A New Approach to Delivering Greener Infrastructure for Developing Countries

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Abstract *— Infrastructure is a major component of a country's public asset. Transport is a major component of this substantial asset and road pavements are a critical transportation infrastructure asset.*

Index Terms *— Greener infrastructure, developing countries.*

PAGE LAYOUT

Infrastructure is a major component of a country's public asset. Transport is a major component of this substantial asset and road pavements are a critical transportation infrastructure asset. Almost 60% of the World Bank's infrastructure lending portfolio is transport and of this some 70% is invested in highways. In many developing countries around 60% of the funds invested in highways are spent on road pavements.

Sustainable ('Green') infrastructure is constructed in a manner so as to minimize its impact on climate change. With the World Bank actively pursuing means to reduce greenhouse gas (GHG) emissions associated with lending projects, transport projects that include a large investment in infrastructure should be a key area of focus. There are, for instance, a number of new and emerging "green pavement" technologies that significantly reduce the carbon footprint especially those emissions associated with the production and laying of asphalt. These technologies are available to many Bank client countries but there are two perceived impediments to their adoption:

These approaches are perceived to cost more than traditional technologies and construction in the short-term; and,

Lower-Income Countries (LIC's) are often unaware that these options exist.

Insufficient evidence is available on the durability and cost-effectiveness in whole-life terms (including total environmental costs) and benefits of alternatives

However, the World Bank's Carbon Finance Unit (CFU) can leverage emissions trading to offset the additional costs of adopting these technologies and they can, therefore, be made more affordable to clients. Thus, through the development of appropriate information materials, there is the scope to assist the LICs in adopting more sustainable infrastructure technologies which will reduce the GHG emissions from Bank projects.

There may also be substantial carbon reductions from the use of labor-based or intermediate technology in specific areas such as rural transport and in the development of greener alternatives and in reductions in the use of bitumen, cement and, as a consequence, in the use of fossil fuels. There are also very different features and operational environments in road works within developing countries and the different carbon consequences l could justify the need for a separate evaluation of impacts from that in developed countries.

An important factor is also the size and physical design of infrastructure and the factors which determine greener preferences. For instance, planning a road to go over or through a hill presents design options of which the green consequences are unclear, taking into account factors such as the longer-term additional fuel consumption to go over a hill against the more immediate environmental consequences of tunnelling.

A useful tool for future decision making in the design and management of transport infrastructure could be a 'Carbon Bill of Quantities' (CBOQ) for every construction and maintenance activity in parallel with the usual BOQ, and could be assessed through a life cycle analysis approach. Alternative techniques for each construction and maintenance activity and knowledge of the greenhouse gas implications for each potential option will be necessary. A model is required that will be able to accommodate factors such as local materials and technology, logistics, environment and alternative methods and practices with the objective of producing a carbon footprint table for, for example, each road surfacing and pavement option in terms of construction and maintenance operation needs from natural earth surface through to concrete paving options.

With this approach, an increase in the percentage of uptake of greener infrastructure projects in Lower Income Countries could be achieved. These countries will benefit from lower cost (in terms of total environmental and economic impact) and greener infrastructure with the adoption of new technologies, methodologies and planning guidelines If this approach is adopted, even on a limited scale, it will contribute towards the reduction in the GHG emissions.

Decision makers are realizing that they can offer their countries a triple benefit: the right investments can simultaneously create jobs today, lay the foundations for growth tomorrow, and fight environmental degradation and climate change.
Typically road transport accounts for about 90 percent of the transport sector's CO2 emissions with an average increase in energy use by road transport increasing more than fivefold between 1970 and 2010. Developing countries also suffer from the importation of used vehicles from developed countries that fuels vehicle fleet growth
leading to an increase in the average fleet age and concerns about low efficiency engines and exaggerated emissions of air pollutants.
In order to reduce greenhouse gas emissions in the transport sector there needs to be an evaluation of what makes a greener infrastructure and why. Three areas to focus research upon are

- Optimizing transportation routes,
- using less energy thirsty materials,
- adapting construction techniques

Initial analysis has revealed the importance of addressing transport issues in an integrated and programmatic approach rather than as individual measures. The interventions with the largest potential that are most cost-effective are those that decrease the percentage of carbon the most whilst not diminishing quality or value for money principles.

Initial meta – analysis findings indicate that benefits can easily be achieved by -

- Promoting more sustainable transport planning and infrastructure policies can provide numerous co-benefits in addition to climate change mitigation, including reductions in traffic congestion (and the associated time savings per trip) and improvements in public health as a result of reduced air pollution.

- Promoting also the lower carbon alternatives for material use and construction techniques, such as eliminating hot mixed asphalt use and reducing cement use in structures.

The research that this paper proposes will address some of the issues, myths and perceptions about what 'Green Infrastructure' actually is and why. It will describe some of the initiatives being undertaken that hope to take advantage of the subsidies available in providing green infrastructure and whether or not current initiatives are succeeding.
The research will consider options of different approaches and incentives to providing green infrastructure and provide examples of instances where these approaches have been put into practice and what the outcomes were. It will also look at future needs for research. It will also give some insight into what also needs to be investigated for this topic and what the likely cost to benefits ratio might be.

