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# Technology selection and its sustainability for low volume, rural road in low-income countries

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PROTOCOL

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# Contents

# List of abbreviations

| | |
|---|---|
| AFCAP | Africa Community Access Project/Programme |
| ASCAP | Asia Community Access Project |
| DfID | Department for International Development (UK) |
| EPPI-Centre | Evidence for Policy and Practice Information and Co-ordinating Centre |
| GNI | Gross national income |
| ILO | International Labour Organisation |
| km/h | kilometres per hour |
| LIC | Low-income countries |
| LVRR | Low-volume rural roads |
| M | metre |
| mph | miles per hour |
| SSA | Sub-Saharan Africa(n) |
| WB | The World Bank |
| WoE | Weight of evidence |

# 1. Background

This protocol provides the structure that will guide DFID's Round 3 Systematic Review No. 3, which addresses the question:

> *What is the evidence supporting the technology selection for low-volume, rural roads in low-income countries and what evidence is there to support the sustainability of different rural road technologies?*

It provides some background to the review and outlines the conceptual framework and methodology that will be used.

## 1.1 Aims and rationale for review

As part of the longstanding poverty reduction development objectives of the UK Department for International Development (DfID), it is funding a new Rural Roads and Transport Services Research Programme (DfID, 2014a). The programme will consist of two components: phase 2 of the Africa Community Access Project (AFCAP2) and a new Asia Community Access Project (ASCAP). AFCAP2 and ASCAP are poverty-targeted low-volume rural transport research programmes. They are founded on the successes of preceding research initiatives, AFCAP (2008-2014) and the South East Asia Community Access Programme (SEACAP, 2004-2009), which facilitated the provision of safe, reliable and sustainable all-season access to markets, healthcare and education for rural communities across Africa and South East Asia through strengthening and promoting research to influence policy and practice in these areas for the construction and maintenance of rural roads (DfID, 2014b). The programmes worked closely with national governments and other bilateral and multilateral donors to build on investments in low-volume road construction, maintenance and transport services. The new Rural Roads and Transport Services Research Programme will continue the earlier approaches, identifying and supporting the uptake of low-cost, proven solutions for rural transport that maximise the use of local resources (labour, materials, enterprise and ingenuity). AFCAP2 and ASCAP will fund applied research to address rural transport issues, communicate the research outcomes to stakeholders, support the uptake of the research results into practice and build research capacity in Africa and Asia. AFCAP2 will build on the existing country partnerships developed in AFCAP (Ethiopia, Democratic Republic of the Congo, Kenya, Malawi, Mozambique, South Sudan and Tanzania) and will seek to enlarge the programme to 14 countries by including those in West Africa. ASCAP will focus on approximately six Asian countries to be defined, but are likely to include Bangladesh, Burma, India, Nepal, Pakistan and Vietnam (DfID, 2014a).

DfID's new Rural Roads and Transport Services Research Programme will commission research projects which are associated with the development and use of rural road technologies in the low- and low-middle-income countries mentioned above. Therefore an assessment of evidence concerning technologies which have already been proven to be sustainable in such countries, as provided by the systematic review, will be important in helping to identify suitable projects for DfID to support under the new research initiative. It will also help identify technologies which have not been successful and will therefore provide a basis for future policy.

To enable service users, practitioners, and policy makers to benefit from the findings of the systematic review, it is anticipated that the results from the study will be published in the academic literature and at conferences, and presented and discussed in short courses on the road sector run by the University of Birmingham.

## 1.2 Definitional and conceptual issues

For the purposes of this review, the definitions of terminology given in Table 1.1 will be used.

