THE BENEFITS FROM INCREASED TRANSPORT RESEARCH CAPACITY IN DEVELOPING COUNTRIES

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Abstract

Evidence shows that countries that invest in research develop faster economically. Research is the mechanism for the advancement of knowledge and economic growth is directly linked to investment in research. Increased investment in research in by developing countries will result in local and appropriate solutions to their transport problems... This paper gives examples of the benefits from investment in research in the transport sector, describes programmes designed to facilitate innovation and research in the sector gives examples of research needs and suggests ways in which developing country organisations can establish a framework for carrying out research.

1. INTRODUCTION

Governments in the developed world provide financial support to developing countries with the aim of helping them achieve the ultimate goal of economic self sufficiency so that these nations can play a full part in world economic and trade activities. Development agencies support projects and programmes designed to support the recipient country's development agenda. In the transport sector, this support is often aimed at increasing the accessibility and mobility of the urban and rural poor. The World Bank is committed to improving the sustainability of the sector through increased efficiency and making the supply of transport services more responsive to the needs of users [1]. Knowledge derived from research is an essential ingredient for sustainable development in that it provides the information needed for technological development and the social and economic benefits that accrue from it. The United Kingdom Department for International Development (DFID) continues to fund transport research in developing countries by providing both bi-lateral and multilateral support with international partners. Its current support for transport research is around £4 million annually.

Collaborative programmes between development agencies and local government and private institutions are funded to support research initiatives, initiate knowledge transfer, increase awareness of appropriate technology and adopt new approaches proven through research that are expected to make a positive and lasting impact in solving a country's transport problems. The donor support phase for such programmes usually has a limited time frame with the expectation that the host nation will become aware of the potential long-term benefits of the initiative and will embed it into national policies and strategies. When this does happen, the initiatives can be said to be mainstreamed with high prospects of their continuance and resulting long-lasting benefits.

Unfortunately, many initiatives, however potentially beneficial they may have been to the recipient country, have fallen away within a relatively short period after donor support was withdrawn. When this happens, the substantial human and financial investment in the development initiative by both donor and recipient country agencies is undermined. Even more damaging for local poor communities are circumstances where improvements in livelihoods, which began under the initiatives, are reversed when they fail.

This situation is particularly prevalent in research in many developing countries. Some countries once had a significant in-house research capacity, but this has dissipated with time which has resulted in increased dependence on external agencies. In others, research has received only lukewarm support with the result that the capacity for innovation in these countries is low. In this regard, the transport sector is similar to others with an added factor that engineers are often reluctant to adopt solutions developed elsewhere and are sometimes particularly sensitive to perceived risk.

Research is the mechanism for the advancement of knowledge and economic growth and is directly linked to investment in research [2]. Research is also directly linked to innovation and countries that fail to invest in research are not only likely to lag behind in the development of appropriate local solutions to their problems but also in economic development. There are numerous examples of foreign consultants proposing and implementing recommendations that are inappropriate to local conditions. This should not be surprising. Local problems need local solutions and foreign practitioners are not best placed to understand local needs. A far better way of addressing these problems is to invest in the local research capacity needed to develop appropriate, innovative solutions required to solve local problems. However, any investment in research must be matched by a local commitment to sustaining a research capability and must also include creating an environment that will attract and retain skilled professionals with an interest in research.

As a background to the case for increased developing country capacity for transport research, examples of research needs and the impact of completed research projects are described in the paper together with the problems related to technology transfer and the mainstreaming of new technologies.

2. BUILDING DEVELOPING COUNTRY CAPACITY FOR RESEARCH

Research effort is needed in most of the areas related to transport for the provision of safe and sustainable access and improved mobility for poor communities in developing countries. Yet, despite the large benefits from research in the transport sector as in the examples given in this paper, investment in transport research is woefully small and even non-existent in many countries. The current situation in which foreign entities carry out transport research for developing countries, even if it is in partnership, is not sustainable in the longer term.

It is not by accident that the countries that invest most in research make the biggest strides forward economically and there are a number of examples where countries which have developed a research capacity and were once thought of as ‘developing’, are now on their way to becoming economic giants. India and China are two such examples. Unfortunately, there are fewer examples from the African continent apart from South Africa, which for many years has been at the forefront of transport research. The recent decision by the Ethiopian government to elevate research to directorate level in the Ethiopia Road Authority is very encouraging. ERA is now embarking on the construction of its own Road Research Centre.

If countries display a commitment in developing a research capacity, then development agencies committed to transport and research are more likely to provide initial support. For this to happen,

there must be a clear demand by the partner government for assistance and an unremitting commitment to its future. What has to be avoided is a situation where the partner country reverts to its previous position when donor support is withdrawn.

Partner countries in the developing world are usually expected to contribute to donor-funded projects and taxpayers in both the donor and the recipient country should have a reasonable expectation that the initial investment in research will be sustained and that the research will be productive.

The basic factors required for creating the environment for sustainable research are not likely to be significantly different from those suggested for the sustainability of other projects.

These are that it should be:

- Politically supported
- Socially acceptable
- Institutionally embedded
- Environmentally sustainable
- Financially sound
- Economically viable
- Technically appropriate

There could however, be additional factors for research projects.

People who are attracted to a career in developing country research are usually those who can identify gaps in knowledge, are able to design research projects and get satisfaction from the impacts when the (often) innovative outputs from research are applied for the benefits of others.

