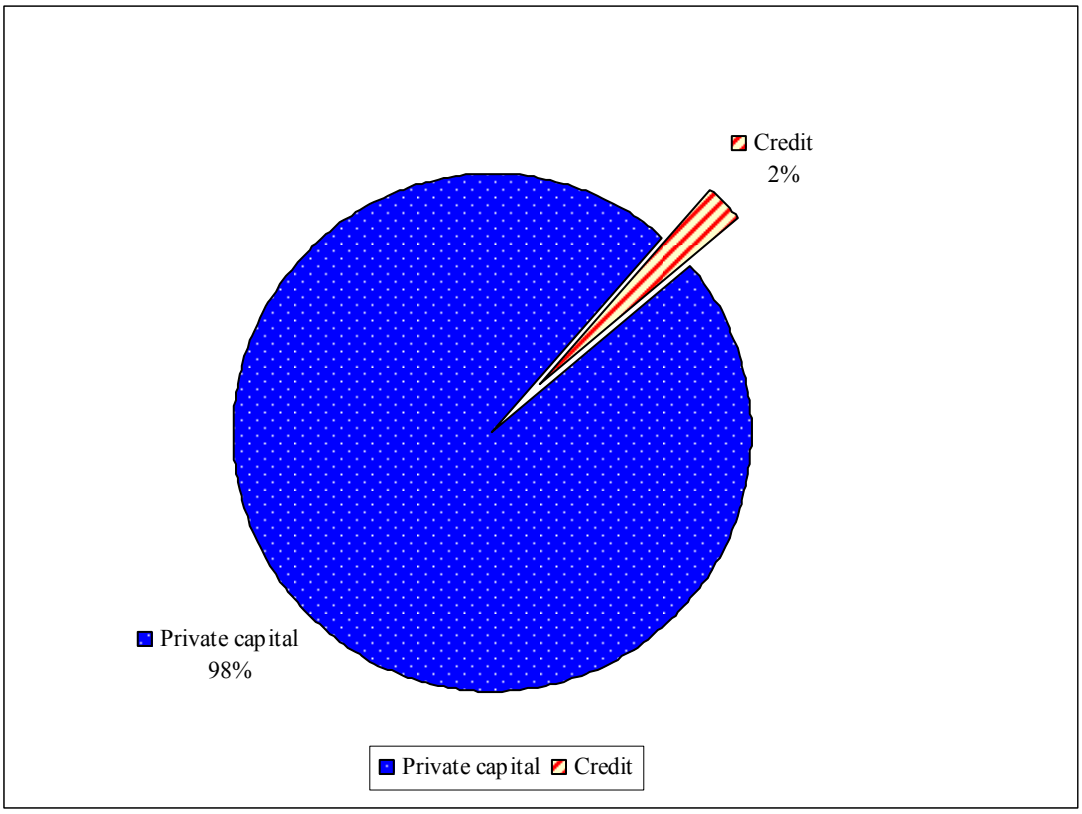
Equipment	Percentage of contractors imported/considered importing		
	Total	Cambodia	Vietnam
Tipper Truck	4	3	5
Flat Truck	0	0	0
Tractor 2WD	0	0	0
Tractor 4WD	0	0	0
Trailer	1	0	3
Wheelbarrow	0	0	0
Roller (ride on vibratory)	5	5	5
Roller (pedestrian vibratory)	0	0	0
Roller (towed vibratory)	1	0	3
Roller (ride on deadweight)	1	0	3
Roller (deadweight, hand drawn)	0	0	0
Roller (towed deadweight)	0	0	0
Vibrating Plate	0	0	0
Water Bowser (self propelled)	1	0	3
Water Bowser (towed)	0	0	0
Concrete Mixer	1	0	3
Concrete Vibrator	1	0	3
Mobile Small-Scale Stone Crusher	0	0	0
Motor Grader	3	0	5
Towed Grader	0	0	0
Bitumen Heater	4	0	8
Bitumen Hand Sprayer	4	0	8

APPENDIX XVI

Equipment manufacturers

Equipment	Equipment Supplier	Address	Country
Tipper truck	Construction Electrical & Mechanical Equipment Co Ltd.	145 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Flat truck	Truong Hai Company	2 Ngo Gia Tu - Long Bien, Hanoi	Vietnam
	Cuu Long Motor	500 Hung Trac, Van Lam, Hung Yen	Vietnam
	Xuan Kien Automobile Company	Tien Phong commune-Me Linh district, Vinh Phuc Province	Vietnam
	Truong Hai Group	Tam Hiep industrial zone, Nui Thanh, Quang Nam	Vietnam
Tractor 2WD	Vietnam Engine and Agricultural Machinerary Corp.	Trieu Quoc Dat Street, Hanoi	Vietnam
	1-5 Machinery Company	Dong Anh Town, Hanoi	Vietnam
Tractor 4WD	Vietnam Engine and Agricultural Machinerary Corp.	Trieu Quoc Dat Street, Hanoi	Vietnam
Trailer	Cuu Long Motor	500 Hung Trac, Van Lam, Hung Yen	Vietnam
Wheelbarrow	Hol Korb Lathes	#66S2, St.163, Toul Tumpoung I, Khan Chamcarmon, Phnom Penh	Cambodia
	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	3-2 Machinery Company	18 Giai Phong Str., Dong Da Dist., Hanoi	Vietnam
Vibrating Plate	Rong Riet	109, Highway 1A, Thanh Xuan Precinct, District 12	Vietnam
Concrete mixer	Hol Korb Lathes	#66S2, St.163, Toul Tumpoung I, Khan Chamcarmon, Phnom Penh	Cambodia
	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	Hoa Phat	Pho Noo Industrial Zone, Hung Yen	Vietnam
	1-5 Machinery Company	Dong Anh Town, Hanoi	Vietnam
	3-2 Machinery Company	18 Giai Phong Str., Dong Da Dist., Hanoi	Vietnam
	IMI Institute	34 Lang Ha Str., Dong Da Dist., Hanoi	Vietnam
	Rong Riet	109, Highway 1A, Thanh Xuan Precinct, District 12	Vietnam
Mobile Small-Scale Stone Crusher	Hoa Phat	Pho Noo Industrial Zone, Hung Yen	Vietnam
Bitumen heaters	Construction Electrical & Mechanical Equipment Co Ltd.	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Bitumen handsprayers	Construction Electrical & Mechanical Equipment Co Ltd.	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam

