INTEGRATED RURAL MOBILITY & ACCESS: MAINSTREAMING ENVIRONMENTAL ISSUES IN COMMUNITY TRANSPORT PLANNING AND CONSTRUCTION PROJECTS

Mac Mashiri, Bizzar Madzikigwa, James Chakwizira, *Phillip Nyoni and *Molibi Makgalemane

CSIR: Built Environment, P O Box 395, Pretoria 0001
E-mail: mmashiri@csir.co.za,Tel: +27 12 841 -2942, Fax: +27 12 841-4054
*Mpumalanga Department of Roads and Transport

ABSTRACT

The Mpumalanga Department of Roads and Transport (MDORT) developed and published a Rural Transport Strategy for the province in May 2006. One of the cornerstones of the strategy is the realization that an integrated approach to rural development is the key to sustainability. In this regard the MDORT adopted the Integrated Rural Mobility and Access (IRMA) approach to project implementation as articulated in the Rural Transport strategy for South Africa (DOT, 2003). In essence, the IRMA approach endeavours to find innovative solutions to challenges related to accessing socio-economic opportunities by communities within the ambit of environmental sustainability. These interventions would include inter alia, the provision of appropriate and integrated rural transportation infrastructure [including pedestrian bridges, paths, and low-level crossings] and services [including non-motorised transport services] complete with adequate funding streams for maintenance and development. MDORT has interpreted and piloted the IRMA concept in the Albert Luthuli Municipality (formerly Elukwatini/Carolina) in Mpumalanga.

This paper presents empirical findings relating to environmental challenges emanating form the planning & implementation of IRMA i.e. community-based, labour- intensive construction of community infrastructure such as pedestrian bridges, paths, low-level crossings running the gamut from awareness raising [especially through the auspices of the Environmental Management Steering Committee which became an effective conduit for imparting information on the environment to beneficiary communities] to proactively putting in place practical countermeasures demonstrating and entrenching the benefits of environmental sustainability in the Albert Luthuli Municipality in Mpumalanga Province.

1 INTRODUCTION

1.1 Background

Communities the world over are increasingly concerned about the environment (Kneebone & Berry, 1997). The South African government recognises the need to integrate economic, social and environmental actions to provide for current needs and for posterity. The way in which the transportation system is employed and managed plays a crucial role in contributing to national and international sustainability goals. Transportation helps shape an area's economic health and quality of life (World Bank, 2003). Not only does the transportation system provide for the mobility of people and goods, it also influences patterns of growth and economic activity by providing access to land (Bryceson et al,

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2003). The performance of the system affects public policy concerns such as air quality, environmental resource consumption, social equity, land use, urban and rural growth, economic development, safety, and security. Rural transportation planning recognizes the critical links between transportation and these other societal goals.

1.2 Transport and the environment

It is germane to note that the transportation sector significantly contributes and impacts on the dynamics of environmental change and sustainability. Transport sector activities can lead to environmental change in many ways including the following:

- ***Opportunity cost of land occupied by roads:*** The existing road network occupies substantial tracts of land that could potentially be used for other uses, for example, roads are often built for practical and economic reasons through ecosystems such as forests causing a change in the micro climatic conditions that are crucial for a specific ecosystem type to function properly or divide ecosystems into smaller units rendering them unsustainable overtime. The unsolicited bid to construct a toll road between Port Edward and Mthatha in the Eastern Cape approval took long, as it was initially successfully opposed on the same grounds. However, the incorporation of environmental mitigation plans through stakeholder consultation and consensus has meant that finally the Minister of environmental Affairs and tourism has now approved the second EIA for the proposed wild coast toll road. Remote areas are made more accessible via road networks that could lead to unwanted or increased harvesting of ecosystem products.
- ***Greenhouse gases:*** The transport sector plays a starring role in terms of ambient air pollution such as the emissions of greenhouse gases (with global warming implications). In South Africa for example, the transport sector in total emitted about 14%, 0.5% and 3% of the total national emissions of CO_2, CH_4 and N_2O respectively in 1994 (Department of Environmental Affairs & Tourism, 2000). Road vehicles contributed the most to these emissions. Diesel engines emit more CO_2 and N_2O (direct greenhouse gases) per unit of energy input than petrol engines. It is of interest to note that a significant number of vehicles that ply rural roads in the study area utilize diesel as a propellant.
- ***Human health impacts:*** The transport sector plays a significant role in terms of ambient air pollution in terms specifically of human health impacts. The Brown Haze report indicated that 65% of the growing air pollution problem in the Cape Metropolitan Area is caused by vehicle exhaust emissions, of which at least 48% is attributable to diesel powered vehicles (Cape Town Brown Haze Study, 1997). Petrol vehicles account for 17% of the problem (News release, 1999). Diesel exhaust is a highly complex mixture of gases, vapours and particles (soot) consisting of a very large number of elements and compounds. Diesel particulate matter has been found to be carcinogenic in animal experimental studies and associations between lung cancer and diesel exhausts have been demonstrated in limited human epidemiological studies (Terblanche, 1992). Dust from untarred road surfaces in mainly informal and rural settlements has human health impacts for people living in juxtaposition to the roads. In Europe, it has been estimated that the transport sector contributes between 30 – 35% of the total PM emissions. Emissions of volatile organic compounds (VOC) and NO_x lead to the formation of ground level ozone that has serious human health impacts.
- ***Impact on nature:*** Transport sector activities often have deleterious impacts on the environment, for example, forests, lakes, crops, and wildlife suffers substantial damage from high levels of airborne pollutants. Oxides of nitrogen (NO_x), for instance, can be transported over hundreds of kilometres before being deposited as

