



DFID'S CONTRIBUTION TO TRANSPORT RESEARCH AND KNOWLEDGE

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Abstract	
Over the last 40 years, UK's aid administration has financed a wide range of transport research and knowledge dissemination that has had an important impact. This research placed the UK in a leadership position in terms of transport research and influencing best practice in road design standards in low-income countries in Africa and Asia. This paper outlines key features of the UK funded transport research and knowledge programmes indicating, where possible, an indication of its impact.	
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ACRONYMS

ACE	Association for Consultancy Engineering
AFCAP	Africa Community Access Programme
AICD	Africa Infrastructure Country Diagnostic
AsCAP	Asia Community Access Programme
DBST	Double Surface Bituminous Treatment
DFID	Department for International Development
DIME	Development Impact Evaluation
GDP	Gross Domestic Product
GIS	Geographic Information System
GRSF	Global Road Safety Facility
gTKP	Global Transport Knowledge Partnership
HDM-4	Highway Development & Management (model version 4)
IRR	Internal Rate of Return
LICs	Low-Income countries
MAAP	Microcomputer Analysis Package
ORN	Overseas Road Note
PIARC	World Road Association
PPIAF	Public-Private Infrastructure Advisory Facility
RAP	Rural Access Programme (of Nepal)
ReCAP	Research for Community Access Partnership
RMI	Road Maintenance Initiative
SADC	Southern African Development Community
SLoCaT	Partnership on Sustainable Low Carbon Transport
SuM4ALL	Sustainable Mobility for All
SSA	Sub-Saharan Africa
SSATP	Sub-Sahara Africa Transport Program
TRISP	Transport and Infrastructure Services Learning and Sharing Partnership



TRS Transport Research Support Project

TRL Transport Research Laboratory

UK United Kingdom



1. Introduction

Over the last 40 years UK's aid administration has financed a wide range of transport research and knowledge dissemination that has had an important impact, particularly in the areas of road design, road planning and road safety. This research placed the UK in a leadership position in terms of transport research for Low Income countries (LICs) and influencing best practice in road design standards in Africa and Asia. This note outlines key features of the UK funded transport research and knowledge programmes. The note is inevitably selective, its purpose is to demonstrate the range of research and knowledge covered by the programme and present, where possible, an indication of its impact.

It should be noted that the quantitative impacts of DFID's contribution have not been comprehensively presented, due to limitations in the availability of such information from available sources. Notwithstanding the information gap, this paper presents the qualitative impacts based on cases that have been derived from the historic and current research undertaken by DFID.

2. The Transport Research Laboratory

Prior to the 1990's direct subvention funding to the Overseas Unit, of Transport Research Laboratory (TRL) was the main direct channel of influence for UK to the transport sector of developing countries. The Overseas Unit had a professional staff of 20 to 30 that included engineers, geologists, physicists, statisticians, economists, planners and other social scientists. When needed the work would also draw upon the substantial resources from main body of TRL (with staffing up to a thousand people) and its extensive laboratory facilities. Collaboration was also undertaken with a range of other universities and UK consultants.

Through a wide range of research, over many years in many countries, TRL became, the most influential road research institute for the developing world. The overseas work covered road engineering design and maintenance, materials and geotechnics, highway planning and road economics, road safety, urban transport, rural roads, rural transport and freight transport operations, Disability and Gender. Although there was an emphasis in Africa a considerable amount of work was also carried out in Asia and the Caribbean. In 2009, around 500 research reports, papers and manuals produced by the Overseas Unit were listed in the DFID Transport-Links website.

Key results were captured in a series of Overseas Road Notes (ORNs) that provided direct practical advice. These were State of knowledge documents that varied from policy guides to design manuals that saw a wide usage and often the only tools available to engineers and scientists in LICs. (Overseas Road Notes are discussed later in the report.) This work was later built upon by a number of other initiatives, involving TRL but also financed by other donors, such the Southern Africa Development Community (SADC) infrastructure research, that led for example to the SADC guidelines on low volume roads.

TRL helped to support the establishment and development of research centres such as the Building and Road Research Institutes in Ghana and Nigeria and the Materials Testing and Research Department in Kenya.

3. Knowledge partnerships and community access programmes

Competitive bidding for research was brought in the beginning of the 1990's and range of initiatives were established. These include:

- Knowledge and Research programme;
- Global Transport Knowledge Partnership (gTKP);
- South East Asia Community Access Programme (SEACAP);
- Africa Community Access Programme (AFCAP); and
- Research for Community Access Partnership (ReCAP).

In the early 1990's DFID's Engineering Knowledge and Research Programme was expanded and research contracts on a range of engineering topics, including transport, were let on a competitive bidding process.



TRL, which became an executive agency in 1992 and was privatised in 1996, remained a major supplier of transport research to DFID.

The Global Transport Knowledge Partnership (gTKP) was established in 2005 to help coordinate and establish transport knowledge dissemination. Initially concentrating on rural road engineering, (transport services were added later) major research contracts were let through the South East Asia Community Access Programme (SEACAP) (2004 to 2009), and Africa Community Access Programme (AFCAP1- 2008-2014). The ReCAP (2014 -2020) incorporates a second phase of AFCAP and also covers Asia Community Access Programme (AsCAP). Further information about these programmes are provided later in the text.

4. International co-operation with Development Banks

The UK has also played a major role in supporting cooperative transport knowledge programmes which have an important transport focus, particularly with the World Bank and Asian Development Bank these include:

- Highway Development & Management (HDM-4);
- The Sub-Sahara Africa Transport Programme (SSATP);
- Public-Private Infrastructure Advisory Facility (PPIAF);
- Global Road Safety Facility (GRSF);
- The Transport and Infrastructure Services Learning and Sharing Partnership (TRISP) and Transport Research Support Project (TRS) transport knowledge programmes;
- Africa Infrastructure Country Diagnostic (AICD);
- Development Impact Evaluation (DIME) and Impact Evaluation –Connect for impact (IE Connect); and
- SuM4ALL.

DFID has contributed to a range of knowledge programmes located at World Bank, these include the SSATP, PPIAF, TRISP, TRS, GRSF, AICD, DIME, ieConnect, SuM4ALL. One of most successful components of the wide ranging SSATP was undoubtedly the Road Maintenance Initiative (RMI) sub-programme which involved the commercialisation of roads and development of 2nd Generation Funds. Here SSATP worked closely with the World Bank to support a completely different approach to road management and road finance, to deal with the gross underfunding and poor management of road maintenance that had been a feature of the 1970s and 80s. In Africa, during the 1990s and early 2000's, 27 Road Funds were set up that secured a new source of revenue, principally from dedicated fuel levies. As a result, the underfunding of road maintenance was substantially reduced. Road administrations were also restructured on more commercial lines and maintenance contracts were let, rather than by relying on force account.

The DFID funded TRISP and TRS knowledge programmes helped prepare a number of transport knowledge products at the World Bank. The most well-known is the development of Rural Access Index (RAI) which was the only transport indicator adopted for International Development Association (IDA) 14, (Roberts et.al 2006). It is currently being refined and developed by DFID, under the ReCAP programme the Sustainable Development Goals.