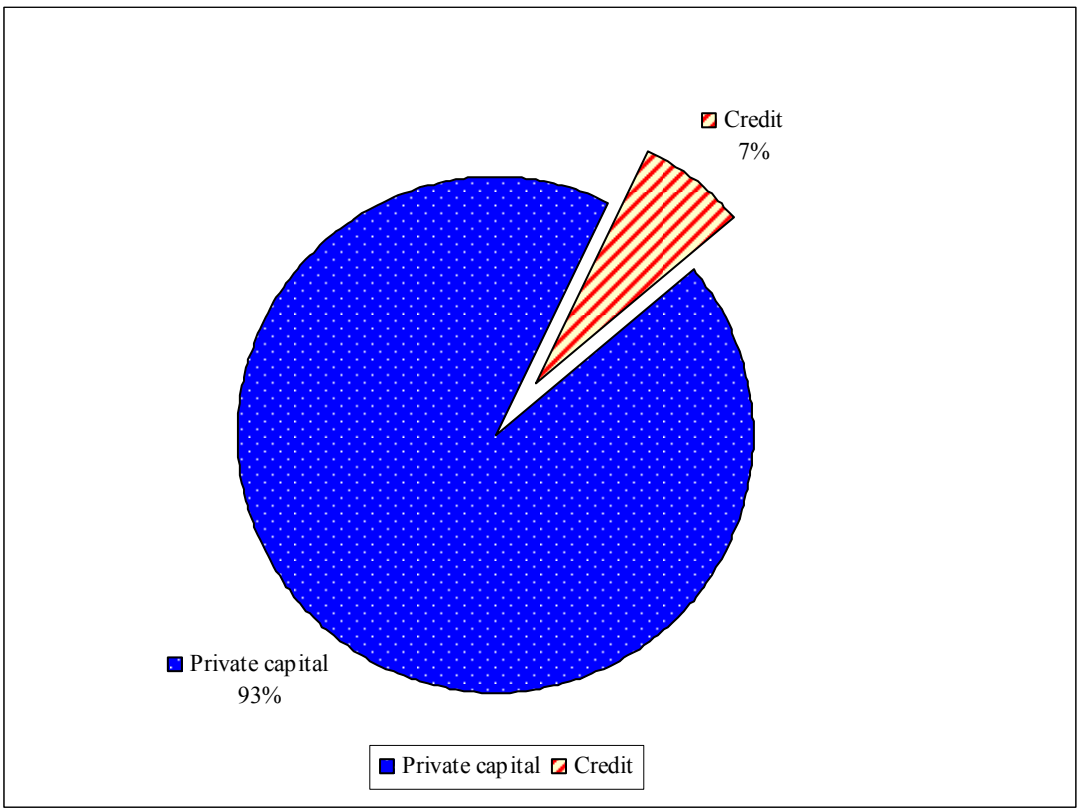
Method of equipment finance (Cambodia)



Source: Contractor surveys

APPENDIX XVIII

Method of equipment finance (Vietnam)



Source: Contractor surveys

APPENDIX XIX

Grader unit operating costs for equipment purchase (US$ per hour) when the motor grader is being utilised at 900 hours per annum

New/Second hand	Model & Brand	Technology	Size	Depreciation (US$/hour)	Interest (US$/hour)	Maintenance costs (US$/hour)	Cost of tyres (US$/hour)	Fuel & lub. Costs (US$/hour)	Operators wages (US$/hour)	Overhead (US$/hour)	Total Operating Costs (US$/hour)
New	CAT 120H	Motor Grader	Medium	15.56	20.86	1.11	0.67	9.79	2.00	0.50	50.49
New	Lee Boy 635	Motor Grader	Small	6.69	8.97	0.48	0.67	3.29	2.00	0.22	22.31
New	Simba & Kobuta 9570	Towed Grader & Tractor	Medium	5.10	6.84	0.84	1.20	5.58	2.82	0.22	22.60
New	Cam Grader & Kobuta MX500	Towed Grader & Tractor	Small	2.75	3.69	0.62	0.45	5.12	2.82	0.15	15.60
Second hand	CAT 120H	Motor Grader	Medium	21.11	14.16	1.11	0.67	9.79	2.00	0.49	49.32
Second hand	Lee Boy 635	Motor Grader	Small	8.89	5.96	0.48	0.67	3.29	2.00	0.21	21.49
Second hand [a]	Simba & Kobuta 9570	Towed Grader & Tractor	Medium	4.30	3.49	0.84	1.20	5.58	2.82	0.22	18.44
Second hand	Cam Grader & Kobuta MX500	Towed Grader & Tractor	Small	2.25	1.68	0.62	0.45	5.12	2.82	0.15	13.09

Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

[a] For second hand options, the towed graders are purchased new with a second hand tractor.

APPENDIX XX

Grader unit operating costs for equipment hire (US$ per hour) when the motor grader is being utilised at 900 hours per annum

Model & Brand	Technology	Size	Hire cost (US$/hour)	Cost of tyres (US$/hour)	Fuel & lub. Costs (US$/hour)	Operators wages (US$/hour)	Overhead (US$/hour)	Total Operating Costs (US$/hour)	Cost per km (US$)
CAT 120H	Motor Grader	Medium	21.00	0.30	9.63	0.90	0.32	32.15	80.37
Lee Boy 635	Motor Grader	Small	9.06	0.30	3.23	0.90	0.13	13.63	34.07
Simba & Kobuta 9570	Towed Grader & Tractor	Medium	11.88	0.54	5.53	1.27	0.19	19.41	53.93
Cam Grader & Kobuta MX500	Towed Grader & Tractor	Small	8.42	0.20	5.07	1.27	0.15	15.12	42.00

Source: Equipment supplier interviews, equipment manufacturers and consultant's estimates

[a] For second hand options, the towed graders are purchased new with a second hand tractor.

APPENDIX XXI

Grading Equivalent Cost Using Manual Labourers

Grading activities can be executed using manual labourers. Instead of using grading machines, the following procedures can be followed:

- prepare formation of work area;
- gravel/soil loaded into wheelbarrows using shovels;
- gravel/soil hauled to desired area and unloaded;
- gravel/soil spread over desired area using rakes; and
- gravel/soil compacted to the required standards and specifications using levelling devices such as hand rammers

Empirical evidence from published sources (ILO/ASIST, 1998) and ITT experience provides the productivity levels for the above activities which are presented in the table below.