Additional factors in attracting motivated professionals into research is that they have the opportunity to work in an environment conducive to research, (i.e. in a respected research institution), have an assured career path with adequate standing within the organisation in which they work and that remuneration is at a level which will attract good professional staff. In some countries, transfer into the research branch is seen as a demotion. Whilst some experience in one's chosen field is often of additional benefit in a research career, being shunted into what is regarded as a dead end career-wise is hardly likely to inspire people to take up research or to attract the calibre of people who are the idea generators.

Components of sustainability for training and keeping good quality staff include:

- Strong and respected research institutions that are well managed.
- Present and future funding streams
- Career paths with fair advancement channels
- Remuneration compatible with the level of education and achievement.
- Partnerships with organisations of researchers and other research institutions
- Interesting and rewarding projects

Universities and other transport engineering education establishments also have a vital role to play in ensuring that engineers are aware of the potential impacts and benefits of research and innovation. These establishments have the opportunity to encourage students not only to take an interest in research where it might lead to a higher degree but also to take up research as a long-term profession.

Research is sometimes carried out to quantify what is known qualitatively or for adapting previous experience to current conditions and the local environment. This is especially relevant in adapting research requirements and outcomes to developing country needs.

Reviewing what has been done in the past and sharing knowledge with others are important aspects of successful research. Turning ideas and concepts into fully-fledged research projects is often achieved through discussion between professionals having similar interests. Therefore, links at both the personal level and between national and international research organisations are often considered essential in successful transport research.

Developing-country research projects in the transport sector can be particularly rewarding and enjoyable to work on. There is often a clear demand for the work and the impacts when the results are (eventually) implemented are often clearly appreciated by the local communities for whose benefit the research has been conducted.

Another important factor influencing both research and the take-up of research outputs is that donor funded research projects are invariably short-term whereas all the evidence suggests that its takes considerable time to build a sustainable research capacity and even longer to mainstream research outputs. 'Staying the course' is important if the benefits are to be accrued from investment in research. This also strengthens the case for building indigenous research capacity where the research and mentoring of the uptake of the outputs are not influenced by externally imposed time constraints.

The provision of the relatively small amount of funding needed for researching solutions would appear to be a sound investment for most developing countries, yet funding for transport research is still virtually zero in many of them.

3 RESEARCH NEEDS IN DEVELOPING COUNTRIES

3.1 Contribution of transport to MDG's

In developing countries, transport services are a vital component for the social and economic development of poor urban and rural communities. Reliable and sustainable access provided by good roads and efficient transport services enable the benefits from investment in other sectors such as health, education and agriculture to be fully realised. Indeed, although no transport goals *per se* were included in the Millennium Development Goals (MDGs), it is now widely accepted that the access and mobility provided by good transport services will be a key factor in the achievement of the MDGs in other sectors. The importance of the provision of transport services is recognised by the World Bank with 23% of its loans allocated to the transport sector.

These problems require specific local solutions and research is an important mechanism for deriving appropriate solutions and promoting innovation. Thus, research effort is needed in most of the areas related to transport. Collaborative research is effective, only if it fully involves local practitioners, education institutions and local research facilities. Community participation is a key factor in the acceptance and implementation of projects based on research evidence. The involvement of local practitioners, institutions and communities is vital in identifying local problems associated with the provision of access and transport services. These inputs are also essential in helping devise the solutions that meet the need for safe and sustainable access and greater mobility for people living in urban and rural areas of the developing world.

Components for increasing the likelihood of project success include:-

- The inclusion of implementers into the project planning process
- The use of good quality local researchers with respected credibility
- High level support and awareness from local partners
- The use of media support to increase public awareness of potential benefits

3.2 Quantitative evidence of research benefits

Research is the mechanism for the advancement of knowledge and for social and economic progress worldwide. It is the proven method for developing and testing new and innovative ideas. The results of successful research, combined with demonstration projects, enable practitioners to adopt and apply new and innovative approaches with confidence. A UK government report in the mid 1990's concluded that for every £1 million spent on R&D, society in the UK benefited by £20m annually [3].

Unfortunately, the transition from successful research/demonstration to the implementation and mainstreaming of new technology is often extremely difficult and it seems to be particularly difficult in road engineering. In the UK, it has been reported that "although the UK has a good track record in the intellectual aspects of Research and Development, it tends to be less equipped to apply and exploit the results and that somehow, the country's undoubted technical ability often fails to be carried through to application". Therefore, it seems that the process of transference of knowledge into practice might well be a universal problem.

There is relatively little evidence available that provides a broad quantitative overview of the cost effectiveness of transport research. Individual projects are occasionally subjected to economic evaluation but there is little evidence of the economic case for global investment in transport research. Studies that have been conducted have been carried out by research institutions themselves as part of the justification for investment in their research activities, although these studies also appear to be in relatively short supply for the transport sector in general. More evidence is available on the benefits from individual innovative and demonstration projects based on the results of research. However, only rarely are the benefits related to the investment costs of the research itself, on which these initiatives were based.

The benefits of research aimed at influencing policy are difficult to evaluate in monetary terms as are research projects that yield social or environmental benefits. Many of the benefits from rural transport initiatives yield benefits that are predominantly social, such as facilitating visits to health centres, opening up employment opportunities, providing improved access to education etc. It is often difficult to quantify these benefits in monetary terms, even if there is alternative evidence that the results of the research, when implemented, have a positive impact. The importance of identifying these benefits is now well recognised as is the need to quantify them in monetary terms wherever possible. A number of papers published recently give guidance on the evaluation of social benefits directly or by proxy or by assigning weights to these benefits to enable them to be included in economic appraisal and evaluation rather than as an add-on as has often been the previous practice.