**Table 1.1:** Definitions

| Term | Definition |
|---|---|
| Low-income countries (LICs)* | The World Bank defines countries by income group. Economies are divided according to 2012 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $1,035 or less; lower middle income, $1,036-4,085; upper middle income, $4,086-12,615; and high income, $12,616 or more (World Bank, 2014). |
| Low -volume rural roads (LVRR) | There are no universally accepted definitions of low-volume rural roads (LVRRs). However, they are normally considered as roads with, for example, an average daily traffic (ADT) of less than 400 motor vehicles per day, with design speeds typically less than 80 km/h (50 mph), and corresponding geometry. Most roads in rural areas in LICs are LVRRs. |
| Technology | Technology is suggested to include, but not be limited to: resources (local/imported, materials, labour, equipment, credit/capital), management tools (e.g. economic appraisal, planning tools, computer tools), design, construction and maintenance methods. |
| Sustainability | Capable of being maintained and performing to the planned, designed and constructed standards with the available financial and physical resources and the local operational arrangements, in the local environment. |

## 1.3 Policy and practice background

In the 1960s and early 1970s rural transport research and the poverty-focused agenda promoted labour-based road works methods in countries that had previously moved towards more equipment-intensive methods. Large national labour-based road construction and maintenance programmes were initiated with development agency assistance in countries such as Kenya, where local community labour was employed on new and rehabilitated road networks extending to about 11,000km through the Rural Access Roads Programme, Minor Roads Programme and Roads 2000. Ensuing studies found that benefits related to domestic and subsistence activities were more dominant than the road-focused economic issues traditionally considered. Village-level travel and transport surveys studies managed to quantify household travel demand in relation to livelihoods. Pilots were effected in a number of sub-Saharan African (SSA) countries, such as Ethiopia, Malawi, Nigeria and Tanzania. Labour-intensive techniques were also successfully utilised in post-crisis emergency programmes.

Initially, most projects concerned force account or direct labour arrangements (i.e., paid for by a public body rather than contracted out); however, the focus moved to private-sector approaches through initiatives to develop small-scale labour-based contractors. There was already a long-established culture of labour-based road works in China, India and some other Asian countries. The use of labour-based technology formed therefore an important part of the Low Volume Rural Roads (LVRR) strategy for both the World Bank (WB) and the International Labour Organisation (ILO), which commissioned additional field studies of road construction technologies.

Further projects in the early 1990s reported mixed success in SSA countries such as Benin, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Mozambique, Namibia, South Africa, Uganda, Zambia and Tanzania. More recently various technologies, via WB and Department for International Development (DfID) funding amongst others, have been introduced in several Asian countries, including Bangladesh, Cambodia, Laos, Nepal, the Philippines, Sri Lanka and Vietnam.

Since the 1990s, the investigation of LVRR technology has developed beyond the previous focus on unskilled labour versus heavy plant technology, to consider the wider perspective of better use of local resources (e.g. materials, skilled and unskilled labour, local enterprises, manufacturing processes). There has also been increased interest in the use of intermediate equipment, with its potential for low-capital investment and flexibility to be used also in non-road rural sectors. Recent DfID-funded research has supported investigation and compilation of experience with various local resource-based road surfacing, paving and structures.

## 1.4 Research background

Although there is a substantial body of documentation on the justification and experiences of rural road technology, much of it has been generated by parties related to an institutional vested interest in creating employment opportunities. There has been limited analytical work on the enabling environment for such approaches and their sustainability outside the traditional heartlands of such approaches in South and East Asia. Whilst the use of various technologies for rural roads has been studied since the early 1970s, in particular, labour based, few studies have been carried out which can demonstrate the sustainability of the approach using historical information rather than conjecture. Further, whilst the available literature on economic appraisal techniques discusses the issue of benefit distribution, operational applications are often restricted by ideological considerations. A large amount of the evidence given in these studies to support the use of technologies is either subjective and based on argument or, where objective analysis has been carried out, on the creation of indices or methodologies. Since developments in rural road technologies have taken place concurrently with other initiatives such as the development of low-cost transport solutions and other rural sector initiatives, it may be difficult to assess direct evidence of the contribution of rural road technologies to socio-economic benefits.