Productivity levels of labourers

Activity	Budget Productivity (man days/m3)
Prepare formation	0.2
Load, haul, unload	0.3
Spread, compact	0.2
Total	0.7

Source: ILO/ASIST (1998) and ITT experience

The cost of grading related activities using manual labourers is presented in the table below. It costs approximately US$120 to grade soil/gravel using labourers.

Estimated costs of grading using labourers

Variable	Unit	Value
Road width	m	6
Surface thickness	m	0.15
Proportion of surface requiring maintenance	%	10%
Total volume of grading required	m3	90
Total man days required	days	63
Total cost including overheads and equipment	US$/km	118

Source: ILO/ASIST (1998), ITT experience and consultants' estimates

APPENDIX XXII

Equipment suppliers

Equipment	Equipment Supplier	Address	Country
Tipper truck	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Vehicle Assemble Factory Company	Donekoy, T 4 Road, Hatsayphong District, Vientiane	Laos
	Sovann Yaun Company	#271 E0, St Tep Phan, Phnom Penh	Cambodia
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
	Komatsu Vietnam JSC	K2 Office - 14 Thuy Khue Street, Tay Ho District, Hanoi	Vietnam
Flat truck	Vehicle Assemble Factory Company	Donekoy, T 4 Road, Hatsayphong District, Vientiane	Laos
	Sovann Yaun Company	#271 E0, St Tep Phan, Phnom Penh	Cambodia
	Xuan Kien Automobile Factory	2 Trieu Quoc Dat Street, Hanoi	Vietnam
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
Tractor 2WD	Insithong Motor Company	Ban Nongdouang Neau, Samsenethai Road, Sikhottabong District, Vientiane	Laos
	Agriculture Development Co. Ltd.	# 117, St 126, Phnom Penh	Cambodia
	Vietnam Engine and Agricultural Machinerary Corp.	2 Trieu Quoc Dat Street, Hanoi	Vietnam
Tractor 4WD	Insithong Motor Company	Ban Nongdouang Neau, Samsenethai Road, Sikhottabong District, Vientiane	Laos
	Agriculture Development Co. Ltd.	# 117, St 126, Phnom Penh	Cambodia
	Vietnam Engine and Agricultural Machinerary Corp.	2 Trieu Quoc Dat Street, Hanoi	Vietnam
Trailer	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
Wheelbarrow	Hol Korb Lathes	#66S2, St.163, Toul Tumpoung I, Khan Chamcarmon, Phnom Penh	Cambodia
	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Roller (ride on vibratory)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Dong Loi Joint Stock Machinary Company	G7, Lang Quoc te Thang Long – Cau Giay Dist, Hanoi	Vietnam
	KLC Ltd Company	A22-Lot 9 – Dinh Cong, Hanoi	Vietnam
Roller (pedestrian vibratory)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Seak Ly Co. Ltd.	#286, St 182, Phnom Penh	Cambodia

Equipment	Equipment Supplier	Address	Country
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Roller (towed vibratory)	Tu Chau Construction Equipment Cooperation (XCMG)	24 T2 Building, Trung Hoa-Nhan Chinh New Urban Area, The 17 Floor, Hanoi	Vietnam
Roller (ride on deadweight)	Seak Ly Co. Ltd.	#286, St 182, Phnom Penh	Cambodia
	Transport Material and Equipment Sharehold Company	Khuat Duy Tien Road - Thanh Xuan Dist, Hanoi	Vietnam
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
Roller (deadweight, hand drawn)	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Chhim Chiv	#2100A, St 68, Phnom Penh	Cambodia
Roller (towed deadweight)	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
Vibrating Plate	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Sam Sokhom	#2058 E0, St 68, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
Water Bowser (towed)	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
Concrete Mixer	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Hol Korb Lathes	# 66S2, St 163, Phnom Penh	Cambodia
Concrete Vibrator	Pheng Ly Co.	#111, St.155, Sangkat Toul Tompoung 1, Khan Chamcarmon, Phnom Penh	Cambodia
	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
	Megastar Motor Company	No 406 Tran Khat Chan Street - Hanoi	Vietnam
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Mobile Small-Scale Stone Crusher	Hoa Phat	243 Giai Phong Rd., Dong Da District, Hanoi	Vietnam
	Thien Hoa An	146 Truong Chinh Str., Dong Da, Hanoi	Vietnam
Motor Grader	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos

Equipment	Equipment Supplier	Address	Country
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Metro Group Fo Cambodia Co Ltd.	#1778, St 5, Phnom Penh	Cambodia
	Dong Loi Joint Stock Machinary Company	G7, Lang Quoc te Thang Long – Cau Giay Dist, Hanoi	Vietnam
	V-TRAC	16th Floor, Hoa Binh Tower -106 Hoang Quoc Viet, Cau Giay Dist, Hanoi	Vietnam
	Komatsu Vietnam JSC	K2 Office - 14 Thuy Khue Street, Tay Ho District, Hanoi	Vietnam
Towed Grader	DTW	Unit 17ab&c, Street 528, Phnom Penh	Cambodia
Bitumen Heater	Keo Motor Heavy Equipments	Nonghai, Hatsayphong District, Vientiane	Laos
	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa Development	Ban Thongkhankham, Chanthabouly District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam
Bitumen Hand Sprayer	Khounxay Bridge & Road Conatruction Company	Ban Nongbouathong, Sikot District, Vientiane	Laos
	Kongchai Spare Parts and Heavy Equipments	Ban Phakhao, Saithany District, Vientiane	Laos
	Loa - Singapore Construction Ltd	Ban Vatnak, Sisattanak District, Vientiane	Laos
	Construction Electrical & Mechanical Equipment Co Ltd.,	144 Duc Giang- Long Bien- Gia Lam, Hanoi	Vietnam

Source: Equipment supplier interviews

APPENDIX XXIII

Mobile Crusher Interview Summary Report

SSCs were identified and subjected to a 'Mobile Crusher Interview'. The SSC were asked questions over the phone and the SEACAP 020 team managed to acquire a sample size of 14, all Vietnamese based. The findings of the mobile crusher interviews are presented below.