acid rain, which can acidify soil and, because of its ability to fertilise the soil, can cause changes in species composition and biodiversity. NO_x also reacts with VOCs in the atmosphere in the presence of sunlight to form ground level ozone, a significant component of summertime smog. Ozone is also a long-range pollutant which can cause direct effects on sensitive vegetation. It has been associated with reduced yields in crops and forestry, as well as with changes in species composition and biodiversity in natural and semi-natural ecosystems.

- ***Ecosystems impact:*** The sector plays a role in terms of water and soil pollution. Surface run-off from tarred roads usually contains a mixture of oil, diesel and petrol. This can be collected in storm water pipes, streams or soaked into the ground. Terrestrial and aquatic ecosystems can be damaged depending on the amounts of oil, petrol and diesel spilled or leaked into the system.
- ***Fire hazards:*** Spillages and leakages of diesel and petrol may cause potential fire hazards. Depending on the area, meteorological conditions, season of the year and type of vegetation, this could lead to large-scale ecosystem (natural and agricultural) damage or loss. Motorists are also a major cause of fires leading to damages to ecosystems and man-made structures when, for example, burning cigarette butts are thrown out of car windows.

The summation of this theoretical review is to underscore the importance and necessity of grafting environmental considerations into any transport related project activity.

1.3 IRMA and the environment

The Mpumalanga Department of Roads and Transport (MDORT) developed and published a Rural Transport Strategy for the province in May 2006. One of the enduring cornerstones of the strategy is the realization that an integrated approach to rural development is the key to sustainability. In this regard the MDORT adopted the Integrated Rural Mobility and Access (IRMA) approach to project implementation as articulated in the Rural Transport strategy for South Africa (DOT, 2003). In essence, the IRMA approach, which is predicated on environmental sustainability, endeavours to find innovative solutions to challenges related to accessing socio-economic opportunities by communities. These interventions would include inter alia, the provision of appropriate and integrated rural transportation infrastructure (including pedestrian bridges, paths, and low-level crossings) and services (including non-motorised transport services) complete with adequate funding streams for maintenance and development. MDORT has interpreted and piloted the IRMA concept in the Albert Luthuli Municipality in Mpumalanga. IRMA's philosophical fulcrum is hinged on sustained positive socio-economic developmental impacts. Clearly, central to the IRMA process is environmental integration and mainstreaming.

This paper, which is based on a project undertaken by the CSIR on behalf of the Mpumalanga Department of Roads and Transport (Mashiri et al, 2007), presents empirical findings relating to environmental challenges emanating from the planning, designing and implementation of IRMA projects in the Albert Luthuli Municipality in Mpumalanga Province i.e. community-based, labour-intensive construction of community infrastructure such as pedestrian bridges, paths, low-level crossings running the gamut from awareness raising to proactively putting in place practical countermeasures demonstrating and entrenching the benefits of environmental sustainability. These IRMA projects are intended to facilitate improved circulation within project communities to enable them to access socio-economic opportunities. Gomide et al (2004) argue that mobility and access to services and activities that guarantee human dignity and social integration, such as leisure, visiting friends and relatives, and shopping, among other things, assist in combating rural poverty, reducing isolation and deprivation and, sometimes acting as a stimulus for local economic development.