The Global Road Safety Facility (GRSF) has been a very successful programme in road safety, working both within the World Bank, where it is based, and with other development banks. The GRSF has had a major influence with donors and developing country governments. As a result, now all World Bank road projects must have a safety component. The GRSF is world leader in Road Safety and its success, including the adoption of the "Safe Systems Approach" has been widely recognized. The Road Safety Management Award, from Prince Michael of Kent was awarded to the GRSF, in 2017 (DFID, 2018).

DFID was a founding member of PPIAF which provides technical assistance to governments to improve the enabling environment for private investment in infrastructure. In presenting evidence the International Development Committee in 2011, a leading academic, and formerly of the World Bank, Professor Antonio



Estache has said that “DFID's support to PPIAF... may be one of the most impressive success stories in the collective efforts of donors to support infrastructure ”¹.

The DFID funded Africa Infrastructure Country Diagnostic (AICD) grew out of the pledge by the G8 Summit of 2005 at Gleneagles to substantially increase ODA assistance to Africa, particularly to the infrastructure sector. The AICD studies, located at the World Bank, were founded on the recognition that Sub-Saharan Africa (SSA) suffers from a very weak infrastructural base, and that this is a key factor in the SSA region failing to realize its full potential for economic growth, international trade, and poverty reduction. Based on 24 detailed country studies a flagship report “Africa’s Infrastructure: A Time for Transformation”, (edited by Foster and Briceño-Garmendia, 2010) was prepared together with a separate report on transport infrastructure was also prepared (Gwilliam K, et al. 2008). These reports were extremely influential in helping to increase infrastructure spending in Africa by many other bilateral and multilateral organisations for the first time the report provided the essential data with which interventions could be planned, designed and implemented.

5. The HDM-4 road planning model

In order to get the best value for money and ensure that road engineering design is most appropriate for the projected traffic a road planning model is required. This is particularly important in developing countries, where funding is scarce, and a wide range of surface types are currently in use, that have different properties, and associated vehicle operating costs. The HDM-4 road planning model has been the most influential and most widely used road planning and management tool, used across the developing world. In 2015 it was estimated that US\$ 35 billion of road works had been evaluated using the model. Based on work carried out by the Transport Research laboratory, in Kenya and Caribbean in the 1970s and 1980s, UK aid helped develop the first road planning model RTIM, suitable for road appraisal in developing countries, this was combined with other research and used to construct the Highway Design Model (HDM) and its subsequent developments. UK worked cooperatively with the World Bank, the Asian Development Band and other donors to develop the Highway Design and Maintenance Standards Model (version 3) and later HDM-4 (World Bank, 2000). In 1998 the World Road Association (PIARC), has been responsible for the overall development of the model. In 2000 the first version of HDM-4 was released, having been developed at Birmingham University. In 2004 the HDMGlobal, consortium, based at Birmingham University, was awarded a service concession for the dissemination and updating the software.

The HDM-4 model incorporates a huge amount of research relating to earth, gravel and different types of paved roads as well as information on vehicle operating costs. For any combination of road structure, road alignment, terrain, climate, maintenance treatment, and traffic composition, the model is able to predict how the road surface will deteriorate over time. This data is then used to predict how vehicle speeds and vehicle operating costs will change over time in relation to the interventions. The data is then incorporated into an economic model and decision criteria such as Net Present Values, Internal Rates of Return (IRRs) can be calculated. The model is used to both plan and prioritise new road investments, to determine the most effective maintenance treatments and act as a road maintenance and asset management system.

The model has become the standard road appraisal model of the World Bank, the Asian Development Bank and other agencies. Many hundreds of projects, involving thousands of kilometres of roads have been assessed by the model, and by 2015 it was estimated that a total value of £35 billion of road works has been appraised by the model. In addition, over 1,400 software licences have been issued².

Specific HDM-4 planning cells have been set up in many countries (including countries such as Bangladesh, Pakistan, Tanzania and Zambia) to plan highway development and identify maintenance priorities.

¹ <https://publications.parliament.uk/pa/cm201012/cmselect/cmintdev/848/848we02.htm>

² <http://www.ukcds.org.uk/ourwork/theglobalimpactofukresearch/buildingbetterroadnetworks>



6. Birmingham University training

UK Aid has had a major impact in training road engineers from Africa and Asia. In the late 1970's a Masters' Programme "Highway Engineering for Developing Countries" was set up at Birmingham University with two lecturers (Dr Martin Snaith and Mr. Richard Freer Hewish) supported by UK Aid to run the course. The course was also supported by specialist lecturers from the Overseas Unit of TRL. The course covers a wide range of topics including road safety, rural roads, transport policy, road design and planning, road asset management, road economics and financing and pavement engineering. Students also undertake an individual research topic. The course has been regarded as an "enormous success" by University staff. The average intake was around 23 student per year, so around 800 students have taken the course since its inception.

The course proved initially to be very particularly popular with engineers from East Africa and South Asia. Later students were also drawn from West Africa, and from East Asia including China, Malaysia and Thailand. Since 1996 about one third of the students came from Africa and a third from Asia with the balance from Europe, UK and elsewhere. Students went on to do high level jobs including a Deputy Director General (Malaysia), Permanent Secretary of works (Botswana), and running a road research Laboratory (China). Substantial goodwill was generated by the courses, being very helpful for British engineers and academics working in countries represented in course.

The success of the course can be judged by the fact that the course has continued long after direct UK aid funding ceased. It also contributed to Birmingham University becoming recognized as a world leader in the field which led to its selection for work on the development of the HDM-4 road planning model and being chosen by the World Bank (and now supported by the International Road Federation) to host the Senior Roads Executive Programme, which has, since the late 1990's, helped to train senior staff from road authorities, road funds and transport and road ministries.

7. The benefits of research on paved road deterioration

Research, funded by UK aid, on paved road deterioration, has had a major impact on paved road design in tropical countries. Although it is very difficult to estimate, the benefits of this research probably runs into billions of dollars.

Research undertaken by the Overseas Unit of TRL in Kenya in the 1970's and 80s, found that thick paved road surfaces did not deteriorate as expected. The study covered 80 test sections on eight different sites in Kenya. Surprisingly, it was found that the thickness of the overlays and the weight of the traffic had practically no effect on the length of time that it took for the overlays to suffer from cracking. (Smith et. al 1984, 1986).

Standard theory indicates that cracking should be very dependent on traffic and layer thickness, and that with loading, cracking should start at the bottom of the layer that is under the greatest strain. However, the Kenya studies, (which are subject to much higher temperatures, rainfall and axle loads than in the UK) clearly showed that cracking started at the top. It appeared that rapid oxidation and weathering played a far greater role than previously thought. Because this was contrary to expectations it was initially difficult to convince engineers that this type of failure is by far the most common in the tropics. (Rolt, 2001).

Unfortunately, engineers worldwide had witnessed similar early failures and their response was to design more conservatively using the established methods, thereby adding thicker and thicker layers of asphalt, at greater expense, in an attempt to provide designs which would last longer. These attempts were unsuccessful because the mode of failure had been misunderstood.

TRL's subsequent research programme has shown how best to combat the problem. The results have shown that improved mix design by itself is not sufficient and have demonstrated that simply by adding a surface dressing to the asphalt layer, much better performance can be obtained.