Out of the 14 respondents, 7 of the respondents owned mobile crushers produced in China and 7 owned versions made in Vietnam (5 of which were produced by Hoa Phat). All Chinese versions were purchased second hand, their ages range between 5 to 12 years, and prices ranged between $1,000 and $1,500. The vast majority of the Vietnamese versions were purchased new, typically costing the contractor between $1500 and $4000. Vietnamese (or new) crushers are currently between 1 and 4 years of age and Chinese (or second hand) crusher are over 10 years of age.

Overview of the crushers in the Mobile Crusher Questionnaires

Model	Country	New/Second Hand		Current Age (years)	Purchase Price (2007 US$)[39]
		Status	Age (years)		
-	Vietnam	Second Hand	8	16	1968
KA C-1A	Vietnam	New	N/A	11	1655
NHHP-PEX-175	Vietnam	New	N/A	3	2765
NHHP-PEX-175	Vietnam	New	N/A	2	2622
NHHP-PEX-215	Vietnam	New	N/A	4	3937
NHHP-PEX-215	Vietnam	New	N/A	1	3985
NHHP-PEX-215	Vietnam	New	N/A	1	4051
-	China	Second Hand	5	12	1565
-	China	Second Hand	12	16	1338
-	China	Second Hand	8	15	1173
-	China	Second Hand	8	15	1173
-	China	Second Hand	9	15	1232
-	China	Second Hand	12	15	1345
-	China	Second Hand	6	9	1494

[39] All prices were converted to 2007 prices, by applying Vietnamese inflation rates. Inflation rates were derived from a combination of sources:
Development Data Group, The World Bank. 2007. 2007 World Development Indicators Online. Washington, DC: The World Bank. Available at: http://go.worldbank.org/3JU2HA60D0 and VietnamNet. Available at http://english.vietnamnet.vn/biz/2007/02/665915/

Pairwise Analysis: Percentage of Small Mobile Crushers From China/Vietnam Purchased Either New/Second Hand

Status	Chinese	Vietnamese
Second Hand	50%	7%
New	0%	43%

The average age (when purchased) of the Chinese and second hand models were 8.6 and 8.5 years, respectively, the same figure for Vietnamese models were 1.1 years of age. The average price (when purchased) of the Chinese and second hand models were $1332 and $1411, respectively, the same figure for Vietnamese and new models were $2997 and 3169, respectively.

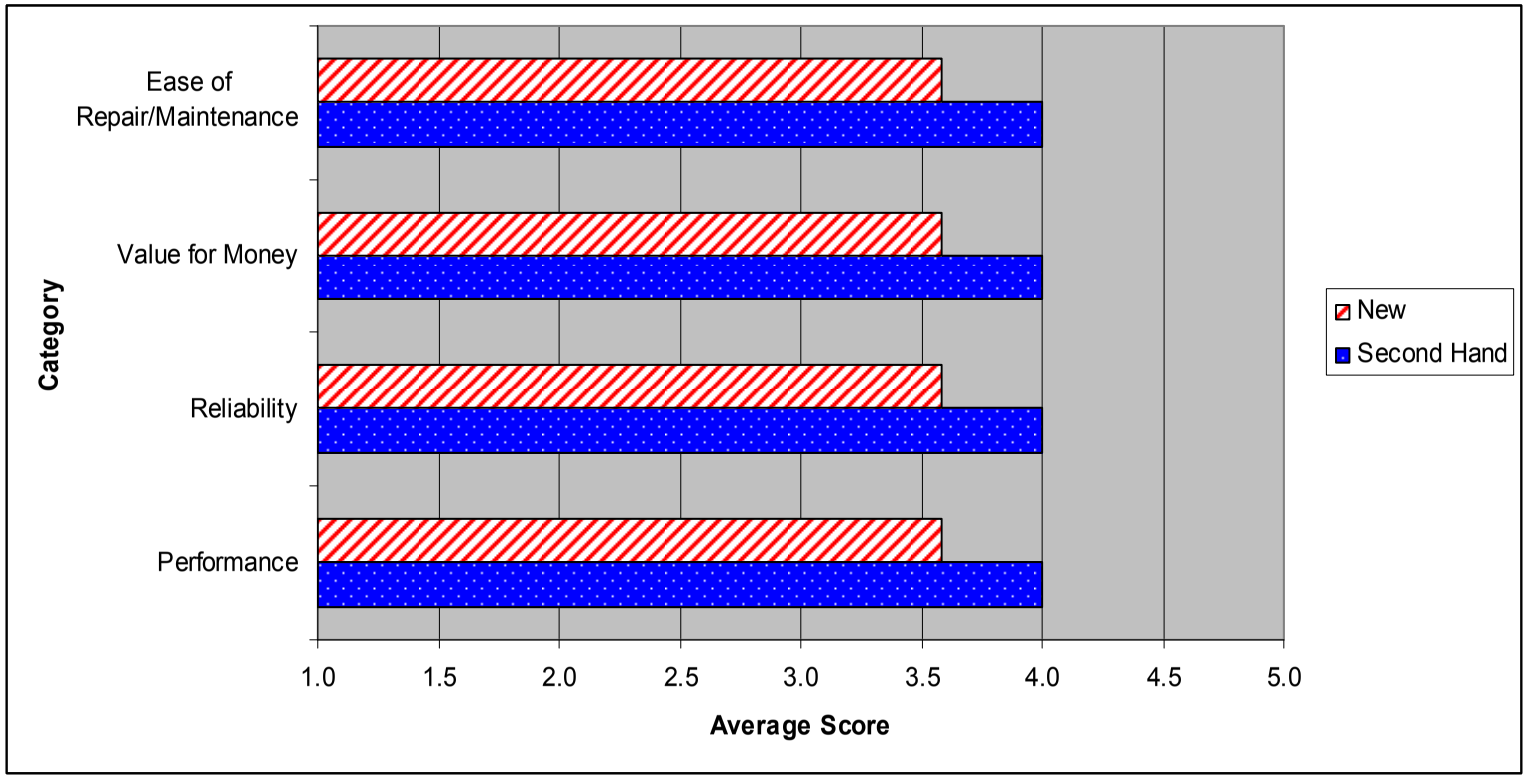
Average Age and Price of Mobile Crusher at Time Of Purchase