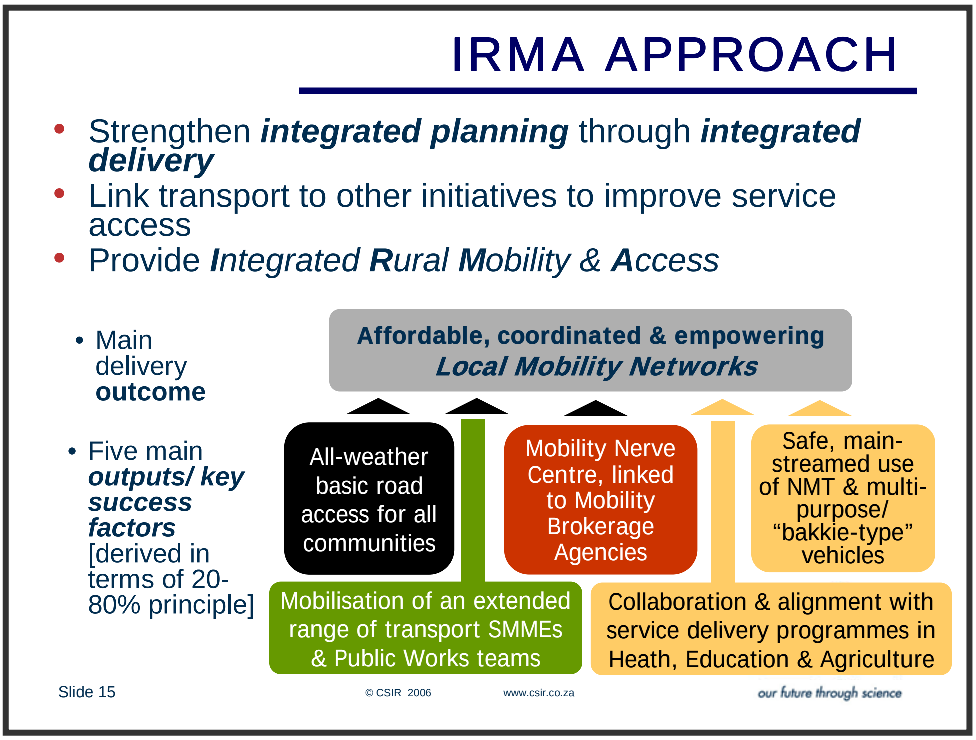

Figure 1: IRMA Approach (Source: Naude et al, 2005; Mashiri et al, 2006)

1.4 Profile of project areas

The IRMA projects are located in hilly and undulating deep rural areas broken up by relatively fast-flowing perennial rivers and streams which make accessing amenities (often located in one area) such as council offices, butchery, high schools, post office, chief's office, undertakers and sports facilities or each other particularly cumbersome especially during the rainy season. Because most of the streams are perennial, villagers, especially learners, often have to wade through the waters of these rivers and streams every school day, which predisposes them to water borne diseases. The risk of being washed downstream especially in summer when the rivers experience regular and flush floods is a distinct possibility. Safe crossings often increase the walking distance to access amenities by two to three times. Dongas, which form a significant part of the landscape, are an environmental challenge as they keep widening every succeeding year destroying valuable land for agriculture and other uses, as well as creating a barrier between communities in the process. Overtime some dongas have become havens for criminal activity.

2 APPROACH & METHODOLOGY

2.1 Planning approach

The project team worked with and reported to a project technical committee presided over by officials from the participating municipality. This committee in turn reported to a steering committee chaired by the municipal mayor who had political oversight for the project. The general approach revolved around a multi-sectoral gender-sensitive methodology involving a combination of qualitative and quantitative methods to gather information to facilitate the assessment of identified problem areas, identification of priority projects and then planning, designing, costing and implementing IRMA intervention options. This approach ensured that research participants (ward councillor, ward committee, key informants such as teachers, learners, households close to the project site, etc.), including the most marginalized contributed to and informed priority areas of enquiry and intervention.

Reconnaissance visits were followed by detailed evaluations of prioritized project areas and comparison of various alternatives to arrive at sustainable solutions. Rapid rural appraisal techniques entailing, focus group discussions, individual household interviews, as well as key informant interviews employed the AKAP technique – Attitudes, Knowledge, Awareness and Preferences surveys to gain in-depth relating to rural mobility and accessibility. This technique yield the following questions – What is the existing/current and envisaged prevailing *attitude (s)* by stakeholders with regard to rural mobility and accessibility? What is the current knowledge by stakeholders in terms of their understanding of key mobility and accessibility issues in their context? What is the level of awareness and consciousness of stakeholders regarding mobility and accessibility issues that affect their livelihood and lifestyles? What is the existing and projected mobility and accessibility agenda preferred by stakeholders? Technical observation, physical tests and audits outputs sought to confirm or refute community constructs generated through opinion surveys.