It is difficult to pin down precise benefits from this research however results of technical advice by TRL in Ghana, Kenya, Tanzania, Jordan and Malaysia found that savings in the use of asphalt premix alone, could



amount to around £ 40,000 per km, in today's figures. – This excludes the benefits of reduced vehicle operating costs from lower road roughness which might be many times this amount³.

In Sub-Saharan Africa, there are around 350,000 km of bitumen surfaced roads. If just 10% of these roads benefitted from the research, and that the reduced construction cost benefits occurred over 15 years (the lifespan before major rehabilitation) then the benefits would be around £ 93 million, per year or a total of over £ one Billion. This is in comparison with a “one off” total research expenditure of around £2 million in today's prices.

To put these figures in context it is estimated that in Sub-Saharan Africa spending on roads amounts to around 2% of Gross Domestic Product (GDP) per year. This is equivalent to a current expenditure on roads of US\$ 33 billion per year (based on 2017 GDP figures), with an expenditure of around US\$ 9,000 per km on main roads per year. (Gwilliam, et.al. 2008).

8. Road engineering guidance notes, manuals and systems development

In order for research to be translated into practise it is often necessary to produce guidance notes and manuals that formally incorporate the research findings. Among the 500 papers and research reports listed in the 2009 Transport Links website that recorded UK funded research of the Overseas Unit of TRL, are 35 ORNs and manuals. The following examples show the diversity of work covered:

- ORN31 (1993) A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries;
- ORN6 (1988) A guide to geometric design;
- ORN1 (2003) Maintenance management for district engineers;
- ORN5 (2005) A guide to road project appraisal;
- ORN9 (1992) A guide to small bridge design for highway engineers;
- ORN20 (2003) Management of rural road networks;
- ORN12 (1993) Design guidelines for busway transit;
- ORN13 (1996) The use of traffic signals in developing countries;
- ORN21 (2004) Enhancing mobility of disabled people: Guidelines for Practitioners;
- International road maintenance handbook: Practical guidelines for rural road maintenance (Vols 1 to 1V) (2006); and
- Towards Safer Roads in Developing Countries (Ross et al. 1991).

The TRL Overseas Road Notes and maintenance handbooks can be accessed at the following website:

<http://transport-links.com/archive/>

ORN31 relating to the structural design of bitumen surfaced roads is perhaps the most widely quoted and most influential of all the reports produced by the Overseas Unit of TRL.

Following on from this work, it was recognised that advice also had to be fully incorporated into each country's procedures and systems. Researchers have frequently found that although local engineers were fully aware of the relevance and efficacy of particular research, they were very reluctant to use the research findings unless it had been fully incorporated into the design manuals and standards of their local countries. This is purely because of concerns over accountability.

Under the DFID funded SEACAP, AFCAP, ReCAP, and other initiatives a whole series of country and regional based manuals have been produced. Examples include:

- Ethiopia: Pavement design manual –Vol 1 Flexible Pavements (2013, AFCAP);
- Ethiopia: Pavement design manual Vol 2. Rigid Pavements (2013, AFCAP);

³ Communication from John Rolt, former Chief Scientist, TRL 2018



- Ethiopia: Design manual of low volume roads (2016, AFCAP);
- Lao: SEACAP21: Slope maintenance manual (2008, SEACAP);
- Liberia, Sierra Leone, Ghana: Development of low volume design manuals and update of specifications and detailed drawings for three AFCAP members in West Africa (2017, AFCAP);
- Malawi: Design Manual for low volume sealed roads (2013, AFCAP);
- Tanzania: Low volume roads manual (2016, AFCAP);
- South Sudan: Low volume roads design manual (2013, AFCAP);
- Vietnam: SEACAP1. RRST guidelines: rural pavement and surface condition monitoring (2007, SEACAP); and
- Southern Africa Development Community (SADC): Low Volume Sealed Roads Guideline (Pinard et.al. 2003). Funded by DFID, Norwegian Agency for Development Co-operation and Swedish International Development Agency.

The SEACAP, AFCAP and ReCAP manuals and other reports, can be accessed from the ReCAP website: www.research4cap.org/SitePages/Rural%20access%20library.aspx.

Under Technical Assistance arrangements, DFID has also supported a range of management and systems development for national and rural road programmes. For example, in 2002 the Ekiti Rural Access Road Programme, in Nigeria was developed to establish sustainable systems for the maintenance of rural access through institutional reform, capacity building, physical infrastructure provision and pilot initiatives in mobility and accessibility planning. Through the programme a template was developed for a holistic Rural Accessibility Programme which has been adopted by both the African Development Bank and World Bank for the delivery of the Rural Access and Mobility Programme (RAMP).

Similarly, under the Nigeria Infrastructure Advisory Facility Phase 2 a programme was initiated in 2012 to develop a national Road Asset Management System.

9. The benefits of the SEACAP road research programme in Vietnam

The DFID funded South East Asia Community Access Programme (SEACAP) undertook research into the road surfacing and paving options for low traffic volume rural roads. The majority of the research was carried out between 2003 and 2012. The research proved the viability of Double Surface Bituminous Treatment (DBST) in Vietnam's conditions and also showed that the use of penetration macadam (penmac) was outdated and expensive and that gravel surfaced roads deteriorated quickly because of poor quality, climate and a lack of maintenance.

Prior to the SEACAP work the standard road surfacing for Commune Roads was earth or gravel with the occasional use of concrete or penetration macadam. In 2015 the Commune Road network accounted for 145,000 km out of a national total of 385,000 km. In 2004, in the early stages of the research programme, just 2% of Commune Roads were paved. However, by 2005 with DFID financed advisory support the case for using DBST was taken on board by both the Ministry of Transport and the World Bank, who were preparing the Third Rural Transport Programme (of Vietnam).

By 2015, the proportion of Commune Roads, that were paved had risen to 58%, representing an increase of 81,057 km, following a concerted road construction programme undertaken by the Government of Vietnam, over the decade between 2005 and 2015. Figure 1 below shows the growth of the paved network in Vietnam.