Status	Number	Av. Purchase Age (years)	Av. Purchase Price (2007 US$)
Second Hand	8	8.5	1411
New	6	0	3169
Chinese	7	8.6	1332
Vietnamese	7	1.1	2997

The responses from the questionnaires revealed that product satisfaction is currently higher amongst owners of second hand mobile crushers. When asked to rate their products between 1 and 5 (higher scores equating to higher satisfaction level) in categories of performance, reliability, value for money and maintenance, second hand crushers scored an average of 4 for every category, and new crushers achieved a score of 3.6 for every category. This would suggest that SSCs are generally satisfied (though not overwhelmingly) satisfied with the crushers they own, but newer crushers less so. There could be many reasons to explain this, such as:

- contractors may opt for a second hand crusher in order to obtain an equipment with superior specification, given a certain price level;
- contractors may have lower expectations with second hand products; and
- superior engineering of small mobile crushers in China

Product Satisfaction: Average Scores (1-5) For Mobile Crushers. 1 Refers To 'Very Poor' And 5 Refers To 'Excellent'



Second hand crushers have a slightly higher output rate than new versions (7 and 6 cubic metres per hour, respectively). This suggests that SSCs substitute between equipment and improved technology. Output rates of the NHHP-PEX175 and NHHP-PEX215, as claimed by owners of the equipment (5 and 6 cubic metres per hour, respectively) are within the range stated by the manufacturer, Hoa Phat (4 to 5 and 5 to 7 cubic metres per hour, respectively). The small mobile crushers are used slightly under half of the days of the year, indicating that there is significant work for owners. They are broken down for approximately a period of a month each year; however, product satisfaction scores reveal that this breakdown rate is acceptable for their owners.

Mobile Crusher Performance

Status	Output (m^3/hour)	Days (per year) In Use	Days (per year) Broken Down
Second Hand	7.0	155	36
New	6.0	163	35

When contractors were asked to name problems encountered with the mobile crusher, the most common faults cited were the rapid erosion of the crusher jaws and the quick breakdown of their sieves. On average the jaws manage to produce slightly over 1300 cubic metres of crushed rock (table below) before needing replacement. However, such erosion rates are strongly dependent on the properties of the materials which are fed into the crusher, and the information gathered regarding such mineral properties were not sufficient to subject to any form of statistical analysis. Sieves usually need replacing twice every year (table below), replacement rates will be highly dependent on the intensity of equipment usage, which is roughly half the days of the year (table above). Therefore, based on the evidence available, it can be concluded that the crusher sieves will require replacing after 3 months of crusher usage.

Average Jaw and Sieve Longevity

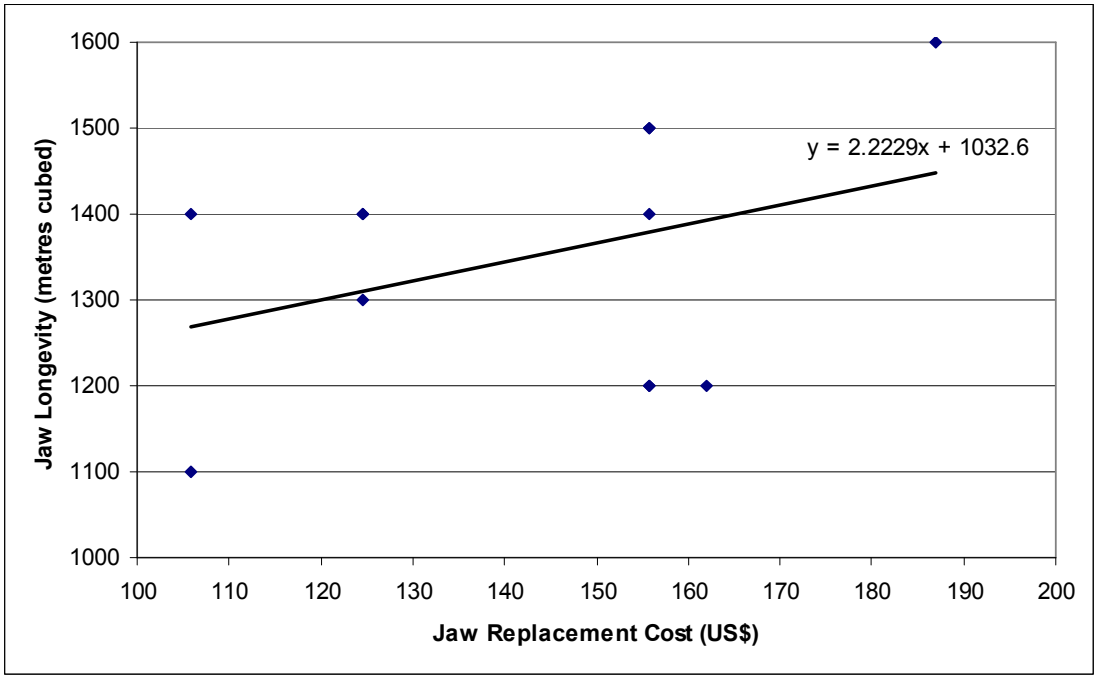
Status	Value
Av. Jaw Longevity (m^3)	1336
Av. Sieve Longevity (months)	7

Jaw replacement costs varied considerably, in the range of $100 to $200; therefore, it was considered sensible to explore the possible relationship between jaw quality and cost. The table below indicates that there is a positive relationship between the cost of the jaws and their longevity. Jaw replacements should manage to crush at least 1000 cubic metres of crushed rock, however, a $100 and $200 jaw would typically produce 1250 and 1480 cubic metres of crushed rock, respectively. Therefore, little benefit is derived, in terms of crushed rock volume alone, by acquiring a more expensive crusher jaw. Such an analysis ignores, amongst other factors, the potential improved output quality of more expensive jaws.

The mean average cost of jaw replacement and crusher output is approximately $150 and 6.5 cubic metres per hour, and a crusher of this output rate best describes the largest of the small mobile crushers produced by Hoa Phat (NHHP-PEX215), Hoa Phat also sells jaw replacement for this crusher for roughly $150. However, the average life of the jaws estimated by Hoa Phat at 1200 hours is overestimated by a magnitude of almost 6. The average life of the jaws, as claimed by the SSCs is approximately 215 hours[40].