The benefits from research begin with the implementation of the results. These can begin to accrue quite quickly, if implementation follows immediately after the completion of the research. More usually, there is a delay between the time that the outputs of the research become available and implementation, and there are a number of reasons for this. For example, changes in legislation may be needed to enforce the wearing of seat belts. In engineering, revised standards and specifications may need to be documented to cater for significant changes in practice. Deregulation may be required to encourage or allow competition in the provision of new transport services. In these circumstances, the initial benefits from research may be delayed but benefits may then continue to accrue over many years.

Cost Benefit Analysis (CBA) is the normal method used for economic evaluation of projects and the results are usually quoted as the Benefit/Cost ratio (B/C), Net Present Value (NPV) or Internal Rate of Return (IRR). The NPV can be regarded as profit from the research. The ratio of benefits to cost (NPV/RPV) provides evidence of the profit in relation to the cost of the research. The IRR is the discount rate that reduces the NPV to zero. This measure is sometimes favoured

by aid agencies because it does not require disclosure of a country's discount rate. The '1st year rate of return' is a measure which is sometimes used for timing the start of projects.

In order to compare the costs and time dependent benefits, costs that are incurred over the research period and the benefits that subsequently occur over a given time period are discounted (or compounded) to a fixed point in time usually referred to as the base year. The rate at which costs and benefits are discounted over time is referred to as the discount rate. This rate has a considerable influence on the value of benefits that accrue over the analysis period with long-term benefits being valued less than those that occur in the short-term. In general, the higher the discount rate then the lower will be the total benefits over time, discounted to the base year.

One of the few attempts to evaluate the benefits of a range of transport research projects and relate them to input costs was carried out by the Transport Research Laboratory (TRL) in the United Kingdom [4]**.** This work was completed some 15 years ago and the costs and benefits reflect the value of the currency at that time but it remains relevant in terms of demonstrating the benefits/cost ratios of the research.

The benefits were estimated for a twenty year period from the time that they started to accrue. This does not imply that benefits would not continue to accrue after this period but they would be significantly reduced in the economic analysis through discounting. Assuming the benefits were the same every year, they could be expected to increase by an additional 13 per cent on average, if the analysis period was extended to 30 years.

Predicting benefits is uncertain but the study was conducted approximately halfway through the 20 year analysis period. Thus for most projects, it was possible to assess the impact of the research for the first 10 years with some certainty about the achieved benefits; and possibly with less uncertainty than is usually the case, in predicting future benefits for future years. For each project, estimates were made of the NPV, NPV/RPV (RPV - the present value of the research) and IRR for three scenarios, namely 'low success', central estimate and high success. The central estimate results are shown in Table 1.

Table 1 Summary of Return on TRL research projects – central estimates

Purpose of Research	Cost of research £m	Average Benefit over 20 yrs £m	NPV from 1992 base £m	NPV/PV of research Ratio	IRR %
Reducing road construction and maintenance costs	0.48	3.3	25	43	51
(a) Soil nailing	0.75	2.6	26	28	60
(b) Reinforced embankments on soft soils	1.21	15.0	114	75	56
(c) Off-site recycling of bituminous materials	0.1	0.2	1.7	14	45
(d) Strengthening masonry arch bridges					
Saving accidents					
(a) Effect of macro-texture on accidents	2.6	284	1783	447	49
(b) Seat Belt wearing	8.59	112	3241	73	33
(c) Accidents at roundabouts	0.62	14	142	106	50
(d) Urban safety management	5.35	62	526	28	44
(e) Front under-run guards on HGV's	0.66	20	107	91	31
Cutting congestion					
(a) Roadworks on motorways	0.57	11	109	165	- [(a)]
(b) SCOOT urban traffic control	3.92	54	942	112	73
(c) MOVA self-optimising signal control	2.23	32	248	69	43
Average for 12 projects	2.26	51	605	104	49

Source: TRL Project Report 86

(a) Implementation of the research on "road works on motorways" began within one year of the start of the research, which is unusual. The IRR is very sensitive to early returns and gave a value in excess of 1400% for this project.

With 1992 as the base year, the total central estimate of the NPV of all the projects was £7300 million with a range from £3500 million for the low success scenario to £11800 million for the high success scenario.

The results showed that all twelve projects in the study would pay for themselves within less than 6 months. *The annual benefits for the 12 projects over 20 years was 15 times the annual costs of all TRL projects (over 400) being undertaken in the base year.*

Whilst the study demonstrated very clearly the large benefits that can accrue from research, it also showed that even projects that produce high returns may take over 10 years to do so.

Additional evidence is available from selected case studies from other research facilities on the observed and projected benefits of the implementation of the results of various research projects and these are shown in Table 2.

Table 2: Returns on investment on implementation of research projects

Project	Benefit/cost Ratio
Louisiana Pavement Research Facility	5.3
California heavy Vehicle Simulator Programme	3.7 – 8.3
Australian Accelerated Pavement Testing Programme (ARRB)	3.8 – 4.9
Asphalt servicing for roads in tropical environments (TRL)	8.0
Transport Research Board Projects (USA)	2 – 44
Utah Department of transportation research	9.0
Selected Research projects in Texas	77 – 3200
Kansas Transport Research Programme in total	15
Canadian research into heavy vehicle weights and dimensions	1 000

A smaller study was undertaken by the Australian Road Research Board (ARRB) and a more recent review of the benefits of research was included in a paper entitled 'Why invest in research? – A Review of past research outcomes [5]. The benefits from research investments in the roads sub-sector were reviewed in the paper. Other examples are available in research literature in which the qualitative impacts of research are evident but they have not been quantified in economic terms.