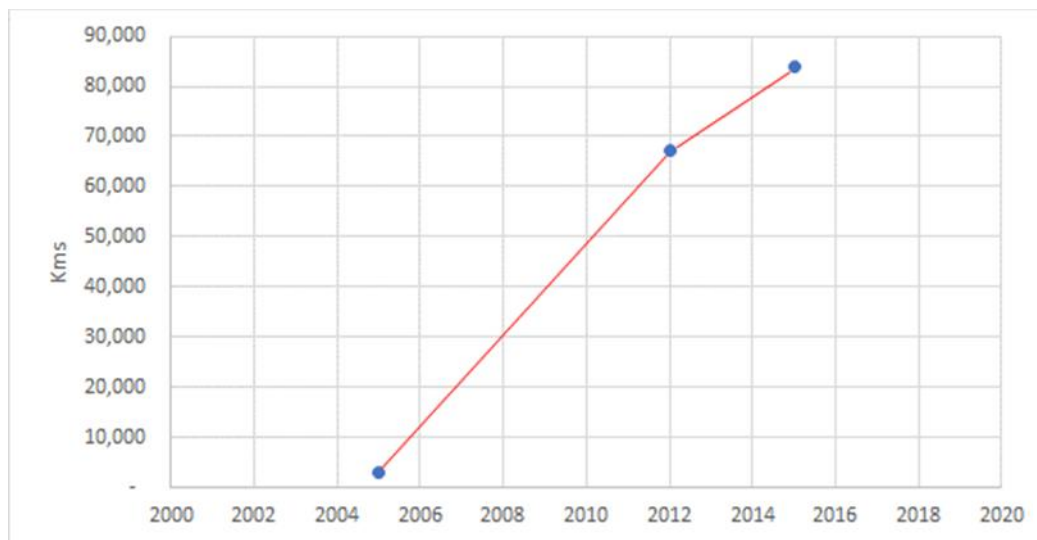
There is compelling evidence that SEACAP research was the principal influence in the change in the rural road surfacing policy of the Ministry of Transport in Vietnam and World Bank, this is documented in the World Bank RT2 Completion Report (World Bank, 2007). An additional analysis also found that out of 24 countries Vietnam was in third place for the increase in total paved road density from 2005 to 2015. Vietnam was behind China and India, that have both experience significant and concerted road construction programmes under various government schemes.

A range of social and economic benefits have been found from better rural accessibility in Vietnam. Cuong (2011), found that the presence of an all-weather road increased per capita income by 9%. While Nguyen



et.al. (2017) found that rural road projects led to an 11% increase in access to safe drinking water, and a 12% increase in mobile phone ownership. There was also a marked increase in industrial employment.

Figure 1: Length of the paved commune road network in Vietnam



The total cost of the research was £1.2m. A cost benefit calculation for the 10 year commune paved road, combined with the research costs, was carried out. The main benefits were calculated changes in vehicle operating costs. Attributing just half of the benefits to the combined programme, the following were calculated:

- Internal Rate of Return (IRR): 31%;
- Net Present value (discounted at 12%): US\$ 972 million; and
- Benefit to Cost Ratio (BCR): 2.46.

Source: "Cost/Benefit Analysis of SEACAP Trials in Vietnam" Kaenzig et al. (2018)".

10. Road safety

The UK Aid has, for many years, financed road safety research and is currently a key supporter of the Global Road Safety Facility (GRSF), located at the World Bank.

It is now recognised that road injuries are the 10th leading cause of death worldwide, killing 1.25 million people per year, with 90% of deaths in low and middle-income countries. and it is the leading cause of death among young people of between 15 to 29 years old.

The Overseas Unit of TRL, was the first organisation worldwide to identify the growing problem of road deaths and injuries in the developing and emerging nations of Africa, Asia Latin America and the Middle East.

Early work at TRL concentrated on identifying the magnitude of the problem thus alerting Aid Agencies and nations to the growing problem. It was initially estimated that road deaths had an equivalent effect of reducing GDP by around 1% (Fouracre and Jacobs, 1976), although later estimates suggest a higher figure. Later work was done to establish the nature of the problem and how this differed from that of high-income countries. Detailed research was carried out on the road safety consequences of road user behaviour, road layout and design, vehicle safety, public transport and drink-drive issues (Jacobs, 1986 and 1995; Yerrell and Downing, 1989). In selected Asian countries, research was carried out on the impact that fatal and serious road crashes have on households of varying income levels. This showed that mid-income households prior to the crash were plunged into poverty with the loss of the breadwinner with significant changes in lifestyle. (Aeron-Thomas et.al. 2004).

Major items of work included the publication of "Towards Safer Roads in Developing Countries", by TRL (Ross et.al. 1991), a manual which dealt in detail with accident reduction and prevention by highway engineering measures. About 4,000 copies of the manual were printed and widely distributed. A Spanish edition was



produced for use in Latin America. A follow-up document dealt with road safety in suburban conditions, ribbon development vulnerable road users and design of drainage ditches etc. Manuals were also produced which dealt with road safety education setting out ways in which lessons in road safety can be introduced in schools and guidelines for Ministries of Education. Finally, under the TRL programme, much effort was directed towards improving ways in which road accident data are collected, stored and analysed. This led to the development of Microcomputer Analysis Package (MAAP), the accident analysis package which is now in use worldwide. (Hills and Baguley, 1995).

Besides support for road safety at TRL. The GRSF has had a major influence with donors and developing country governments. As a result, now all World Bank road projects must have a safety component. The GRSF is world leader in Road Safety and its success, including the adoption of the "Safety Systems Approach" has been widely recognized. The Road Safety Management Award, from Prince Michael of Kent was awarded to TRL for its overseas work in 1999, and to the GRSF, in 2017.

In recent years there has been an enormous growth (often amounting to more than 20% per year) in the use of motorcycles in many African countries. To help address the inevitable accident issues a programme safety research was launched by the AFCAP and ReCAP programmes. So far, a range of research studies into motorcycle, and three-wheeler, safety issues have been carried out in Tanzania, Ghana, Uganda, Kenya, and Democratic Republic of Congo. The topic covered included the use of motorcycle helmets, appropriate training, regulation, methods of sensitising drivers to safety issues, black spot analysis and geometric standards.

11. The Rural Access Programme (RAP), Nepal

The UK aid funded Rural Access Programme (RAP), which is still ongoing, was originally conceived in 1999 as a poverty alleviation programme that uses labour-intensive construction of transport infrastructure as an entry point for improving the poorest and most marginalised people in remote areas of Nepal. The project aimed to lift 20,000 people out of poverty through access to work (in the construction of roads) and skill training. It also promotes equal access to work opportunities for women.

RAP is now in its third stage of implementation. So far it has constructed 250 km of new roads, maintained 2,300 km improving access for 2.1 million and created employment for 8,100 people.

Recent monitoring reports suggest that there has been a 20% decline in poverty, (equivalent to 30,000 households) in the area of western Nepal where RAP has been concentrated. And poverty has fallen much faster in locations that are in close proximity to RAP roads than areas further away.

The programme has a very strong knowledge component and the World Bank has drawn on its experience in the design of its own programmes in Nepal. RAP has won seven engineering awards and has produced a large volume of guidelines and training materials and runs training programmes with the Nepali authorities. It also has an excellent website. As examples of its awards, it was the winner of the Association for Consultancy Engineering (ACE) Research, Studies and Consulting Advisory Engineering Excellence Award in 2015, while in 2018 it was the winner of the ACE Consulting and Engineering Awards 2018 - Social Impact Champion of the Year Award.

Besides a comprehensive set of progress reports on its website RAP has listed 25 manuals and 39 briefing papers. These are typically 4-page notes on various management topics in connection with the programme. In addition, it has produced a 29 module, engineering training course covering planning, design, procurement, and implementation.

Examples of the manuals it has produced are as follows:

- Specific Maintenance Groups Implementation Guideline;
- Enterprise Graduate Programme;
- Health and Safety Emergency Guidelines;
- Internal Audit Guidelines;
- Orientation Brochure for District Stakeholders;



- Human Resources Manual;
- Socio-Economic Development Manual for field Staff;
- Social Audit Guidelines;
- Local Road Network Road Safety Assessment Guidelines;
- District Transport Master Plan Guidelines;
- Annual Road Asset Management Plan Guidelines; and
- Rural Road Standards.