Identification of transport infrastructure interventions and site selection were undertaken through relatively lengthy and drawn out but necessary community participation processes. Through a parallel process, the local political representatives (councillors) selected and prioritized project areas. The project team then made reconnaissance visits followed by study visits for detailed investigations with a view to generating appropriate and innovative transport infrastructure designs. In addition to the process described above, prioritized project site information to facilitate intervention designs was generated through "ground-truthing" site inspections wherein levels, measures, bearings, flood levels, measuring and levelling at proposed crossing locations to determine, for example, the stream or channel profile, locational latitude and longitude points were taken. In addition, geotechnical surveys were undertaken for all sites.

2.2 IRMA guiding principles and standards

The impact of transportation on people cannot be judged solely on the basis of the indirect benefits through economic efficiency, but also on the immediate and direct outcomes it has on household's economic, subsistence and social well being. The following under listed objectives form part of the guiding principles, standards adopted and applied in IRMA's project planning, implementation and management:

- The use of local materials so as to minimize the cost associated with procurement of high-technological and conventional materials which require a lot of initial capital, highly qualified operatives and equipment
- Use of local labour so as to provide employment opportunities to the community during the construction phase of the project as well as supporting LED
- Shorten travel distances of pedestrians, especially learners who often have to travel long circuitous routes to the nearest safe crossing point every school day or perhaps even miss school where a river has flooded
- Enhance the movement of communities and their goods by providing crossings that allow a variety of non-motorized transport technologies such as animal drawn carts and bicycles to effortlessly cross the rivers
- Ensure projects enhance the villages' spatial connectivity thereby deepening, for example, social contact and cohesion

2.3 Implementation process

Given the large number of projects spread across a municipality such as Albert Luthuli, the Department of Roads and Transport would be hard-pressed to mobilize managerial expertise to monitor, evaluate, supervise and support contractors that it has employed to implement the nineteen individual projects. This is particularly severe if cognizance is taken of the fact that the prospective winning bids will largely be small mostly local contractors that require substantial assistance to accomplish their assignments on budget, on time and according to specifications – leaving a decent profit margin for themselves. These small contractors need regular and visible monitoring as well as support. Given that the success of IRMA is predicated on capacity building across the board – running the gamut from community members who work labour-intensively on the IRMA projects, small contractors who undertake the construction work, local authority officials who have the duty of maintaining the infrastructure long after the external impulses have stopped, consulting firms that will assist in scaling up IRMA and provincial officials who have to account for their initial investment. This entailed mentoring, counselling, resource mobilization and project milestone management, problem diagnostic support work and remedial action, knowledge training and management and skills and technology transfer facilitation. And, strengthening the capacity of small contractors also means that municipalities and the provincial government would have at their disposal, a constant supply of expertise from which to draw for their development projects.

3 FINDINGS AND DISCUSSION

3.1 IRMA planning process

IRMA planning and implementation is an interactive process designed to foster involvement by all users of the system, such as the business community, community groups, environmental organizations, the travelling public, freight operators, and the general public, through a proactive public participation process. The business community and freight operators were consulted through their respective Provincial representatives (Mpumalanga business community association and freight operators). Environmental organisations were represented by the Department of Agriculture and Department of Environment and Tourism. Random convenience surveys and interviews were conducted with members of public who were using the footpath, roads or crossing points to elicit their qualitative evaluation of the access and mobility infrastructure and services in their immediate environment. Input from all these sectors was analysed and continuously informed the whole planning, design and implementation process approach. IRMA's transportation planning process approach included the following steps:

- Auditing and visual condition assessment of existing rural transport infrastructure and services
- Forecasting future population and employment growth, including assessing projected land uses in the region and identifying major growth corridors, routes, access roads, footbridges and footpaths
- Identifying current and projected future transportation problems and needs and analyzing, through detailed planning studies, various rural transportation improvement strategies to address those needs
- Developing long-range plans and short-term programs of alternative rural capital improvement and operational strategies for moving people and goods
- Estimating the impact of recommended future improvements to the rural transportation system on environmental features, including air quality, and

- Developing a financial plan for securing sufficient revenues to cover the costs of implementing strategies.

3.2 Environmental Management Steering Committee

The environmental problems and challenges discussed in this paper emanate from the construction of footpaths, low level crossings and footbridges – construction activities which could indeed disturb the flora, fauna and aquatic lifestyles, reproductive systems, patterns and systems of survival and livelihood. It was thus crucial at the outset that environmental issues were factored into the planning, design and implementation of the IRMA project. In this regard, an Environmental Management Steering Committee (EMSC) was established comprising of the CSIR, Albert Luthuli Municipality, provincial departments of Roads & Transport, Environment, Agriculture, Water & Forestry. EMSC was established to ensure:

- Compliance and adherence to best practice in environmental issues
- Conduit for information dissemination to beneficiary communities
- Platform for capacity building for the community, councillors and officials
- Forum to discuss questions of community transport infrastructure asset ownership, vandalism, maintenance, etc.