[40] Derived by dividing the jaw longevity (m^3) by the crusher output rate (m^3 per hour)

Relationship between crusher jaw longevity and crusher replacement cost



When contractors and key informants were asked of the potential benefits of low cost equipment, many cite their potential to stimulate the local manufacturing industry of the area. For such a 'second order effect' to materialise, a critical mass of demand is most importantly required, but other factors that need to be considered is the potential engineering and manufacturing capability of the local community and the steady demand for replacements. The SSCs were asked which component, if any, of their small mobile crusher has been locally manufactured. The only components that were mentioned were the frame (93%), the sieve (43%) and the belt (36%).

The frame will very rarely need replacing, as it was not stated as one of the major faults of the crusher, and because the concentration of small mobile crusher in one village would not typically be huge, such local manufacturing capability is unlikely to generate significant revenue for the local community. On a national (or possibly regional) level the ability to manufacture locally fabricated frames may stimulate commercial benefits amongst a handful of companies.

The belts of the crushers were not typically cited as a major source of faults; therefore, this is also unlikely to generate maintenance/production activity.

It is typical to replace a sieve an average of twice a year, consequently, such a replacement rate, may generate work for the local manufacturing industry within the community. But this will require a high concentration of small mobile crusher ownership in a particular area. The potential market for mobile crushers in Cambodia is estimated to be too low to generate significant second order benefits; however, this is not the case in Vietnam, partially as a result of their ambitious paved road programme.

APPENDIX XXIV

Recycling Waste Construction Materials

The introduction of mobile crushers provides the opportunity to contractors of producing recycled aggregate from demolished construction materials. There are two approaches to this:

- To transport waste materials to a central processing site where they are crushed by large machines; and
- To crush the materials on site using a mobile crusher.

The second option is preferred in order to reduce handling and transport of the materials.

The two main materials recycled into aggregate are asphalt paving and concrete. In the USA about 10% (200 million tonnes per year) of all aggregates are recycled material[41], roughly half asphalt and half concrete. They are approved for a number of uses but the main use (around 70%) is for sub-base of paved roads. Their use is increasing and is being encouraged because of the environmental benefits in reducing the use of natural aggregates and also in reducing the disposal of the waste materials in fill sites.

The opportunities to recycle construction materials into aggregate in the region will be much lower than in the USA because of the much lower level of demolition and redevelopment of infrastructure. However, there are good benefits from exploiting the limited opportunities using mobile crushers. Rubble waste from the construction industry can be recycled into crushed aggregate to re-supply to the construction industry, particularly for the base course of paved roads. Concrete, brick and asphalt can be recycled cost-effectively instead of incurring energy, cost and environmental penalties in waste disposal. The recycled concrete can provide good quality and cost effective construction material[42]. A case study of an application of recycled construction rubble in the UK is presented in **APPENDIX XXV** .

Conclusion

Development brings an increasing demand for crushed stone and rock, particularly in road construction and maintenance. It is estimated that in the USA the demand is 10 tonne per person per year (see footnote 15), in the UK it is estimated to be around 5 tonne per person per year[43]. The demand in the study region is much lower than this but can be expected to grow yearly in line with growth in GDP[44]. This will create increasing opportunities for SSCs to benefit from the acquisition and use of mobile stone crushers. The main benefits have been outline above as:

- They can allow contractors to make use of sources of stone and rock that may be closer to the construction site than commercial quarries therefore saving in transport costs that are a large component of aggregate costs
- Contractors have control over extraction costs and avoid the overhead and profit margins incorporated in the price of purchasing aggregate from the commercial quarries
- Mobile crushers provide opportunities to produce aggregate from recycling waste materials from the demolition of infrastructure which can save costs for the contractor and also benefit the environment. This is likely to be a growing benefit in the future.

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41 Encyclopaedia of Earth, www.eoearth.org/article/Recycled_aggregates.

42 From a study conducted by Rice University in 2006.

43 www.publicsectorreview.com/transport

44 Thomas Kelly: Crushed Cement Concrete Substitution for Construction Aggregates – A Materials Flow Analysis; U.S. Geological Survey Circular 1177

APPENDIX XXV

A Case Study in Recycling Rubble

The subject of the Case Study is a Company that recycles rubble, Shillibier, and supplies the construction industry with concrete and road surfacing aggregate.

The Company has as its base a large compound situated in an industrial estate, strategically located to cater for the recycling needs of two cities and three large towns. These centres lie within a radius of twenty miles from the compound, and they are in a continuous state of industrial and urban commercial development, with the demolition of redundant buildings proceeding apace. The access and exit ramps of an expressway are two miles from the Company's compound and the approach of the contractors' dump trucks is facilitated by the excellent connecting feeder road.

Stockpile of Mainly Mass Concrete Rubble

The Company owns one 'EXTEC' large scale mobile crusher and several small-scale mobile crushers. Each of the small-scale crushers is capable of crushing 24 tons of rubble per day (Red Rhino 4000). The 'Red Rhinos' are easily transportable and can be hired out as and when they are available.

The compound is large enough to stockpile the loads of rubble delivered and offloaded by a constant flow of contractors' dump trucks. As the trucks arrive their loads are briefly inspected and, depending on the type of rubble they are carrying, the trucks are directed to one of four stockpiles: mainly reinforced concrete; mainly mass concrete; mainly brick; and mixed rubble. In many cases, the newly dumped rubble will contain contaminated building material such as wood, plastic, tile, aluminium etc., which must be sorted and removed by hand and the Company retains a small labour team for this purpose. Concrete containing a large proportion of heavy rebar is also transferred to a separate stockpile, where the steel is removed as the chunks of concrete are broken by hand with a pavement breaker.

The 'clean' rubble is fed into the crusher with a front end loader.

The recycled aggregate products consist of crushed concrete, crushed brick and crushed 'mixed rubble', and each grade is stored in a separate bin for reuse by the Company in the manufacture of concrete products or for sale to building and construction entrepreneurs.

Every year since April 2001 landfill tax has risen at a rate of £3.00 per ton - currently £21.00 per ton. This will continue on an annual basis - £3 per ton in April 2007 to £24.00 per ton. As a result landfill operators need to recover the extra cost brought about by this Landfill Directive, which makes the disposal of waste uneconomical. It is a financial necessity to segregate waste at source and recycle. The Red Rhino can offer a solution for the conversion of construction waste to a required aggregate; generating significant cost reduction savings in the process.