## 1.5 Authors, funders, and other users of the review

The review is being undertaken by an academic team from the University of Birmingham, consisting of Dr Michael Burrow (MPNB), Dr Harry Evdorides (HE), Dr Gurmel Ghataora (GSG) and Professor Martin Snaith (MSS). The team is supported by Mr Robert Petts (RP), who is an independent consultant with over 30 years' experience in rural road technology and management in developing and emerging countries.

The review has been commissioned by the DfID, and seeks to inform policy on rural access provision in general, and in particular on supporting sustainable technologies for LVRR in LICs. The review is registered with the EPPI-Centre, which supports the conduct of systematic reviews, including those focused on low- and middle-income countries.

A specialised systematic review software application - EPPI-Reviewer (Thomas et al.2010) will be used to facilitate the management of the systematic review by providing the functions given in Table 1.2.

**Table 1.2:** Systematic review functions

| Function | Tasks |
|---|---|
| Reference management | Importing references from the electronic and other media described in Table 2.2 |
| | Managing references obtained from the literature on LVRR (see Section 2.2) |
| | Duplicate checking |
| | Storing original documents, such as reports on the use of LVRR technology, in an electronic format |
| Study classification and data extraction (see Section 2.2.1) | Coding schemes for classifying relevant studies on the use of rural road technology including:<br>• Inclusion, exclusion and eligibility criteria (see Appendix 1)<br>• Descriptive codes<br>• Capturing detailed information about an identified study |
| | Provides the capability to allow a number of users to access, input, remove and review studies without compromising the integrity of the system. |
| | Text mining |
| | Calculation of common measures of effect (i.e. carrying out standard statistical summaries) |
| Synthesis (see Section 2.3) | Running meta-analyses |
| | Searching of information contained within the EPPI-Reviewer database |
| | Producing reports |
| | Searching full-text documents (see Section 2.2.4) |
| | Diagrams of summaries |
| Review management | Allocation of tasks to reviewers |
| | Work progress reporting |
| | Setting permissions amongst reviewers |
| | Summary flow charts to gauge progress |

Source: Gough et al. (2013)

## 1.6 Review questions and approach

Following a discussion with the project's funders (DfID), the question was decomposed into two parts as follows, with an emphasis on the second aspect:

a) Evidence of technologies (i.e. methods, materials, equipment and tools) which have been, or are used in the appraisal, investment, design, construction and maintenance of LVRR in low-income countries.
b) Evidence on which of these technologies have proved to be sustainable (financially, economically, physically, environmentally).

# 2. Methods used in the review

## 2.1 User involvement

The systematic review process will be overseen by the review team, members of which have specialist subject knowledge. The screening process carried out by the two researchers will be overseen by the academic members of the team who have specialist knowledge in rural road technology. Dr G. Ghataora will scrutinise studies associated with materials technology, Mr R. Petts will focus on labour and equipment, Drs H. Evdorides and M. Burrow will focus on the management process. Drs M. Burrow and H. Evdorides will lead on assessing performance with respect to sustainability. Professor M. Snaith will act as the quality assurance person at all stages of the review process and will lead a team of four independent advisers who have specialist knowledge in a number of areas of relevance to the review. The independent advisers are Dr Ian Heggie (finance), Mr Juan Quintero (environment and sustainability), Mr John Hine (technology) and Dr Richard Robinson (management). The advisers will review the project's reports (including this protocol) and the results of the screening process. They will also suggest studies to be considered in the review.

## 2.2 Identifying and describing studies

### *2.2.1 Defining relevant studies: inclusion and exclusion criteria*

Criteria for considering studies for this review will be categorised according to countries, technologies, study design and comparators and outcomes. Specific exclusion criteria, with are listed in Appendix 1.

***Relevant subjects***
Countries: Studies in any country will be considered if they meet the criteria.

Roads: low-volume and rural (see definitions above).

Technologies: methods, materials, human resources, equipment and tools used in the appraisal, investment, design, construction and maintenance of low-volume rural roads.