Part 1 of this research proposal below examines the effect of non-green roads on health, economics, agricultural productivity and is discussed below

Greener Roads
Part 1 - Dust impacts form unpaved roads
In many developing countries, the majority of roads remain unpaved. In Africa, countries such as Ethiopia and Tanzania have less than 10 percent of the road network paved and in these countries, even parts of the strategic road network remains unpaved. The majority of unpaved roads are in rural areas. However, in many areas of municipal housing and in informal settlements of urban areas, roads are also often of earth or gravel construction.
Residents living near these unpaved roads and the majority of road users in rural areas are regularly exposed to traffic-generated dust. This negatively impacts on their environment, on their health, on their livelihoods and on their safety when travelling. Unpaved roads require frequent maintenance. In many countries good quality gravel resources for road construction and maintenance are rapidly becoming depleted whilst in areas such as the Mekong delta region in South East Asia, gravelly material is extremely scarce. As a result, poor quality material is increasingly being used with the inevitable consequence of an increased frequency in the cycle of deterioration and the need for repair. Materials that are less durable also tend to produce more dust.
Some high-income countries also have significant lengths unpaved roads such as the USA, Australia Canada and New Zealand and it is in these countries that most of the work on dust control has been carried out. Various products have been used to control dust with varying success. Some, if used in the right circumstances can be effective, although repeated application is necessary for effective control. Unfortunately, there is little control over their use in most developing countries resulting in products being marketed beyond their capability for effective dust control and sometimes with adverse impact on the existing natural road material. Paving road surfaces remains the most effective long-term solution.
There is now worldwide awareness of the potential impacts of various activities in the road sector on health and on the environment. An Environmental Impact Assessment (EIA) is now an essential requirement in most road construction and

rehabilitation projects, especially those funded by donor agencies. Air quality is already a major concern in some developed countries such as the USA with standards being set to control emissions, including emissions from gravel roads. It is now known that the finer the particles, then the greater are the potential health risks with fine particles likely to be transported furthest from their point of origin. The USA Environmental Protection Agency has set National Air Quality Standards in terms of the allowable concentrations of particles less than 10μm (P_{10}) and less than 2.5μm ($P_{2.5}$) as shown in Table 1.

The Primary Standards limits are set to protect public health, including the health of 'sensitive' populations such as asthmatics, children and the elderly. Secondary Standards limits are set to protect public welfare, including protection against visibility, damage to animals, crops, vegetation and buildings. The same values have been set for the primary and secondary standards for particulate matter concentrations.

Table 1 National Ambient Air Quality Standards

Pollutant	Primary and Secondary Standards	
	Level	Average Time
Particulate Matter PM_{10}	150μg/m^3	24-hour[(a)]
Particulate Matter $PM_{2.5}$	15.0μg/m^3	Annual Arithmetic Average[(b)]
	35μg/m^3	24-hour[(c)]

(a) Not to be exceeded more than once per year on average over 3 years

(b) 3 year average of the weighted annual mean concentrations not to exceed 15.0μg/m^3

(c) 3year average of the 98th percentile of 24 hour concentrations must not exceed 35μg/m^3

The benefits of such controls on air quality are evident. Dense 'smog', composed of water droplets (fog) and particulate matter (mainly from coal fires), was once common in the Winter months in Britain but these occurrences diminished significantly when smoke-free zones were established in urban areas and such events are now extremely rare.

In many countries, road users in rural areas predominantly comprise pedestrians, pedal cyclists, motor cyclists, users of motor-cycle-drawn taxis and users of other non-motorised vehicles (e.g. ox and donkey carts, hand-drawn carts, etc). For these road users, a smooth bituminised or concrete surface provides an all-weather surface on which they can travel free from the impacts of mud in the wet season and dust in the dry season. Whilst mud has the immediate impacts of impeding travel, studies have indicated that traffic-generated dust could have more serious longer-term impacts on the health and livelihoods of travellers and residents alike.

The rural and urban poor, who regularly walk or travel in open vehicles, will, in general, have a much higher frequency and degree of exposure to dust than users of unpaved roads in developed countries. People travelling in motorised transport in these countries often travel in the open in the back of vehicles such as 'pick-ups' or conventional trucks and are particularly exposed to dust generated both by the vehicle in which they are travelling and by other vehicles. Very few public transport services in developing countries are air-conditioned and ventilation is provided by open windows so that even people travelling in vehicles that may be considered to be enclosed are also exposed to dust.

Traffic generated dust also has cost implications for agriculture as the dust is blown by wind and settles on leaves which inhibits growth and damages crops.

The impacts of dust may be regarded as little more than a nuisance by tourists and casual visitors but for dwellers and frequent travellers in rural areas it is a threat to their health, their livelihoods and to safe travel. However, despite this likely greater exposure and potential long-term risks to vulnerable groups such as children, the elderly and those suffering from chest complaints, very little work has been carried out to assess and quantify these impacts.

Paved roads ensure the provision of the essential and reliable transport services required for year-round access to markets, schools, health centres and employment opportunities as well as ameliorating the impacts of poor road conditions on residents and travellers. As expectations rise, communities served by these roads demand roads with improved surfaces that will ensure year-round access and have fewer adverse impacts on users and residents. Practitioners in the road sector are faced with the increasing problem of the increased costs of the maintenance of gravel roads and the high initial costs of the provision of sealed roads with the likelihood of significant cost increases for these roads as the worldwide demand for oil-based products and other resources increases.

The bituminous industry itself is looking at producing alternative road surfacing products which can be produced at lower temperatures and have less environmental damage in terms of climate change. However, the need remains for alternative road surfacing solutions, which will result in long-term benefits, including those from effective dust control.