It was thus necessary that communities were not only sensitised, but were also involved throughout so as to enhance environmental awareness, acceptance and sustained usage of the completed assets. It is envisaged that this collaborative platform will outlive the project life.

As indicated elsewhere, the planning and implementation process was driven by a technical and a steering committee. All prioritised projects were subjected to a rigorous socio-economic and technical appraisal process by the IRMA Technical Committee employing indicators generated iteratively by stakeholders. These project proposals were then submitted to the steering committee for ratification. The IRMA Technical Transport Committee was also responsible for technical design, contracting out the works to community construction entities, and general supervision and support.

3.3 IRMA geotechnical survey results synthesis

Most of the targeted projects sites were found to be underlain by sandy silt clay in terms of the sieve analysis, Atterburg limits, CSIR, and UCS tests of each test pit. Soil profiles generally consisted of a thin [0,3 to 0,4m] gravel topsoil layer followed by alternating clay silt and very soft rock composed of siltstone layers dipping at 20^o and 30^o in a south-westerly direction. However, the poor soil condition in most of the targeted project sites is a localised phenomenon. The soft rock siltstone had a bearing capacity of between 50kPa and 100kPa. The bearing capacity of the sandy clay silt was expected to be less than 100kPa where it is ferruginous and dry, but below 50kPa when moist and non-ferruginous. The reworked nature of the residual shale and the presence of clay-filled joints will give rise to differential settlements.

The foundation conditions are not uniform across the sites, due to the occurrence of the alternating hard and soft layers. The alternating medium and soft layers will adversely affect the foundations of the abutments and piers of the bridges and the following recommendations were generated and taken into account with regard to the designs and supervision works for the low-cost technology interventions:

- Foundations of pedestrian and low-level bridges were recommended to be positioned at a constant horizontal level after excavation to the required depth and being filled with rocks or compacted material to the required density. This alternative was recommended for founding on sandy clay silt, where the bearing capacity was pegged above 100kPa.
- Alternatively, the soft material in between the hard layers had to be removed and replaced with mass concrete to produce a more uniform foundation surface (to prevent differential settlement) upon which normal foundations with a bearing of at least 150kPa could be mounted.
- Recommended depths of individual footings varied between 1,6m and 3m below existing ground level, depending on the relative position of the footings. On average the foundations are expected to generate bearing pressures of less than 200kPa and can therefore be founded at shallow depth – (>2,0m). Excavations shallower than 2,0m works were carried out through the aid of primarily hard excavation i.e. could be excavated by backhoe. Excavations deeper than 2,0m were mostly soft excavation.

Caution in accommodating possible differential settlements which could occur due to the foundations being founded on rock in places and on soil in other places was a critical consideration. Consequently, it was considered imperative that a Geotechnical Engineer/Engineer should assist in determining the final founding levels during construction by inspecting the excavations for the foundations and piers.

4 IRMA INTERVENTIONS

4.1 Design philosophy

Many problems encountered in the road sector in emerging and developing countries can be attributed to the application of inappropriate technology, as well as problems of inadequate policy guidance, insufficient funding, inadequate institutional arrangements, poor manpower development and motivation and inadequate decision making arrangements (World Bank, 2003). The suite of IRMA projects provide an opportunity to put into practice appropriate technology concepts. The approach was to innovatively design structures that can be labour-intensively constructed using labour from the local community and construction materials found in the area so as to minimize leakages in project funding.

The planning, designing and implementation framework was premised on two major objectives, namely, cost (cost-reduction, cost-saving, low-cost) and impact (poverty reduction, employment generation, knowledge and skills transfer, gender and local economic development [LED]). While reducing the costs of the individual construction projects was a key requirement of the project, it was done without compromising the quality and finish of the product. Related to the cost element was a deliberate effort to employ local resources including local contractors, materials and labour. Furthermore, the IRMA projects were planned, designed and implemented such that their developmental impact reverberates and filters through to the most marginalized in the project areas by way of visible livelihood improvement.

While the low cost transport infrastructure intervention designs were generated on the basis of conventional methods, concepts and principles for the design of bridges, culverts and associated structures, the design departed somewhat from the exclusive use of conventional construction materials for some structures with a view to employing locally available natural materials such as stones and rocks. Key factors and guiding planning and design parameters included, access, mobility, health, environment, safety and connectivity.