***Study design and comparators***
As stated above, the work will seek to identify studies which have been carried out over the entire life-cycle of a low-volume road. Ideally, each should address a different type of technology and demonstrate the sustainability of the technology. Other studies to be considered should compare the outcomes before and after the implementation of the technology (e.g., the effect of a new construction or maintenance technique on maintenance needs). These studies need not necessarily be from the same geographical location, provided that they demonstrate similar climate, road and subgrade composition and historical levels of traffic and maintenance.

Studies will also be considered which may disprove the sustainability of a technology.

***Outcomes: measures of sustainability***
A technology will be considered to be sustainable if it has ensured that the road on which it has been applied has at least maintained or enhanced the capability of the road to perform to its planned, designed and constructed standards with the available financial and physical resources, and using the local operational arrangements, in the local environment.

***Language***
The majority of the relevant studies are likely to have been carried out in English although it is recognised that some may be in French or Spanish and will not be excluded on this basis.

### *2.2.2 Identification of potential studies: search strategy*

***Search approach***
The initial search will identify what technology choices are available or have been used in the sector. The review question lends itself to an unbiased aggregation approach where the aim of the study is to identify a sufficient numbers of studies which demonstrate the

sustainable use of technology in different contexts (Gough et al., 2013). Given unlimited resources, such an approach would ideally seek to identify all relevant literature. However, given the resource constraints of the study, this is not possible, and therefore careful consideration was given to locating an unbiased sample of studies most pertinent to addressing the research question. The strategy thus aims to identify *longitudinal* studies which have been carried out over the entire life cycle of a low-volume road, each demonstrating the sustainability of the technology. This required consideration of the search strategy, including the methods, sources and resources available, as described below.

***Search terms to be used in the review***

In order to clarify the scope of the review, the terminology in the review question was defined (Table 1.1) and a set of study terms was developed as shown in Table 2.1. These will be used to identify relevant studies contained in the sources of information described below.

**Table 2.1:** Study search terms

| Subject | Proxies | Technology | Comparators | Measures of sustainability |
|---|---|---|---|---|
| Low-volume roads<br>Rural roads<br>Low-income countries<br>Other than low-income countries | Single carriageway roads, usually with a maximum running surface width (< 7m)<br>Paved or unpaved<br>Access roads<br>Rural roads<br>Social roads | Materials (local /imported), labour/labor, equipment (heavy/ intermediate)<br>Finance (credit/capital), management tools (economic appraisal, planning tools, design methods, computer tools), design, construction and maintenance methods | Life cycle studies<br>Comparisons of technologies with similar climate, traffic, construction type/ materials, maintenance history | Economic, environmental, political, social sustainability.<br>Net present value/ cost<br>Cost–benefit ratio (Costs may not necessarily be monetary)<br>Rural Access Index<br>Local contractors<br>Locally sourced materials<br>Appropriate technology |

***Sources of information***

The study will utilise websites of organisations involved in the road sector, bibliographic databases, subject specific databases, internet search engines, hand searching of books and journals, scanning reference lists and professional contacts. The primary sources to be used are described in Table 2.2, although it is recognised that this list is not necessarily exhaustive, as others may be identified during the initial scoping process.

As mentioned previously, a number of organisations have commissioned projects which utilised different technologies, and follow-up studies have analysed the effectiveness of the implemented technology. The majority of these studies are available via the organisations' web sites (i.e. organisation-specific databases). Consequently, a large part of the source identification process will be to search these databases. However, it is recognised that the results of these studies reported by some organisations may not always be objective, and the information retrieved will be used with care. A number of studies will also have been reported in the academic literature, and therefore the study will be complemented by searching relevant bibliographic and subject-specific databases. A forward reference list checking exercise will also be carried out using Google Scholar, Web of Science and the University of Birmingham's citation database, FindIT.bham.ac.uk. These will identify research reports, dissertations and journal papers not already identified from the search of the bibliographic databases. The search will be complemented by hand searches of

reference lists contained in hard copies of publications which are not held electronically and will include theses, books and technical reports identified by the search team and steering group.