3.3 Transport research in developing countries

In recognition of the evidence that investment in transport research usually yields high benefits, the UK Department for International Development (DFID), spends about £4m annually funding transport research in developing countries. Research has proved to be effective in devising innovative and cost-effective solutions for the provision of access and the facilitation of transport services that meet the need for safe, sustainable access and greater mobility for the poor in developing countries.

Most developing countries in Africa and Asia achieved independence in the 1960''s and, at that time, there were relatively few qualified professionals available to carry out the essential tasks required by the transport sector. Understandably, research was of a low priority. Although human resource constraints may still occasionally be a problem, many developing countries are now much better equipped to carry out research. However, over 40 years later, many countries still

rely on developed nations to conduct the research required to solve their problems in the transport sector. Although developing countries are increasingly aware of their problems, few have set up the institutional frameworks required to facilitate the transfer of existing knowledge or to conduct the research in the transport sector that would help solve these problems.

4. EXAMPLES OF THE BENEFIT FROM RESEARCH IN THE TRANSPORT SECTOR

4.1 Examples of beneficial research

In many developing countries, much of the documentation for the provision of roads was inherited at independence and stemmed from technology and research carried out in Europe and the USA some 30 – 40 years ago, usually in vastly different environments. Many of the approaches for rural roads were based on roads designed to carry considerably higher volumes of traffic. Thus the methods often reflected inappropriate standards and technologies and did not address developing country conditions in terms of traffic, human resources, climate and materials. Local knowledge was rarely recognized. Changes have inevitably occurred, although this situation still prevails to some degree in many countries.

Recognizing these issues, the UK government funded research in road engineering specifically to address these problems in southern Africa in the early 1980's. The research was conducted in Botswana where an extension of the road network across the Kalahari Desert was planned which would link the eastern and western parts of the country. In this region, good building materials which met existing specifications were scarce. At that time, the sand did not meet the specifications for sub-base, the calcareous gravels did not meet the specifications for base course and the harder aggregates meeting the strength requirements for surfacing stone were not available.

The research carried out by the UK Transport Research Laboratory (TRL) identified many anomalies in our previous understanding and questioned some of the accepted paradigms associated with the provision of low-volume roads [6]**.** It showed that such roads can often be provided more cheaply and cost effectively and indicated the need to re-think the whole approach to providing low-volume sealed roads (LVSRs). When the results of this research have been implemented, usually in the countries in which it has taken place, the impact has invariably been highly beneficial. However, for some time, uptake of the research was poor and there is clearly a major problem in the transition path from the acquisition of new knowledge to its embedment in engineering practice.

4.2 Responding to problems and issues in the transport sector

The provision of effective and efficient transport is not only a pre-requisite for greater rural access, it is essential for trade and for economic development. In Africa, 80% of the continent's goods and services are carried by road but it has transport costs that are amongst the highest in the world.

The transport problems in developing countries are inherently different from those in more developed countries and typify the need for local solutions. The prevailing road environment is often different with climatic factors having a considerable influence on the design and performance of road infrastructure. The mix of traffic on both urban and rural roads is different from developed countries and also often differs between developing countries. Pedestrians, pedal cyclists and various forms of non-motorised transport compete with motor cycles, cars, trucks, buses and various other motorised vehicles for the use of the available road space and this often results in situations in which the most vulnerable road users are particularly at risk.

4.3 Gravel roads

In some developing countries, over 90 per cent of the road network remains unpaved. Maintaining these roads in a condition that provides all-weather access is becoming increasingly difficult as good gravel resources become depleted whilst traffic increases. In many developing countries, gravels for road construction are simply unavailable within economic haul distances and even in others with gravel resources, supplies are depleting rapidly. This leads to a situation where gravels of decreasing quality are used for both road construction and maintenance with an ever-increasing frequency in the cycle of deterioration and the need for repair. Maintaining unpaved roads to a standard that ensures sustainable access is thus becoming an increasingly difficult task.

Rural road networks consist predominantly of roads of gravel or earth construction as shown in Figure 1. In some countries, much of the trunk road network also remains unsealed. In Tanzania, for example, only some 7 per cent of the entire classified road network is bituminised. Rural roads are often a lifeline for rural communities. Studies carried out in S.E Asia found a strong correlation between lack of access to basic infrastructure and poverty. Conversely, villages provided with road access produced more than they did before [7]. The problem with gravel roads is that they often deteriorate rapidly, especially in the wet season, disrupting transport services and access to health centres and markets when it is most needed.

There are many issues surrounding the low initial-cost provision of gravel roads. These include

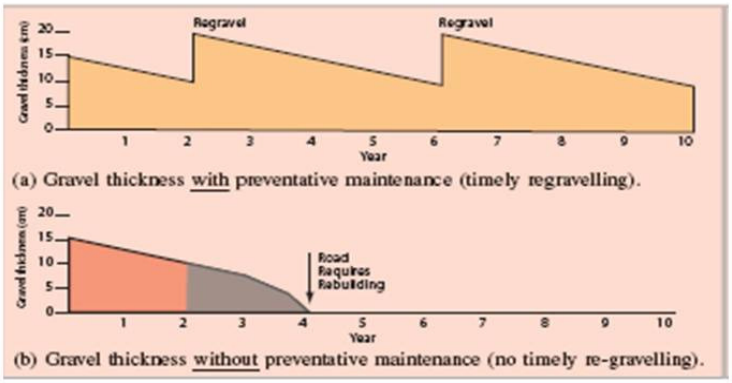
- Short road-life expectation due to erosion and wear.
- Lack of drainage and watercourse crossings,
- the damage to health and detriment to farming productivity from dust,
- the damage to road users and equipment from rough roads

Figure1. Typical problems on gravel road networks

There is undoubtedly increased expectation amongst communities in general and the rural poor in particular, that governments will provide and maintain roads in a condition that facilitate all-weather access and regular transport services. Despite the best intentions of governments to

provide roads with a sealed surface and the significant benefits that accrue to rural communities from sealing roads in terms of all weather access. For countries such as Tanzania and many others, unsealed roads will remain a significant part of the network for many years to come. This presents a particular problem for maintenance engineers.