It is important at this juncture to note some challenges that were encountered in the field. The key factor in drainage design for example, is the need for adequate data on hydrology, topography and soils (Groenier & Gubernick, 2007). For reasons of a tight schedule, sufficient such data could not be collected to inform rigorous design. Another challenge related to insufficient profile surveys done on site which would also have required more time. These problems were, however, overcome by way of relying on sound engineering judgement and use of available similar information to design robust and safe structures.

4.2 <u>Low water stream crossings</u>

4.2.1 Stream profiles

There are three categories of stream types – perennial, intermittent and ephemeral. Perennial stream have water following in a well-defined channel at least 90 % of the time, intermittent stream has water flow generally occurring during the wet season (50% of the time or less) and the ephemeral stream generally has water flow occurring for short time after extreme storms and channels not well defined (Groenier *et al,* 2007, Gu *et al,* 2003). The recommended maximum allowable depth of flow over a ford is 150mm to allow for safe passage.

All of the streams in project area have water running through them all year round within defined channels and thus can be referred to as perennial streams. The roads to these crossings are dirt roads and majority are gravel roads with traffic flow of less than 20 vehicles per day. In most cases the pedestrian traffic is the most dominant including non-motorized modes of transport such as donkey carts etc.

4.2.2 Low water stream crossings

Low water stream crossings (LWSC) are low-cost structures particularly suitable for low volume roads across streams where the normal volume of flow is relatively low or occurs only during the rainy season. There are three common types of LWSCs, namely, unvented fords, vented fords and low-water bridges. An unvented ford is a stream crossing constructed out of erosion resistant material placed on the stream bed to allow water to flow over the structure. This crossing is normally constructed of crushed stone, riprap, precast concrete slabs, or other suitable material that meets the service requirements (Gomide *et al*, 2004).

A vented ford is a stream crossing provided with pipes under the crossing to allow moderate low flows across without flowing over the structure except in seasons of high flow. The pipes are typically embedded in stabilized fill, coarse aggregate, riprap, or Portland cement concrete. According to Gu et al (2003), a low-water bridge is a flat-slab bridge deck constructed at the elevation of the adjacent stream banks, with the smooth cross-section designed to allow water to flow over the bridge surface without damaging the structure. Selection of sites suitable for low water stream crossings should meet the following criteria:

- ***Type of roadway*:** LWSCS are recommended on unpaved primitive roads, filed access road, roads with no inhabitable dwellings or livestock operations, low traffic volume roads and roads with alternative routes available during flooding

- ***Use of roadway*:** Average daily traffic (ADT) of less than five vehicles is ideal. A LWSC should not be constructed on roads that provide critical travel routes or where future increase in traffic is expected
- ***Type of stream*:** Ephemeral streams are the most preferable stream types, however, they can also be suited to perennial streams only in certain shallow, low velocity cases
- ***Cost*:** Cost comparison with bridge or culvert replacement should indicate considerable savings.

4.3 Design and construction process

4.3.1 Design process

The design process involved a reconnaissance of the river or stream on which a low-level bridge or crossing was to be located. The outline proposed by Gu et al (2003) served as a good practice guideline for the design of low-water stream crossings, as shown in Figure 2 below. The exact positioning of the structures was the prerogative of the technical team to ensure the safety of users, durability (given geotechnical data on stable locations), cost-effectiveness and easy of circulation.

4.3.2 Materials selection

Gabions were a preferred material for construction along with concrete pipes where vented fords were recommended particularly because this resource is plentiful in the project area. Gabions are steel wire fabric baskets filled with stones, providing sufficient mass to resist displacement (Groenier *et al*, 2007). Because gabions are flexible, they are not prone to settlement or undermining. Gabions fill up with silt quickly and thus facilitate the establishment of natural vegetation. Gabions are also less costly than concrete. Gabion installation is also labour intensive and a suitable filter material is required to prevent scouring of the underlying soil. Stone sizes should range between 100 and 200 mm (Gu *et al*, 2003).

Portland Cement Concrete is also used in the design for pavement. Concrete is the most durable ford material and requires the least maintenance in its life cycle. Sufficient thickness is factored in and reinforcement to reduce cracking and prevent differential settlement. Here a combination of both cast in situ and precast slabs are used and all with a camber to enhance self drainage of the surface.

4.3.3 Unvented ford design

Unvented fords can be placed at the level of the streambed or the crossing elevation can be raised up to 1200 mm above the channel (Gu *et al*, 2003). In this design the objective was to have crossings that will allow users to cross without having to drive through water or wading in the water even during low water flows. Therefore all unvented fords were raised and not designed as streambed level fords.