**Table 2.2:** Information sources

| Databases | Search engines | Organisation-specific databases |
|---|---|---|
| ANTE: Abstracts in New Technologies and Engineering | Google.com | ADB (Asian Development Bank) |
| ASTM | Googlescholar.com | AfDB (African Development Bank) |
| Barbour Environment, Health & Safety | FindIT.bham.ac.uk | AfCAP (African Community Access Programme) |
| BASE | | ASANRA (Association of National Road Agencies) |
| British Standards Online | | AusAID (Australian Government Overseas Aid Program) |
| CIS (Construction Information Service) | | CDB (Caribbean Development Bank) |
| Civil Engineering Abstracts | | CIDA (Canadian International Development Agency) |
| Compendex (Engineering Village) | | CSIR (Centre for Scientific and Industrial Research) |
| Concrete Vault | | DANIDA (Danish International Development Agency) |
| DEPATISnet | | DFID (UK Department for International Development) including the Engineering Knowledge and Research (EngKaR) Programme |
| Engineering cross repository search tool | | EuropeAid (European Commission Cooperation Office) |
| Engineering Handbooks Online | | GIZ (the German bilateral aid implementing agency) |
| Engineering Research Database | | Federal Highway Administration (USA) |
| ENGnetBASE | | gTKP (global Transport Knowledge Partnership/Practice) |
| Espacenet - English | | GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit, German Technical Cooperation) |
| GEOBASE (Engineering Village) | | Helvetas - Intercooperation |
| Intellectual Property Office | | IADB (Inter-American Development Bank) |
| Internet for Civil Engineering | | IFRTD (International Forum for Rural Transport Development) |
| Knovel | | ILO Advisory Support, Information Services and Training (ASIST) |
| OECD Main Science and Technology Indicators | | IRC (Indian Roads Congress) |
| Patent and intellectual property | | |

| Databases | Search engines | Organisation-specific databases |
|---|---|---|
| Patent Office | | Institution of Civil Engineers, UK |
| Patents Information | | IRF (International Road Federation) |
| SciCentral | | Irish Aid |
| Technology Research Databases - ProQuest | | ITTransport |
| United States Patent and Trademark Office | | JICA (Japan International Cooperation Agency) |
| Virtual Technical Reports Center: eprints, preprints, and technical reports on the web | | KFW (Kreditanstalt für Wiederaufbau) |
| Web of Science (ISI) | | NORAD (Norwegian Agency for Development Cooperation) |
| | | OECD (Organisation for Economic Co-operation and Development) |
| | | Practical Action |
| | | REAAA (Road Engineering Association of Asia and Australasia) |
| | | RAEng (Royal Academy of Engineering) |
| | | SABITA (Southern African Bitumen Association) |
| | | SDC (Swiss Agency for Development and Cooperation) |
| | | SIDA (Swedish International Development Cooperation Agency) |
| | | SKAT (Swiss Resource Centre and Consultancies for Development) |
| | | SLoCaT (Partnership on Sustainable Low Carbon Transport) |
| | | SSATP (Sub-Saharan Africa Transport Policy Program) |
| | | Tanzania Transportation Technology Transfer (TanT2) Centre |
| | | Transport Links |
| | | Transport Research Laboratory (TRL) Ltd |
| | | UNDP (United Nations Development Programme) |
| | | UNOPS (United Nations Office for Project Services) |

| Databases | Search engines | Organisation-specific databases |
|---|---|---|
| | | USAID (United States Agency for International Development) |
| | | US Army Corps of Engineers |
| | | WB (World Bank/IDA) |
| | | WHO (World Health Organization) |
| | | WRA (World Road Association/PIARC) |

*2.2.3 Screening studies: applying inclusion and exclusion criteria*

The initial screening will be based on the title of the source; a finer screening process will be based on the abstract and thirdly the full text will be reviewed. Two researchers, working independently, will screen the literature. One of these will screen the entire literature, whilst the other will screen randomly selected datasets. A cross-comparison will then be completed to ensure consistency between the results obtained by the two researchers. Documents selected by only one reviewer will be subject to further scrutiny.