The need for greater sustainability from investments in rural roads is well recognised. Gravel roads are reconstructed or rehabilitated at frequent intervals often with little in the way of lasting improvement (Figure 2). In the SADC region of Africa alone, it is estimated that some 150 million cubic metres of gravel are consumed annually. Gravel roads will remain a significant part of many rural road networks in developing countries worldwide for many years. The cost of maintaining these roads to an acceptable standard is unsustainable in the longer term as good gravel resources become depleted, regravelling cycles become more frequent and haulage distances increase; a situation that already exists in some countries whilst in large areas of other countries, road building materials that meet conventional standards are just not available.



Gravel roads deteriorate rapidly if not maintained by timely grading and regravelling

Figure 2 Maintenance of gravel roads

In recent years, the management of road maintenance has improved significantly in some countries through the establishment of Roads Boards with dedicated funding for maintenance derived from road user charges and fuel levies. There is, however, a limit to the scale of the charges that can be incurred before they increase road user costs and impact negatively on the economy of the country overall. As economies grow and traffic increases the rates of deterioration on gravel roads are likely to escalate and the problems associated with the maintenance of gravel roads will be exacerbated. Gravel roads will remain a significant proportion of rural road networks for the foreseeable future. There is a need to consider options that make investments in sealed roads more attractive through technical innovation and the capture, in monetary terms, of the social, environmental and other benefits as well as the economic benefits of upgrading to a sealed road standard.

Despite the establishment of Road Funds that have increased funding for road maintenance, financial resources remain insufficient to pay for the ever increasing maintenance as road networks expand. Rural communities are demanding roads that provide year-round unimpeded

access and better opportunities for improved mobility. This presents a major challenge for practitioners in the road sector

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4.4 Urban mobility

The programmes highlighted in this paper are aimed primarily at improving safe and sustainable access for the rural poor but the mobility of the urban poor is also of concern. A significant movement of the rural population to urban centres is underway in many developing countries as the rural poor seek access to economic opportunities in the hope of improving their livelihoods. In some countries where most people once dwelled in the rural areas, the urban population now exceeds 60% of the total population. It is estimated that in Asia, by 2020, 4 billion people will be living in 2,500 cities with populations exceeding 100,000 [8]. The effect of urban population growth on traffic congestion is already apparent in many towns and cities in Asia and elsewhere. The problem of moving people in these cities is one that will exacerbate in the future. Research will also be required to help devise solutions that meet the mobility needs of the urban poor.

4.5 Road Safety

The safety of all road users in developing countries is of increasing concern. While the rate of road accidents is decreasing in Europe, it continues to rise in most developing countries. Over 3,000 deaths from road accidents are reported every day worldwide with 85% of these in developing countries [9]. Over 30,000 serious non-fatal injuries are *reported* per day but the actual figure is estimated to be much greater and is currently estimated to be of the order of 150,000 [10]. This is not only an enormous human tragedy but it comes with a severe economic cost. Many developing countries are losing over 2% of GDP due to road accidents. This cost to society in developing countries in 1997 was estimated to be $65 billion, which was equivalent to the total official investment in development aid.

Road traffic accidents in the developed world are decreasing, mainly through the introduction of road safety legislation, awareness and training based on research. Development agencies have funded research into road safety in developing countries through various organisations such as Sweroad, TRL, ARRB and others. As early as the mid 1960's newly independent nations were alerted of the growing problem of road deaths and injuries in Africa, Asia and Latin America. However, road accidents in the developing world continue to rise. The poorest road users, such as motor cyclists, pedal cyclists, users of NMTs and pedestrians are particularly vulnerable. Pedestrians form between 13% and 20% of road casualties in the USA and Western Europe but this figure rises to between 50% and 60% for developing countries. However, road planners and designers rarely make provision for these traffic categories, even in circumstances where they comprise the majority of road users.

Road design is only one factor in road accidents but appropriate design is particularly important on rural roads for the safety of these vulnerable road users. Research is being undertaken together with implementation programmes to improve the design of roads that provide safe as well as sustainable access.

5 KNOWLEDGE DISSEMINATION AND TRANSFER

There is little point in carry-out research and producing innovation, if due to minimal dissemination, awareness is stifled, implementation is spasmodic and few beneficiaries. from the investment.

5.1 gTKP

DFID supported the establishment of the Global Transport Knowledge Partnership (gTKP) [11] to facilitate the sharing of knowledge. It is an innovative partnership working through existing initiatives established by its partners to make effective use of available knowledge and increase

the capacity of less developed countries to access and apply knowledge and good practice. gTKP is a global organisation providing opportunities for networking between practitioners and the building of partnerships through its website.

Good road infrastructure is essential for developing countries to compete in world trade. Change is needed now to have an impact by 2020. gTKP aims to contribute by facilitating knowledge sharing of new initiatives and research outcomes in the transport sector. Evidence of good practice is made available to policy makers through the Technology, Infrastructure and Planning Resource Centre (TI-UP).

gTKP's activities are overseen by a steering group comprised of international experts with day-to-day activities managed by the Core Management Group. gTKP offers advice and support in seven theme areas

- Environment and Climate Change
- Finance and Economics
- Governance
- Road Safety
- Rural Transport
- Social Development
- Urban Transport

Each theme is headed by a champion and gTKP services are free.
Development agencies such as the DFID in the UK and the World Bank also support activities to stimulate knowledge sharing and the uptake of good practice derived from research.