The extraction of aggregates from the environment (sand, gravel and crushed rock) represents 82% by tonnage of all non-fossil fuel minerals extracted from the land and sea in the UK. The extraction, transport and eventual disposal of these aggregates have significant implications for the environment.

By 2012, if UK demand increases by an expected 1% per annum, 20 million tonnes of extra aggregates will be needed each year. – this will inevitably mean a rise in purchase costs for construction companies in which such costs are likely to be passed onto consumers in the form of a surcharge. A possible solution which will reduce the demand for extra aggregates is to recycle building rubble.

The following points highlight how such a company provides benefits in the UK and how such benefits relate to the situation in the project countries:

- Companies will not need to pay for skip hire to take care of transporting rubble away from original site. In the UK, the average cost for a skip hire is between £80 to 120 per day (depending on size). In the project countries, companies are unlikely to go through the hassle of getting rid of the business rubble. In some case building waste is just left, therefore the cost is transferred (via externalities to the local community)
- Companies have no need to pay landfill tax, in the UK this costs £21 per ton. In the project countries, companies are unlikely to go through the hassle of getting rid of the business rubble. In some case building waste is just left, therefore the cost is transferred (via externalities to the local community)
- No need for haulage costs as vehicles are not required to transport the material. In the case for the project countries is such that if companies do decide to move the rubble, then the economic costs are likely to be higher due to vehicle operating costs and the damage such movements will incur on the nations roads.
- No need to purchase aggregates. Crushed rock costs a minimum of 8 per tonne.
- Save space – crushed material covers one third the space of rubble. However, in the project countries, if all the recycled rubble is re-used within the construction industry, then the space saved is likely to 100%.

APPENDIX XXVI

Factors in the Selection of a Mobile Crusher

A number of functional factors need to be considered to select a suitable crusher for the crushing operations to be carried out:

1. **Compressive Strength of the stone or rock to be crushed –** the most common materials used for aggregate are limestone, granite and basalt. Properties of these rocks are shown in the table below.

Compressive Strength of Common Rocks

Rock type	Bulk Density (Tonne/m^3)	Compressive Strength (MPa)
Limestone	2.2 – 2.6	30 – 250
Granite	2.6 – 2.9	100 – 250
Basalt	2.8 – 2.9	100 – 300

Jaw crushers are generally rated for crushing rock up to a compressive strength of 320 MPa which adequately covers the rocks included in the table above.

2. **Capacity** – this relates to the rate at which material can be crushed. The main use of the crusher will be producing aggregate for the base of paved roads. The typical thickness of the sub- base is 25cm. For a 6m wide road the volume of aggregate needed per m length is 1.5m^3 and the volume needed for a work rate of 100m per day is 150m^3. The largest crusher produced by the local manufacture, Hoa Phat, the NHHP-PEX215 has a rated capacity of around 6 m^3 per day and an equivalent crusher. This indicates that a mobile crusher can produce an upper limit of aggregate for sub-base of a paved road of around a length of 35 to 40m per day. It has to be decided if this meets contract requirements or whether additional crushers may be needed.
3. **Maximum input size** – the maximum size of lumps that can be fed into the crusher decreases with a lower size and power of the crusher. Methods of breaking and handling of the rock must therefore be matched to the crusher size. Smaller crushers will require greater inputs of labour or machine time to break the rock into smaller lumps. Larger crushers will require consideration to be given to safe handling of the larger lumps that can be fed into the crusher.
4. **Size of output aggregate** – jaw crushers have a crushing ratio that determines the maximum reduction in size that can be achieved in one throughput of the material through the crusher. If the required output size of aggregate cannot be achieved in a single pass then a secondary pass will be needed. The capacity of the crusher is linked to the crushing ratio, the lower the ratio the higher the rate of crushing.
5. **Loading and unloading the crusher** – it is essential to integrate the crusher into an overall effective operating system from excavation of the stone or rock through to delivery on the working site if the use of a mobile crusher is to be efficient and cost-effective. The ancillary operations of excavation, breaking the rock and loading and unloading the crusher are likely to be more costly than the operation of the crusher and they need to be carefully worked out to match the crusher and local situation. In particular the addition of a conveyor to load the crushed material directly into trucks is likely to be cost-effective.

APPENDIX XXVII

Specifications of Jaw Crushers (Hoa Phat Company, Vietnam)

Model	Unit	NHHP-PEX15	NHHP-PEX175	NHHP-PEX215
Capacity	M^3/hr	1 to 3	4 to 5	5 to 7
Maximum size of input stone	Mm	150 x 250	175 x 300	215 x 300
Size of output stone	Mm	8 to 40	8 to 40	8 to 60
Diesel engine power	Kw	9	13.5	18
Size of crusher	Mm	860x620x780	995x842x970	3400x1400x2550
Weight	Kg	400	900	2,000
Cost[45]	US$	1,420	2,560	4,245
Cost[46]	US$	1,370 (estimated)	2,700	3,990
Life of crushing jaws[47]	Hours	215	215	215
Cost of replacement jaw	US$	42.50	87.50	156.25

Source: Hoa Phat and mobile crusher surveys.

[45] Prices provided by the supplier
[46] Average prices obtained from the survey of contractors
[47] The average life obtained from the survey of contractors

APPENDIX XXVIII

Mobile crusher unit operating costs for equipment purchase (US$ per hour) when being utilised at 1,000 hours per annum

Model & Brand	Size	Depreciation	Interest	Jaw costs	Maintenance cost (ex Jaws)	Fuel & lub. Costs	Operators wages	Overhead	Total Operating Costs
NHHP-PEX215, Hoa Phat	Large	0.53	0.57	0.73	0.14	5.52	1.02	0.09	8.59
NHHP-PEX175, Hoa Phat	Medium	0.32	0.34	0.41	0.10	4.14	1.02	0.06	6.39
NHHP-PEX15, Hoa Phat	Small	0.18	0.19	0.20	0.07	2.76	1.02	0.04	4.46

Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

APPENDIX XXIX

Mobile crusher unit operating costs for equipment hire (US$ per hour) when being utilised at 2,000 hours per annum