*2.2.4 Description of included studies*

The studies remaining after application of the screening criteria will be described according to four key dimensions as outlined in the conceptual framework; i) types of road, ii) country setting, iii) type of technology investigated and iv) types of sustainability outcomes reported. Further contextual details may also be provided depending on the type of studies identified and included in the review.

*2.2.5 Identifying and describing studies: quality assurance process*

Inclusion and exclusion criteria will be applied successively to (i) titles and abstracts and (ii) full reports. Full reports will be obtained for those studies that appear to meet the criteria or where there is insufficient information to decide. The inclusion and exclusion criteria will be reapplied to the full reports and those that did not meet inclusion criteria will be excluded. EPPI-Reviewer software (Thomas et al. 2010) will be used for screening, coding and analysing, providing a single web location to house the documents and monitor progress of the review.

## 2.3 Methods for synthesis

*2.3.1 Assessing the quality of studies and weight of evidence for the review question*

A weight of evidence framework will be used to assess the quality and relevance of a study. A framework which will be used to judge studies as high, medium or low quality is given in Table 2.3 (Gough et al., 2013). For a study to receive an overall rating of high, and therefore be used in the review stage, it needs to achieve a rating of high in both A and B categories and at least a medium in category C.

**Table 2.3:** Weight of evidence

| WoE | Tasks |
|---|---|
| A. Soundness of studies | ***High:*** Explicit and detailed methods and results section for data collection and analysis; interpretation soundly based on findings. Critical comparison with other similar work.<br>***Medium:*** Satisfactory methods and results sections for data collection and analysis; interpretation partially warranted from findings. |
| B. Appropriateness of study design for answering the review question | ***High:*** Covers the life cycle of the road pavement, from construction through at least two periodic maintenance cycles following construction (approximately 12 years). Road condition data should be collected at least yearly over this period and the frequency and type of routine and periodic maintenance carried out should also be recorded.<br>***Medium:*** Covers at least one periodic maintenance cycle after construction. Road condition data should be collected at least yearly over this period. |
| C. Relevance of the study focus to the Review | ***High:*** A 500m section of a low-volume rural road in a low-income country.<br>***Medium:*** One section of at least 500m of a rural road in any country. |

Source: after Gough et al., 2013

### 2.3.2 Synthesis of evidence

The search will try to identify a number of longitudinal studies which describe the use of a technology over the life cycle of a rural road (12–15 years), demonstrating its sustainability (or otherwise). Subsequently, the data from these studies will be synthesised, using narrative methods, to demonstrate the sustainability of the technology as a function of the parameters which affect road pavement performance, and therefore the technology will be demonstrated to be sustainable as a function of: road geometry, structural design, maintenance history, traffic (speed and load) and climate.

An important outcome for the review will be to also identify technology options which do not have robust evidence of sustainable use (despite perhaps being practised), so that future sector research initiatives may be guided by this knowledge.

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World Bank (2014) *Country and lending groups*. http://data.worldbank.org/about/country-classifications (accessed 28 February 2014).

# Appendix 1: Exclusion criteria

Studies will be screened and excluded if:

**Roads**: **do not** investigate low-volume rural roads

**Technologies**: **not** investigating methods, materials, equipment or tools used in the appraisal, investment, design, construction or maintenance of low-volume rural roads

**Study design and comparators:** are **not** carried out over the entire life cycle of a low volume road or have **not** compared the outcomes before and after the implementation of the technology

**Outcomes:** demonstrate whether a technology is sustainable (from an economic, political, social or environmental point of view).

# Appendix 2: Authorship of this review

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**Conflicts of interest**

The authors envisage no conflict of interest in the review team. Petts is an independent consultant who through his professional career has worked with labour, intermediate equipment and heavy plant technology for a large number of development agencies, including the DfID, the World Bank and the ILO.

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