5.2 TRS

DFID is also cooperating with the World Bank on the project for Transport Research Support for inclusive growth (TRS). The aim of this programme is to facilitate interventions in the transport sector supported by the World Bank and other development partners to contribute to sustainable growth and the needs of the poor in developing countries. The programme will use the experiences from previous collaboration in the Transport and Rural Infrastructure Services Learning and Sharing Partnership (TRISP) to focus on key emerging research issues and the application of lessons learned.

5.3 Knowledge transfer into practice

The "local" content in both the consulting and the contracting component of road projects (especially sealed roads) in some developing countries is often small or at such a level that there are virtually no opportunities for local practitioners to influence either the design or the construction methodology. In these circumstances, technology transfer in either direction is stifled and the long-term goal of sustainability through technology transfer, about which so much is spoken, is unlikely to be achieved [12].

Although further research in the transport sector is still needed the benefits from the application of existing knowledge for the cost-effective provision of improved access and mobility of the poor in developing countries are already very large indeed. In the few instances where innovative and unconventional approaches developed through research have been successfully put into practice, the outcomes have invariably been highly beneficial and cost effective. However, even when the results of research are published, there appear to be almost insurmountable obstacles in achieving the processes of technology transfer and subsequent implementation.

There is also a need for engineers and other professionals to be trained at an early stage, not only in good engineering principles but with the skills to be innovative and knowledgeable of alternative sustainable development techniques. This is especially important in situations where conventional specifications are not affordable and appropriate materials are unavailable.

Education and training establishments can play an important role in fostering an environment in which research and innovation are encouraged. Local universities and other tertiary education establishments in developing countries should also be encouraged to partner established research organisations in applied research projects. Such arrangements would foster knowledge exchange, facilitate the longer term commitment to research and enable more time to be given to the mainstreaming of research outcomes.

Engineers in donor agencies, roads departments and consultants need to be far more flexible in the design, construction and maintenance of low-volume roads if the findings from research studies are to be put into practice. Only in this way will the benefits of the investment in research be fully realised. The penalty for not adopting new ideas and technologies is that progress through development is impeded.

The process of technology transfer and mainstreaming new technology would be also facilitated by increased support at the higher political levels and by greater involvement in research by local practitioners.

5.4 The SADC Guideline

In recognition of the need to raise awareness and encourage application of recent developments in low-volume road technology, the transport arm of the Southern African Development Community (SADC) commissioned the TRL to produce a *Guideline on Low-volume Sealed Roads* [13]. The project was funded jointly by the UK's Department for International Development (DFID), the Norwegian Agency for Development Cooperation (NORAD) and the Swedish International Development Cooperation Agency (SIDA).

The document highlighted the need for a change in approach in the various components of low-volume road provision for road users in Southern Africa (Figure 3) and the benefits of applying revised practice based on research evidence.

The first draft of the *Guideline* was compiled following a series of technical workshops attended by delegates that included government officials, consultants, contractors, researchers from the SADC member states and the TRL project team. The key purposes of the workshops were to involve regional practitioners in the development of the *Guideline*, to capture and incorporate local knowledge and to build an authoritative and influential team to take the project forward. At these workshops the format of the document and the outline contents of each chapter were debated and agreed. Further workshops were held in each SADC country to review the draft and complete the document. Thus the project included a total of 18 extensive and detailed workshops, underlining an almost unprecedented degree of consultation and local participation that was considered to be essential for achieving the objectives for local ownership of the *Guideline*.

The Guideline is designed to accommodate the many different road users, all of whom have different requirements and needs, including

- Pedestrians, children
- Cyclists
- Motorcyclists
- Animal drawn carts
- Vehicles and pickups
- Wagons and hauliers.

Figure 3 Typical rural road users in Africa

The main outcomes from the research encapsulated in the *Guideline* are:

- that traditional highway engineering, applicable to roads with higher volumes of traffic, is not appropriate for rural roads in developing countries
- the importance of adopting more holistic, sustainable approaches to the provision of low-volume roads
- the need to revise conventional approaches to planning, economic appraisal and the environment
- the shortcomings of conventional specifications (often imported) and, to some extent, test methods, for assessing the adequacy of local materials for use in the construction of rural roads
- the advantages of adopting more appropriate geometric and pavement design standards that provide for the safe use by all road users
- the economic success of innovative construction methods
- the importance of paying greater attention to the environmental aspects of road provision.
- the need for dialogue with local communities.
- the need to adopt a whole-life or life-time approach to investments in all roads including low-volume rural roads.