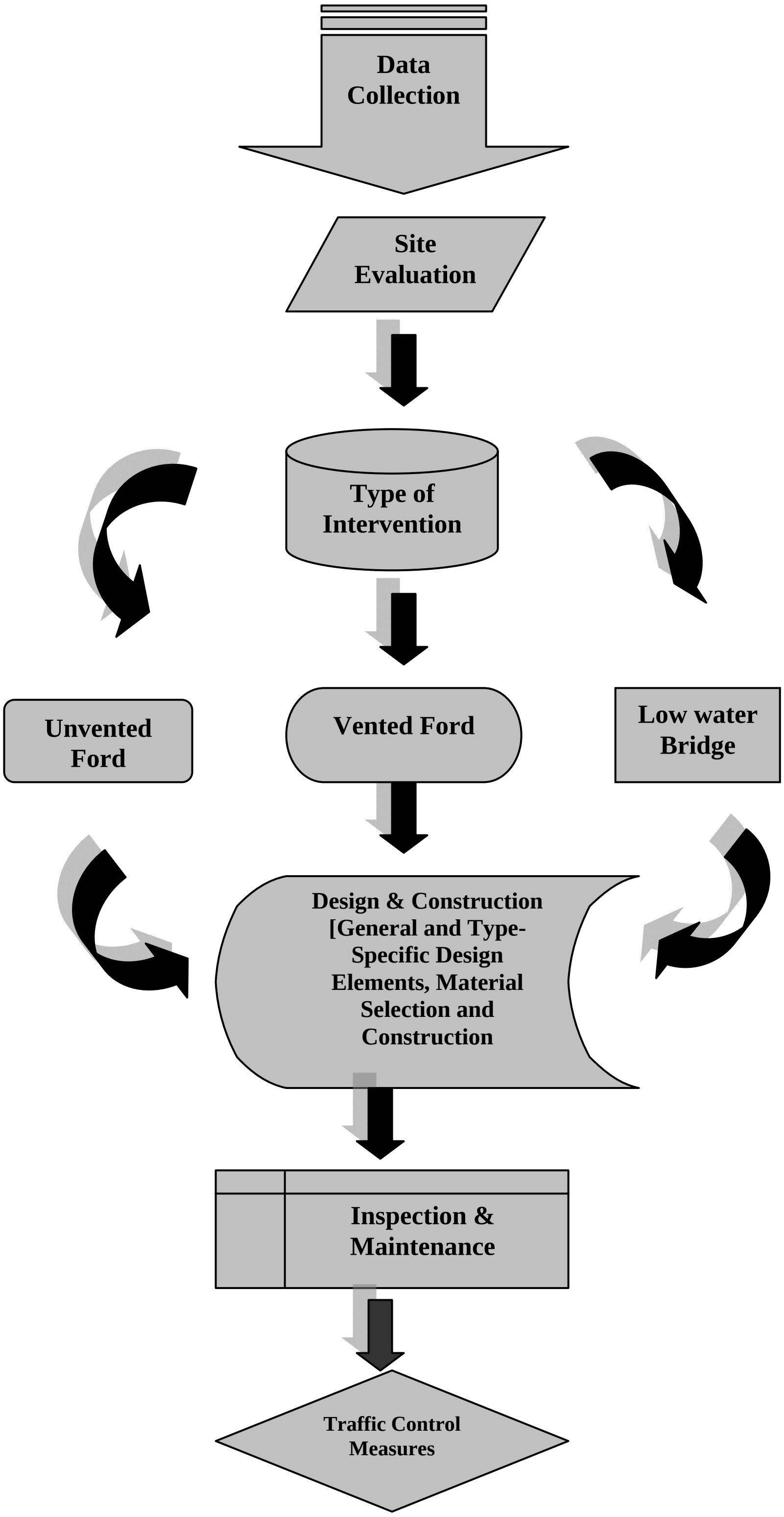

Figure 2: Flowchart for LWSC design and construction

The following equation is used to confirm that the flow depth over an unvented ford on the channel bottom would not exceed the recommended maximum of 150 mm (Groenier & Gubernick, 2007):

$$h = 0.233 Q_e^{0.599} L^{-0.493}$$

Where Q_e is the design discharge in feet3/second, and L is the length of LWSC in feet