The RAP Manuals, evaluation and monitoring reports can be found at the RAP Website:
<http://rapnepal.com/reports-and-publications>

12. Research into infrastructure climate change adaptation and resilience

UK Aid has financed a range of research into how climate change will affect the viability of transport infrastructure and what measures need to be taken to build in resilience. An example is a study by the World Bank and funded by DFID and other donors is “Enhancing the Climate Resilience of Africa’s Infrastructure: The Roads and Bridges Sector” by Cervigni et al, (2017). The study considers a number of aspects including the vulnerability of roads to climate change, integrating climate change into planning, whether there should be a reactive response or proactive adaptation, and what the risks of inaction are. Climate change projections are forecast across Sub-Saharan Africa and the issues are considered country by country. This study finds that:

- Direct damages: tens of billions of dollars in damages to roads, which will require additional maintenance to preserve basic serviceability; preliminary estimation of damage to bridges suggests costs may be even higher (in the order of \$30 billion, mean estimate); and
- Substantial system disruption: apart from increasing maintenance costs, climate changes will cause the disruption of road links, interrupting the flow of goods and people, to the tune of 100 million days of disrupted road links by 2050, all of which has a substantial economic cost.

The study advocates that climate change needs to be incorporated into road asset management and that regular maintenance is a first key step towards increasing climate resilience of roads and bridges. It is also recommended that investing proactively in pavement improvements to withstand higher temperatures is economically justified under most climate projections. On the other hand, in the short term, proactive adaptation to precipitation and flooding events is unlikely to be justified. Nevertheless, in the longer term (by mid-century) the costs and risks of inaction will grow overtime and the case for adaptation will increase. Blanket prescriptions should be avoided and a case by case analysis (for example different countries are likely to be affected in very different ways) should be undertaken.

The DFID funded SEACAP, AFCAP and ReCAP programme has undertaken a range of research including:

- “Study of road embankment erosion and protection”, (Howell, 2008) SEACAP. This paper investigates embankments in the Mekong flood plains and considers using low cost approaches to mitigate damage.
- “Promoting Sustainable Rural Access and Developing a Risk Based Vulnerability Assessment for Rural Communities in the Changing Climate of Sub Saharan Africa” (Hearn, 2014), AFCAP. This study assesses the effects of climate change of the performance of roads on rural communities in Ethiopia.
- Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa: Climate Threats Report. (Le Roux, et al, 2016), AFCAP. This study investigated and identified the vulnerability of different regions in Mozambique from a rural access and climate risk perspective. Mozambique is at a particular risk because of high precipitation and risk of flooding.
- Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa: Recommendations for Phase 2. (Paige-Green, et al. 2016,) AFCAP. This report examines climate resilience and adaptation in Ethiopia, Mozambique and Ghana. Detailed recommendations are made for three roads considering factors such as erosion of embankments, (including next to structures), wearing courses, side drains, excessive sub-grade moisture, flooding, and slope stability.



- Implementing a Geographic Information System (GIS) Based Methodology for Determining Highly Vulnerable Rural Access Roads to a Changing Climate in Ethiopia. (Arnold et.al, 2018), AFCAP The paper outlines how potential high risk areas to climate change were identified, and how they can be prioritised for climate resilient road construction.
- Climate Resilient Concrete Structures in Marine Environment of Bangladesh; Inception Report. (Srinivasan, et.al, 2016), ReCAP. This report describes a research study that will examine the major factors contributing to the premature deterioration of concrete structures in the aggressive coastal environment of Bangladesh. A detailed literature review is included.

13. Research on transport services

UK funded research into transport services can be broadly grouped into three areas, urban public operations, freight transport and rural transport. A substantial amount of work on urban transport, covering buses, minibuses, metro, and bus rapid transit, was undertaken by the Overseas Unit of the Transport Research Laboratory during the 1980s and 1990's. A major study of Pakistan's trucking industry was undertaken by TRL in the mid 1980's this was followed up with comparative studies of freight costs, between Africa and Asia in the 1990s. The very high transport costs, particularly for long distance, and international traffic, found in Africa contributed the case for establishing the African corridor programmes, including "TradeMark East Africa". Under AFCAP a series of studies of rural transport have been carried with a significant emphasis on motor-cycle taxi operations in Africa. Examples include:

- "Travel demand characteristics in three medium sized Indian cities". (Fouracre and Maunder 1987). The study finds that fares levels are an important factor influencing demand, however public transport patronage in medium sized cities is used more by middle and high-income groups, the poor walk and cycle. Household transport expenditure is strongly influence by fare levels.
- "The performance and impact of rail mass transit in developing countries". (Fouracre et al. 1990). The study presents findings collected from 21 developing cities. But these have been at enormous cost. The report concludes that while engineering operations may be praised much criticism can be levelled at planning and financial management. Few if any can be financially viable but can give good economic returns in the right conditions.
- "Liberalisation of urban public transport services: What are the implications?" (Maunder and Mbara, 1996) The study presents material that highlights the positive and negative aspects of both government and private ownership, and of regulation versus liberalisation on the performance of stage bus services in the developing world.
- "Pakistan road freight industry: An overview", (Hine and Chilver, 1991). Based on a nationwide survey of 3,500 truck drivers coupled with data from other surveys, the study presents a range of detailed data on the performance of the trucking industry which appears very competitive and efficient.
- "Halving Africa's freight transport costs: Could it be done?" (Hine and Rizet, 1991). The study compares freight transport costs and operations between Pakistan and three CFA Franc Zone countries (Cameroon, Cote D'Ivoire and Mali). It finds that that freight tariffs in the Africa countries, appear to be up to five times as expensive as in Pakistan. A range of factors account for the difference including a big difference in the nature of competition. In Africa, cartels restrict competition through enforcing a queuing system at truck parks, and drivers have poor mechanical skills and little responsibility for looking after their vehicles.
- "A comparison of freight transport operations in Tanzania and Indonesia" (Hine, Ebden, Swan, 1997). This study, undertaken by Mott MacDonald and TRL, confirmed the earlier study (between Pakistan and Francophone Africa) of the huge difference in transport tariffs between Africa and Asia.
- "The benefits and challenges of increased motorcycle use for rural access", (Starkey, 2016). AFCAP. In 10 years, motorcycle numbers in Tanzania increased from 10,000 to 800,000 and motorcycle taxi services have spread rapidly. They provide substantial benefits, and on some roads 70 to 80% of annual passenger transport is by motorcycle. They even provide access for pregnant women and sick people to hospital. However, they are relatively expensive and road traffic injuries are high, and in most of Africa, they are



totally unregulated. Information needs to be collected on best practise, how to improve safety and on appropriate regulation.