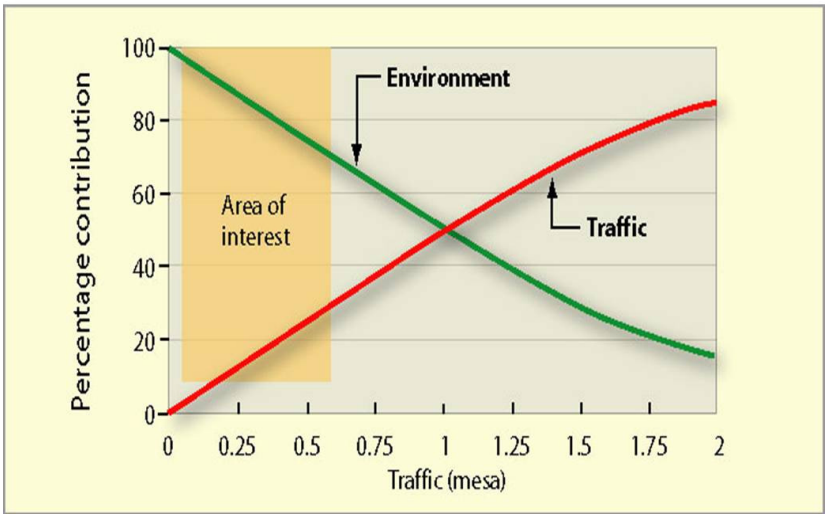

Figure 4 The relatively higher component impact of pavement environment

The results of research demonstrated the influence of road environment on the performance of low-volume roads as being important (Figure 4).Two factors which were found to have a particularly beneficial effect on the road environment were sealed shoulders and crown height. For countries in southern Africa, a sealed shoulder width of at least 1.0metre and a minimum crown height of 0.75metre were recommended. If applied, then these two factors alone help provide a drier pavement environment and have enabled materials that were previously considered to be unsuitable to be used in the pavement structure with much reduced costs. The research also demonstrated the need for local specifications and standards.

Another important development which reduced surfacing costs while increasing durability was the introduction of the Otta seal concept to Africa in research projects carried out by the Norwegian Public Roads Administration (NPRA) on behalf of Norwegian government. The Otta seal enables use to made of locally available weaker aggregates for road surfacing and is ideally suited for rural roads. Specifications were developed through research for the adaptation of this type of seal to African conditions [14].

Perhaps the most important single overall outcome from the research and the life-time costing approach adopted in the *Guideline* is that upgrading to a sealed road can be economically justified at much lower levels of traffic. This has facilitated the upgrading of many more rural roads than would have been possible hitherto.

6. EXAMPLES OF THE APPLICATION OF RESEARCH OUTCOMES

The *Guideline* raised awareness of the new approaches within the SADC region and elsewhere and changes in practice have occurred in a number of countries as a direct result of applying recommendations made in the *Guideline*. The lower life-time cost options for the delivery of sealed rural roads has encouraged some practitioners to try more innovative and sustainable approaches but the take-up has been slow. It seems that creating awareness of new technologies and the results of research are insufficient actions alone to motivate engineers in the road sector to undertake new approaches. Consequently, DFID has embarked on programmes that provide opportunities for practitioners to put evidence-based approaches into practice and act as a catalyst for partner countries to undertake research where this is needed.

6.1 SEACAP

The first of these programmes was initiated in South Asia in the DFID-funded South East Asia Community Access Programme (SEACAP) carried out in collaboration with the governments of Cambodia, Laos and Vietnam, the Asian Development Bank (ADB) and the World Bank.

Picture courtesy of gTKP/OTB

Figure 5. Road Users in S.E. Asia

Examples of roads constructed with different types of surfacing under SEACAP are shown In Figure 5 below. It should be noted that use has been made of non-bituminous local materials converted into materials suitable for road surfacing and include the use of stone sets and clay bricks.

SEACAP provided opportunities for applied research, communicating the research outcomes to stakeholders and supporting the mainstreaming of solutions derived from research. The programme identified and supported the uptake of low-cost, proven solutions for rural access. It focused on the needs of both rural women and men (Figure 5) and aimed to maximise the use of local resources, including labour, materials, enterprise and ingenuity.

Whilst many of the problems of rural roads in Asia are those experienced by road users in many developing countries worldwide, there are also problems which are not common to all countries. Some of these are shown in Figure 6 and again re-enforces the need for local solutions to local transport problems.

The programme started in 2004 and has expanded to include more than 30 projects. It is probably too early to quantify the benefits of the research in economic terms but evidence is emerging of the impact of SEACAP's research, dissemination and mainstreaming achievements.

In Cambodia, agriculture is the predominant activity of rural people and the poorest spend 450% more time travelling 3 times farther than people with better access. The impacts of improved

access roads include an increase of loads by between 2 and 5 times, agricultural surplus comprise 61% of loads, 80% of market traffic is between local villages, 55% of vendors sell goods at lower prices and a 600% increase in the volume of trade. These benefits are quickly reversed if the infrastructure deteriorates [15]. Unfortunately, preservation of the road asset remains a problem that needs to be addressed by better transference of knowledge into practice – the SEACAP objectives.

Figure 6. Typical problems in S E Asia

Access roads in remote areas of Vietnam were in a very poor condition denying rural communities access to education, healthcare and opportunities for economic growth. Revised specifications have enabled greater use to be made of local road-building materials, thus reducing costs and increasing the provision of roads that provide sustainable access.

The SEACAP unsealed road investigations found serious constraints to the use of gravel in most of the studied 16 provinces in Vietnam due to factors relating to material quality, material availability, climate, terrain, drainage provision and maintenance. Overall gravel loss figures indicate that around 58% of the surveyed sites were suffering unsustainable deterioration (>20mm/year), while 28% were losing material at twice that sustainable rate as shown in Figure 7.

The research on gravel roads in Vietnam has yielded valuable information on rates of deterioration and has raised serious questions about the cost and capability of authorities to maintain some gravel roads. The evidence from this study also supports evidence from Africa that it may be more cost-effective in terms of whole-life costs, to construct a sealed road even at relatively low levels of traffic, if access is to be sustainable.