Model & Brand	Size	Hire cost (US$/hour)	Fuel & lub. Costs (US$/hour)	Operators wages (US$/hour)	Overhead (US$/hour)	Total Operating Costs (US$/hour)
Hoa Phat NHHP-PEX215	Large	2.56	5.52	0.51	0.09	8.68
Hoa Phat NHHP-PEX215	Medium	1.54	4.14	0.51	0.06	6.26
Hoa Phat NHHP-PEX215	Small	0.86	2.76	0.51	0.04	4.17

Source: Mobile crusher interviews, equipment supplier interviews, equipment manufacturers and consultant's estimates

APPENDIX XXX

Contractor and Key Informant Opinions on the Mobile Crusher

Cambodia

Intensive interviews with SSCs revealed that contractors are generally interested in the small mobile crusher, however, not in the transport construction industry. Many SSCs cited the fact that the majority of their roads are earth surfaced and that this situation is unlikely to change. Many SSCs also stated the limited resources available (raw materials) to input into the small mobile crusher, although this was often followed by statements which confirmed their knowledge that such inputs could be purchased from larger quarries. Most SSCs were aware of the potential of the small mobile crusher to recycle building rubble and sell the processed product back to the building construction industry, and for this purpose most of the SSCs interviewed were positive.

Anecdotal evidence in the various regions reflected differing opinions towards the mobile crusher. In Kampot province, the SSCs were generally positive towards purchasing a mobile crusher, even if good quality rock may not be found in sizes small enough to feed into the crusher, they stated that it would still remain economically beneficially to purchase broken rocks, ready to feed into the crushers. They also appreciated the potential that the crusher could be used on 'idle days' by producing crushed rock for the local construction industry and therefore adding contractor profitability. They did, however, state that most roads in the rural provinces are earth roads and the crusher would be effectively useless. They expressed that horizontal packaging of contracts may be beneficial for the diffusion of crushers as crushers could be used extensively be a 'specialised contractor', however, at the moment, vertical contracting is more common. They stated that lack of finance inhibited SSCs to gamble with equipment that is not tried and tested. The SSCs also stated that mobile crushers are generally not a necessary requirement for a successful tender bid.

In Svay Rieng Province, the SSCs were unfamiliar with mobile crushers, they were not particularly keen in purchasing one because there is little available rock in the country and the opportunity to sell rock to the construction industry is limited due to the small size of the sector. SSCs were generally interested in purchasing mobile crushers in Champong Cham Province, and there were no shortage of quarries in the country, however, they lacked the funds to purchase such equipment. In Siem Reap Province, SSC were unfamiliar to mobile crushers and they believed that small-scale crushers are far less effective than large scale quarry based crushers and they doubted the ability of crushers in producing aggregates of quality suitable for structural concrete. They did not anticipate a demand for rural roads other than laterite and earth. Although there appears to be a boom in construction work, probably due to its proximity to the Angkor Wat world heritage site, however, such work seems to be monopolised by large scale contractors and the sites are dominated by their substantial concrete batching plants.

Vietnam

Many of the SSCs that were interviewed were pessimistic about using the small mobile crusher for the transport construction industry, mainly because obtaining a permit to mine natural resources require a government permit, which often takes in excess of two years. However, many SSCs were aware of the potential of the small mobile crusher to raise their company's profits by selling recycled building rubble to the building construction industry (such a commercial activity would not require a government permit).

In Yen Bai Province, although there are no quarries in the Province, there was also a general opinion that, should they acquire small-scale mobile crushers they would also be able to put them to good use for the supply of road surfacing, concreting and building construction aggregates.

Laos

Consultants' unofficial conversations with contractors revealed a similar pattern of opinion. Many of the contractors are generally worried by the quality of the crushers currently being imported from China (not very highly regarded in terms of product quality, this view is not corroborated by empirical evidence from the mobile crusher surveys in Vietnam) but nevertheless, a number of SSCs have expressed an interest in purchasing them (high demand) but lack adequate information on where they can be purchased. One particular SSC, who owns his own small mobile crusher, has revealed that the jaws erode far too quickly and he would not be willing to purchase another small mobile crusher once his current one becomes obsolete.

Key Informants

Almost all of the interviewees had heard of the small mobile crusher and the overwhelming majority had seen one. The interviewee's perception of the crusher was more positive than the towed grader. Most of the negative issues that were raised concerned the contractor's ability to access material to insert into the crusher; therefore its viability is very much dependent from region to region. Some highlighted that remote SSC would find crushers more beneficial, in cases where commercial supplies are unreliable. Many stated that due to economies of scale, larger contractors would prefer specialised commercial suppliers and therefore small mobile crushers may of great benefit to SSCs.

Some interviewees stated that SSCs can become more independent if they owned their own crushers; the equipment would provide a form of 'option value', whereby they can use them if they need to or when the financial benefits become greater. The issue of access to spare parts was an issue for some of the clients, especially considering that some of the other interviews had doubts about the durability of some parts of the crushers (especially the jaws). Overall, the general opinions are that they may provide benefits to the local contractor's, provided they prove to be a more cost effective means of acquiring aggregates and the contractor has easy access to a local quarry site.

APPENDIX XXXI

Evidence of Mobile Crusher Usage in Laos

The consultants of the SEACAP 020 have first hand experience of seeing two working examples of small mobile crushers in action in Laos:

Airport runway: This setup is temporary and much smaller than commercial quarries. The crusher is on a large construction site for a new airstrip in Luang Namtha. River gravel is brought from 10km away and an excavator and screen are used to remove all stones larger than about 100mm diameter. These stones are then crushed and used as the sub-base for the runway. The nearest quarry for crushed stone (which is used on top of the sub-base) is 50km from the airstrip. A significant number of the contractors surveyed reported that they would like to carry out a similar operation, but on a smaller scale. They believe that the use of a mobile crusher would have financial benefits but they do not know where to purchase a crusher of suitable size and reliability.

Crusher being used at Lung Namtha, Laos

Individual contractor: One contractor interviewed is the owner of two motor graders, several excavators and a fleet of trucks. He has imported a crusher from China and utilised his own workshop to construct a barrel type screen and mounting for the crusher and engine. He testifies that the crusher jaws are wearing quickly and that he would be interested in purchasing another crusher of a higher quality.

Make shift crusher in Bokel, Laos