14. Research on transport, gender and disadvantaged groups

Over the last thirty years UK aid has supported a range of studies that have investigated the relationship between gender, disadvantaged groups, and transport in various contexts. The studies show the burden of transport poverty commonly falls most heavily on women, girls and the elderly, and have suggested and explored potential routes to improving conditions. Examples of various UK funded studies are given below:

- “The Thuchi-Nkubu road study: Analysis of travel between 1983 and 1989”. Airey (1990). This study carried out by TRL describes in detail the very different patterns of movement between men and women in rural Kenya and how these were affected by a new UK funded road.
- “Women and transport in developing countries” Turner and Fouracre (1995). This is an early review article that considers a wide range of issues including women’s role in society, their access to work and employment issues, differential travel patterns, differential access to means of transport, planning issues, traffic safety, and development policies.
- “At Christmas and on rainy days.” Transport, travel and the female traders of Accra (Turner, et.al, 1996). This book covers transport, household organization, spontaneous co-operation, accessibility for portrage and head loading, the use of the bicycle, family patterns, education for girls and elderly women traders.
- “Intermediate Means of Transport: A Review Paper with Special Reference to Ghana.” (2002 DFID Crop Post-Harvest R7575) The project was designed to test a range of Intermediate Means of Transport (IMTs) mostly with women. The results show the complexities of IMT adoption and impact, emphasising, in particular, the potentially crucial (yet questionable) role of child labour for IMT operation, the difficulties of targeting projects so that IMTs benefit women.
- “Balancing the load: women, gender and transport.” Fernando, P. and Porter, G., (eds): (2002) This edited book, based on work funded by DFID and the World Bank, with 19 case studies is still widely cited as a key statement of gender issues in transport. It shows how the gender division of labour influences women and men's transport needs and patterns and their access to and use of transport infrastructure and technologies.
- “Improving accessibility for people with disabilities in urban areas” Venter et. al. (2004). The paper describes the mobility issues and needs of disabled people in six cities in medium- and low-income countries.
- “Rural transport services for older people in Kibaha district, Tanzania: Report of project findings”, Porter et.al, (2012) AFCAP. Transport is shown to be a major hurdle for older people, particularly for daily domestic needs for water and fuel but also access to health care. In absence of alternatives motorcycle taxis have brought improved mobility, at least in emergency contexts, even for very old people, despite high fares. However, many find travel by motorcycles to be a dangerous and frightening experience.
- “Scaling Up Gender Mainstreaming in Rural Transport: Policies, Practices, Impacts and Monitoring Processes: Final Synthesis Report” Tanzarn, (2017), AFCAP. The report synthesises four country cases studies in Ghana, Kenya, Tanzania and Uganda and analyses transport sector policies, legislation, regulations and programmes. Despite political frameworks and political commitments to gender equality it was found that gender was not mainstreamed in most transport policies and gender is often relegated to specific sections of documents. Traffic and safety regulations were most lacking, as they did not refer to sexual and gender-based violence that is reportedly prevalent in public transport. Gender mainstreaming is often perceived as a donor-driven agenda.

15. Meeting the wider objectives and multi-sectoral impacts of transport

The transport community have long recognized that transport’s profile within major global initiatives, such as the Millennium Development Goals (MDGs), the Sustainable Development Goals (SDGs) and the Paris Agreement on Climate Change has been relatively weak. To help raise the profile of transport on the



international stage, identify the benefits of transport and help embed the role of transport within the wider community, DFID has been a key supporter of initiatives such as Sustainable Mobility for All (SuM4ALL), “Impact Evaluation (IE) — Connect for Impact”, and The Partnership for Sustainable Low Carbon Transport (SLoCaT). Both SuM4ALL and “Impact Evaluation (IE) — Connect for Impact” are based at the World Bank, although the former is managed by an international steering committee with diverse interests.

SuM4ALL, which was established in 2017, has recently produced a “Global Roadmap of Action Toward Sustainable Mobility”. It covers a range of policy measures to support and map mobility and covers measures covering:

- Legal and regulatory issues;
- Technology and engineering;
- Economics and finance; and
- Communications and marketing.

While policy measures address:

- Universal access for both rural and urban mobility;
- Gender;
- Safety;
- Green mobility; and
- Efficiency.

The “Impact Evaluation (IE) — Connect for Impact,” initiative was started in 2015. It aims to radically transform and better inform the way that transport and information and communications technology (ICT) projects are designed and implemented. Although multilateral lending to this key strategic sector comprises 29% of all global assistance, only 0.4% of impact evaluations have had transport as a subject. This initiative aims to fill the gap and bring high quality and valuable feedback to projects — improving design, enabling mid-course corrections, and informing ex-post evaluations ⁴.

The SLoCaT Partnership, founded in 2009, has been instrumental in raising the profile of transport within the SDGs and monitoring and tracking low carbon transport.

15.1 Rural road impact studies

The most widely studied area of transport, where multisectoral issues have been extensively examined, has been the impact of rural roads. In fact, hundreds of such studies have been undertaken, - all presumably fitting within the ‘0.4 percent’ mentioned above. In the past UK aid has supported a number of individual studies covering the impact of roads in countries such as Ghana, Kenya, Malaysia, Nigeria, Sierra Leone and Zambia.

DFID supported a comprehensive Systematic Review of 56 quality rural road impact studies in low and middle-income countries (Hine et al, 2016). Here it was found that rural road investment had a beneficial effect on incomes, consumption and poverty reduction, as well as on agricultural production, agricultural marketing, non-agricultural employment, and educational outcomes. As perhaps expected, health outcomes from better accessibility were mixed, as it can lead to both the easier spread of communicable diseases as well as to better access to health care and better treatment. Overall, the strongest impacts were experienced in countries with low road densities (including Ethiopia which in 1996 had a road density of 0.023 km/sq km), and in general there was less impact for countries with higher road density. This is likely to be because diminishing returns occur with increasing road density. A follow-up study of 20 recent impact studies, confirmed many of the earlier findings. However, the later studies showed a more positive impact on health outcomes from reducing the level of sickness, better preventative health care and better access to safe drinking water. (Hine et al, 2019).

⁴ <http://pubdocs.worldbank.org/en/611011433875382516/TransportICT-Connections-Note17-web.pdf>



16. Ongoing work and strategic outlook

A substantial amount of research work is still ongoing through the DFID funded ReCAP and the new High Volume Transport (HVT) Programme.

The ReCAP programme (also referred to as AFCAP for Africa and AsCAP for Asia) followed on from the earlier (2008 to 2014) AFCAP programme has been working since 2014 in 12 African countries and 5 Asian Countries. It is the largest global research programme on low volume transport. It covers both specific projects in individual countries and regional and cross-regional projects. Various research outputs are referred to earlier in the text. Key projects include:

- Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa;
- Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis;
- Economic Growth through Effective Road Asset Management (Africa);
- Enhancing the Understanding on Safe Motorcycle and Three-Wheeler Use for Rural Transport (Africa);
- Evaluation of the Cost-Beneficial Improvement of First Mile Access on Small-Scale Farming and Agricultural Marketing (Africa);
- Gender Mainstreaming in the Rural Transport Sector (Africa and Asia);
- Interactions: Maintenance-Provision of Access for Rural Transport Services (IMPARTS) (Africa and Asia);
- Road Materials and Aggregate Inventory Database (Africa);
- Transport Sector Leadership Development Programme (Africa); and
- Use of appropriate high-tech solutions for road network and condition analysis, with a focus on satellite imagery (Africa).