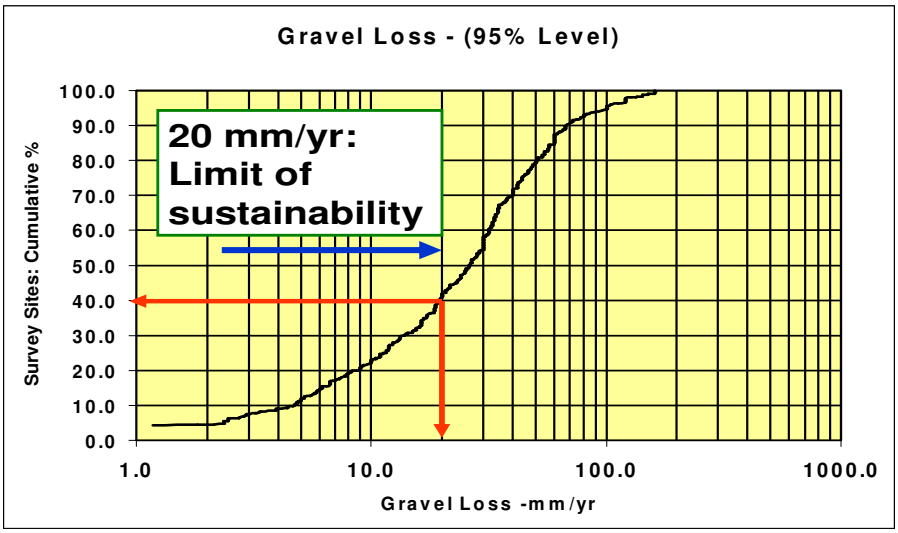

Figure 7. Gravel loss on roads in Vietnam

The combination of steep terrain, weathered soil-rock profiles and high rainfall in parts of Laos, Vietnam and Cambodia result in conditions in which road earthworks can become unstable leading to landslips and erosion as shown in Figure 10. One of the projects in SEACAP consisted of field trials to provide input to the Transport Sector Project for the management of slope stability problems [16].

Figure 10 Landslip and remedial works in Laos

Manuals and handbooks for the management slope stability problems were developed based on evidence from the trials as well as integrating the knowledge base into the National University of Laos (NUoL) engineering curricula. Examples of these problems and the restoration works are shown in Figure 10.

As a result of SEACAP research, revised standards and specifications for low–volume rural roads have been accepted by the MPWT in Lao. Similar work in Cambodia is in the process of being developed and implemented. In Vietnam a range of road specifications have been adopted on a temporary basis by the Ministry of Transport and recommendations have been made for a review of standards [17].

Trials have also been constructed to demonstrate a variety of road paving options in Vietnam, Lao and Cambodia. In Vietnam, for example, over 140km of trial roads have been constructed under SEACAP with over 12km of short sections being regularly monitored for performance [18]. Technology transfer, training and education are also important components of SEACAP. The training programme has received plaudits from the collaborating government departments in the region. Training the trainers is seen as an important way of transferring knowledge from central to provincial and district level.

SIDA and SEACAP are supporting modules in education establishments to raise awareness of the benefits of research and of alternative approaches to rural roads and transport provision by technicians and engineers during their training phase.

Overall benefit ratios for interventions in the transport sector in Vietnam are estimated to be in the range of 5% to 50% [19].

6.2 AFCAP

In 2008 DFID initiated a similar programme to SEACAP in Africa [20]. The African Community Access Programme (AFCAP) is providing advice and undertaking research to facilitate the delivery of safe and sustainable access for poor communities in Africa. It is based around a portfolio of research, demonstration, advisory and training projects and it is linked to the sub-Saharan Africa Transport Programme (SSATP).

AFCAP also aims to 'close the loop' between research and application which has often proved elusive. The outputs of the programme are expected to feed directly into regional and national governments' rural transport policies and strategies for poverty reduction.

Projects are currently underway in Mozambique, Ethiopia, Malawi, Kenya and Tanzania. The projects embrace a wide spectrum of research activities in the transport sector and include topics such as road maintenance, training and knowledge sharing, as well as opportunities for demonstrating innovative engineering solutions to local problems.

The expected outputs of AFCAP have the potential to significantly reduce the estimated $12 billion annual costs of the operation and maintenance of roads in Africa.

6.3 Risk Factors

One of the arguments often voiced against using new technology or approaches is that the level of risk may be unacceptable. Whilst it must be conceded that any departure from well-established standards and specifications may carry some increased level of risk of failure, these risks are mitigated through research. For example, research to characterize the properties of non-standard local materials that have performed well in test sections now make it possible to utilize them with greater confidence and less risk than hitherto. It is the role of researchers to assess the risks associated with revised technologies, methodologies specifications and

standards so that the perceived risks in their use can be sensibly managed. Factors of safety to mitigate against risks are usually incorporated in recommendations emanating from research.

7. SUMMARY

Benefits from research

Countries that invest most in research reap larger benefits.

Research projects in the transport sector generally yield significant social and economic benefits.

The evidence suggests that developing countries need to invest more of their own resources in research and development.

Solutions developed elsewhere can often help solve local problems but the best solutions are often those that are developed locally through research. .

Research has shown that there are very large potential savings to be made from application of research in the transport sector in developing countries, including in low volume road provision.

If developing countries are to attract support from development agencies in building research capacity, then a clear commitment to sustainability and productivity is needed.

Implementing research outcomes

Research itself is insufficient. More effort needs to be made in facilitating research outcomes into practice.

High level local support is required for the prioritisation of research and the mainstreaming of new and innovative technology derived from research.

Researchers (preferably local) should be involved in planning projects in which outputs from research are to be implemented.

Attracting graduates into research

Local education establishments have an important role in encouraging students to take up research as a profession, establishing an environment conducive to research and in enabling the longer time frame necessary for the implementation and mainstreaming of research outcomes.

For a career in research to be attractive, then the institutional, physical, and financial incentives must be in place to attract people of the appropriate interest, calibre and skills.

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