Details of the Programme can be found on the ReCAP website: <http://research4cap.org/SitePages/Home.aspx>

16.1 High Volume Transport Applied Research (HVT)

The High Volume Transport Applied Research Programme (HVT) is a five year programme funded by DFID and is part of the UK response to the global paradox: “How can we help make life better for the people living in LICs by developing better transport systems and making it better for all of us by reducing the greenhouse gas emission burden and making transport more inclusive”?

The objective of the Programme is to strengthen the evidence base that will support high-volume road and rail transport to be greener, more accessible, more affordable, more inclusive and safer. This objective will be achieved by producing a body of new research relevant to Africa and South Asia and also updating vital transport research that will help policy-makers and practitioners make informed investment decisions, reduce poverty and develop economies.

The expected main beneficiaries of the project are governments and peoples of DFID priority countries, particularly low-income countries, in Africa and South Asia. The programme will commission research and draw on relevant case studies, other research, and lessons from other countries including those that have made the transition from low- to middle-income country status. In the context of the HVT themes, this research will focus on:

- Climate change mitigation and adaptation;
- Inclusion, gender and road safety;
- Policy and regulation (including engineering);
- Technology and innovation (including data and decision support systems);
- Fragile and conflict affected states; and
- Research uptake and capacity building.

Details of the programme can be found on the HVT website: <https://transport-links.com>



16.2 Opportunities for further transport research

Research has not been a priority within the transport sector (see for example the very low volume of impact evaluations reported for the sector reported in Section 15 above) and it is commonly recognised that spending on research, as a proportion of total spending within the sector, is low. The drivers for further research spending may be identified as follows:

- Historically research has been a low priority within the transport sector;
- Weak planning, coupled with poor integration of transport with other sectors and the social and economic demands of the population;
- A disconnect between the government bodies that provide infrastructure and commercial suppliers of transport services;
- There is a persistent, huge difference in freight transport tariffs between Africa and Asia, largely based on the presence of cartels and inefficient markets. Ways need to be found to address the issue;
- With the slow pace of research and geographic variability in materials, traffic and climatic conditions there is still a long way to go to achieve the most cost-effective road engineering road design solutions;
- Very substantial changes that are now taking place with double digit growth in vehicle populations in many countries and an 'explosion' in motorcycle use, particularly in Africa;
- Road accidents cause of death of 1.25 million people worldwide and between 20 to 50 million are seriously injured. They are the highest cause of mortality and long-term disability of young people between the ages of 15 to 29;
- The development of new technologies such as satellite imagery, drones, mobile phone data, GIS mapping and increased computer power provide new opportunities for research;
- The forthcoming introduction of new 'electric' vehicle fleets;
- The implications of climate change on the design of infrastructure; and
- Rapid urbanisation is creating large towns and cities that create a very poor environment for poor and middle-income people to live. High urban air pollution (now believed to be a major cause of ill health and mortality), and severe congestion are the norm. Many people travel two to four hours every day to go to and from work school and college.

Examples of topics that could be fruitful for research are as follows:

1. Remote sensing, big data and machine learning have the potential to increase our knowledge of road networks in low-income countries without the burden of onerous, expensive and time-consuming physical surveys. A definitive, freely available, georeferenced resource with inventory, condition and transport information in any country provides a wealth of benefits to national, international, government and non-government agencies, local businesses and communities. Such knowledge also has the potential to facilitate monitoring of SDGs, and in the future is likely to be available and regularly updateable through a combination of satellite imagery, mobile phone data and other.
2. Motorcycles are now the most common vehicles on small rural roads. Road agency technical standards and planning mechanisms have not been adjusted to take into account this huge change in road usage. In many rural areas motorcycle taxis are the only transport services available every day. While other larger vehicles may be available on market days. Over-loading is common. The administrations that regulate such services are weak and understaffed and concentrate their resources on urban transport and inter-urban bus services. There are research needs to document and understand the current system and how to improve the situation. By what mechanisms can rural transport services be improved in quality, safety and frequency while maintaining affordability? Is there a need for subsidies as in developed countries?.
3. The ReCAP 'Back Analysis' project (RAF2069A) to develop guidelines and specifications for low volume sealed roads has made important progress, however there is an urgent need to build upon this work. The life of low volume sealed roads (LVSRS) is determined to a great extent by the quality of the thin



surfacing. This is especially true for roads with low axle loads. Moreover, the upcoming changes in bitumen quality are likely to have a major effect on the durability of road surfaces. This issue was brought to light by a presentation by Royal Dutch Shell at the 2019, CAPSA Conference, which stated that with growing pressures to combat climate change, there will be changes in bitumen quality and consistency. This is because fossil fuel sources that would be beneficial towards combating climate change are less suitable for bitumen production (Audny-van-Helden, 2019). There is also a need to do further research to identify the rate of damage on low volume roads by the magnitude of axle loads. Previous approaches based on 'cumulative equivalent standard axle loads' using a constant power factor, cannot easily accommodate the fact that a single pass of a heavily overloaded vehicle could destroy a road pavement.

4. There is an urgent need to up-date the road planning model HDM-4. The last substantial development of the model occurred in 2000. The vehicle operating cost relationships are particularly outdated, relating in part to data collected in the 1980's and before. Vehicle technology has improved significantly over the last thirty years and this should be reflected in the models.

17. References

- Aeron-Thomas A, Jacobs G, Sexton B, Gururaj G and Rahman F, 2004. The involvement and impact of road crashes on the poor: Bangladesh and India case studies. Transport Research Laboratory (TRL), Crowthorne.
- Airey A (1990). The Thuchi-Nkubu Road Study: Analysis of Travel between 1983 and 1989. TRL Working Paper: WP/OU/274. Transport Research Laboratory, Crowthorne.
- Arnold et.al, (2018) Implementing a GIS Based Methodology for Determining Highly Vulnerable Rural Access Roads to a Changing Climate in Ethiopia. Council for Scientific and Industrial Research (CSIR), Proceedings of the AfricaGEO 2018 Conference, Emperors' Palace, 17-19 September 2018.
- Audny-van-Helden (2019). A global View on Bitumen, 12th Conference of Asphalt pavements for Southern Africa, (CAPSA), Sun City, Oct 2019 <https://www.capsa2019.co.za/wp-content/uploads/2019/10/Audny-van-Helden.pdf>
- Cervigni, R. et.al. (2017) Enhancing the Climate Resilience of Africa's Infrastructure: the Roads and Bridges Sector. World Bank. Washington DC.
- Cuong ,N.V. (2011). Estimation of the impact of rural roads on household welfare in Vietnam. Asia-Pacific Development Journal 18 (2): 105-135.
- DFID, (2018). Global Road Safety (GRS) - DFID support to the Global Road Safety Facility (GRSF), Annual Review 2018.
- Fernando P, and G. Porter, (2002), Balancing the Load, Women Gender and Transport, International Forum for Rural Transport and Development, London.
- Fouracre, P. and G. Jacobs (1976). Comparative Accident Costs in Developing Countries. Supplementary Report 206UC. Transport and Road Research Laboratory, Crowthorne.
- Fouracre, P. and D Maunder (1987) Travel demand characteristics in three medium sized Indian cities. TRRL Research Report 121. Transport and Road Research Laboratory, Crowthorne.
- Fouracre, P., R Allport, and J Thomson (1990) The performance and impact of rail mass transit in developing countries. TRRL Report 278, Transport and Road Research Laboratory, Crowthorne.
- Foster, V and C. Briceño-Garmendia (2010) Africa's Infrastructure: A time for Transformation. Africa Development Forum Series, Africa, Infrastructure Country Diagnostic, World Bank. Washington DC.
- Gwilliam K, et al. (2008) Africa Country Diagnostic: Roads in Sub-Saharan Arica. AICS Summary Background Paper 14. World Bank. Washington. DC.
- Hearn, G. (2014) Promoting Sustainable Rural Access and Developing a Risk Based Vulnerability Assessment for Rural Communities in the Changing Climate of Sub Saharan Africa. AFCAP Report HGL 05. Ref: AFCAP/GEN/127/D2. Crown Agents.



- Hine, J and A Chilver (1991) Pakistan road freight industry: An overview" Research Report RR 314, Transport Research laboratory, Crowthorne.
- Hine, J and C Rizet, (1991) Halving Africa's freight transport costs: Could it be done? International Symposium Transport and Communications in Africa, Brussels, 27-29 November 1991.
- Hine, J, Ebdon, J and P. Swan. (1997) A comparison of freight operations in Tanzania and Indonesia. TRL Report 267. Transport Research Laboratory, Crowthorne.
- Hine, J, Abedin, M, Stevens, R, Airy, T, Anderson T. (2016) Does the extension of the rural road network have a positive impact on poverty reduction and resilience for the rural areas served? If so how, and if not why not? London: EPPI-Centre, Social Science Research Unit, UCL Institute of Education, University of London.
- Hine, J, Sasidharan, M., Eskandari Torbaghan, M., Burrow, M. P. N. and Usman, K. (2019). Evidence on impact of rural roads on poverty and economic development. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.
- Hills, B and C Baguley (1995). Accident data collection and analysis: Progress in the use of the Microcomputer Package MAAP in the Asian Region. In Proceedings: Eighth REAAA Conference, Taipei, 17-21 April 1995.
- Howell, J. (2008) Study of road embankment erosion and protection. SEACAP 019. Development of local resource based standards. Unpublished Project Report, TRL. Crowthorne.
- Jacobs, G., Aeron-Thomas, A. and Astrop, A. (2000) Estimating global road fatalities, TRL Report 445, UK Department for International Development, London.
- Jacobs, G (1986) Road Accident prevention: the work of the Overseas Unit, TRRL (1986) British Highways and Urban Traffic Conference, UK Papers presented in Beijing. 1986.
- Jacobs, G (1995) Road safety in the developing World. 5th Annual Public health Forum, London School of Hygiene and tropical Medicine, April 1995.
- Kaenzig, R., Hine, J. and R Petts (2018). Cost/Benefit Analysis of SEACAP Trials in Vietnam. ReCAP Project No. RAS2110B. Cardno. London.
- Le Roux, A, et.al. (2016) Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa: Climate Threats Report. Council of Scientific and Industrial Research (CSIR), Paige-Green Consulting (Pty) Ltd and St Helens Consulting Ltd. AFCAP Project Report GEN2014C Cardno Emerging Market (UK) Ltd, Thame.
- Maunder, D. and T Mbara (1996) Liberalisation of urban public transport services: What are the implications? Indian Journal of Transport Management, Vol. 20, No.2, February 1996.
- Nguyen, C.V., T.D. Phung, V.K. Ta and D.T. Tran (2017). "The impact of rural roads and irrigation on household welfare: evidence from Vietnam." International Review of Applied Economics 31(6): 734-753.
- Paige-Green, P, et.al. (2016). Climate Adaptation: Risk Management and Resilience Optimisation for Vulnerable Road Access in Africa: Recommendations for Phase 2. Council of Scientific and Industrial Research (CSIR), Paige-Green Consulting (Pty) Ltd and St Helens Consulting Ltd. AFCAP Project GEN2014C. Cardno Emerging Market (UK) Ltd, Thame.
- Pinard M, et.al. (2003) SADC Guideline on Low Volume Sealed Roads, Southern Africa Transport Communications Commission (SATCC) and Southern African Development Community (SADC), Gaborone.
- Porter, G. (2002) Intermediate Means of Transport: A Review Paper with Special Reference to Ghana, Report to the Department for International Development, Crop Harvest Programme Project R. 7575, Department of Anthropology, University of Durham.
- Porter et.al, (2012) Rural transport services for older people in Kibaha district, Tanzania: Report of project findings HelpAge International in collaboration with University of Durham and REPOA. AFRCAP Report: AFCAP/GEN/060/F, Crown Agents.
- Roberts, P, S. KC, and C. Rastogi, (2006) Rural Access Index: A Key Development Indicator. Transport Papers, TP-10, World Bank, Washington, DC.



- Rolt, J. (2001) Top-down Cracking: Myth or Reality? The World Bank Regional Seminar on Innovative Road Rehabilitation and Recycling Technologies, Amman, Jordan, 24 - 26 October 2000.
- Ross, A, Baguley, C, Hills, B., McDonald, M, and D Silcock. (1991) Towards Safer Roads in Developing Countries: A Guide for Planners and Engineers. Ross Silcock Partnership, Transport and Road Research Laboratory, Overseas Development Administration. Crowthorne.
- Smith, H, Jones, C. and J Rolt (1984) Early performance of some experimental bituminous overlays in Kenya (1984). 4th Conference on Asphalt Pavements for Southern Africa.
- Smith, H, Rolt, J, and J Wambura (1990). The durability of bituminous overlays and wearing courses in tropical environments (1990) 3rd Int. Conf. on the Bearing Capacity of Roads and Airfields.
- Srinivasan, S., I Gibb, F Chowdhury (2016) Climate Resilient Concrete Structures in Marine Environment of Bangladesh; Inception Report. Mott MacDonald Ltd, ReCAP Report BAN2077A. Cardno Emerging Market (UK) Ltd, Thame.
- Starkey P. (2016) The benefits and challenges of increased motorcycle use for rural access. International Conference on Transport and road research. 15th-17th March Mombasa.
- Tanzarn, N. (2017). "Scaling Up Gender Mainstreaming in Rural Transport: Policies, Practices, Impacts and Monitoring Processes: Final Synthesis Report", IFRTD, AFCAP report: RAF 20441. Cardno Emerging Market (UK) Ltd, Thame.
- Turner, J., and P Fouracre (1995) Women and transport in developing countries. Transport reviews, 15, (1), 77-96.
- Turner, J, Grieco, M and N. Apt. (1996) "At Christmas and on rainy days." Transport, travel and the female traders of Accra. Avebury.
- Venter, C. et.al. (2002) Improving accessibility for people with disabilities in urban areas. Codatu X conference, Lome, 12-15 November 2002.
- World Bank. (2000) Highway Development and Management Model (HDM4), jointly published by World Bank, Washington, DC, and the World Roads Association (PIARC), Paris.
- World Bank, 2007, Vietnam RT2 Implementation Completion and Results Report, Washington DC.
- Yerrell, j and A Downing. (1989) Road safety in Africa-Background and overview. Second African Road Safety Congress, Addis Ababa. Oct 1989.

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