4.3.4 Vented ford design

The design of a vented ford is similar to that of a culvert.
The structure's vent discharge capacity, Q_{vent}, is determined from this equation:
$Q_{vent}=Q_e-Q_{top}$
Where Q_e is the total design discharge from hydrological analysis and Q_{top} is the flow over the ford (all measured in feet^3/second)
Given that overtopping should not exceed 150 mm (h<= 0.5 feet), flow over the ford can be calculated as follows (Groenier & Gubernick, 2007):

$$Q_{top} = 3.538L^{0.823}$$

Where *L* is the length of the LWSC in feet

4.3.5 Road safety

Some paved roads in the study area had safety problems resulting largely from speeding motorists. The problem was exacerbated by the fact that often the existing bitumen surfaced roads do not have shoulders, and as such pedestrians and cyclists shared the same road space with motorized vehicles which predisposed pedestrians, especially young learners to being run over by speeding vehicles, particularly minibus taxis. The recommended solution was a combination of traffic calming devices such as speed humps and separation of vehicular and pedestrian traffic. A speed hump is a cost-effective traffic calming tool designed to slow traffic or reduce through traffic. It has a proven track record, is widely accepted by road users, and does not require law enforcement (Hidas & Mashiri, 1993; O'Flaherty, 1996). Separation of modes was achieved by labour-intensively constructing a 1.5 m wide pathway with paving bricks. To discourage motorists from using the walkway as an extension of the roadway, concrete bollards were planted at 20 m intervals for the length of the walkway.

4.3.6 Pedestrian steel bridges

Some rivers or dongas separating communities are relatively wide with one requiring, for example, a bridge with a 25m span. The recommended interventions in this regard were steel bridges. The bridge structure is made of steel with a pre-cast concrete deck and bollards at both ends to discourage motorists who may be temped to cross the river using the pedestrian bridge.

4.3.7 Side drains and graveling

Other sites required the design of lined and French drains, gravelling of a roads, cleaning of blocked culverts and design of pavements with a vented ford.

5 RECOMMENDATIONS

From the IRMA project experience, the following lessons and recommendations have emerged:

a) ***Community involvement:*** The socio-cultural impact of improved access can be very significant, albeit positive or negative from an environmental sustainability perspective. The establishment of proper community links from inception allows the impacts to be mainstreamed and monitored and at least provides the possibility of complimentary activities to either exploit or mitigate the impact.

b) ***Cost-effectiveness and maintenance:*** The need to properly establish the whole life costs and resources required for proper maintenance of any particular infrastructure before obtaining the agreement and approval from the community and/or local authority that they are prepared to undertake this responsibility. It is also necessary to translate these costs into activities that the communities can comprehend so that they fully appreciate the scale of the obligation and participate in project planning and management. Extending this concept to infrastructure maintenance would guard against the rapid deterioration and abandonment of infrastructure investment. This would link infrastructure investment with the financial and human resources necessary to sustain the system as and when necessary.

c) ***Capacity building:*** Labour based approaches and contracting with community involvement and participation is a complex process that requires time, training, sensitisation and capacity building of group, community leaders and contractors. If a contractual approach is to be used with communities they must be able to understand what is required of them and be able to organise themselves efficiently and effectively. It is inappropriate to exploit community contracts by imposing contractual obligations they cannot meet. Communities can be very inventive and supportive in establishing methods of rural infrastructure provision, resource mobilization for maintenance, but they require assistance and sustained capacity building.

d) ***"Roads are not enough":*** Well-engineered roads for motorised vehicles are often not the answer, but municipal authorities and communities need to be educated to conceptualize development in this way. Too often the option is restricted to a well-engineered road or nothing at all. It is for this reason that "roads being not enough" is an apt epitome and a prelude to the IRMA approach which emphasises inter and intra village and ward access by, for example, improving footpaths, providing pedestrian bridges and low-level crossing points.

Most planning efforts are generally broad in scope with environmental concerns addressed at the project level as development occurs. However, due to changing philosophies in environmental policy and regulations, the environmental consequences of planning activities are now a part of the equation in long-range plan development. The IRMA approach provides a framework for planning, designing and implementing rural transportation infrastructure interventions with environmental sustainability as the bedrock.

6 CONCLUDING REMARKS

This paper has discussed the IRMA approach with regard to planning, designing and implementation of appropriate transportation infrastructure interventions with the attendant beneficiary community benefits, such as employment creation, poverty alleviation, improved local economy at least during the construction period, and building of community circulation assets with a view to influencing the trajectory of this "second economy". While the physical footprint of the infrastructure is relatively small, it is envisaged that the impact will be far-reaching. Once village, ward, local authority circulation infrastructure is in place, the other side of the IRMA coin, which has not been discussed in this paper, relates to planning, designing and implementing "intelligent" rural transport and logistical services. Environmental considerations have been discussed as an inevitable, endemic midwife for the IRMA framework. The project outcomes corroborate Bryceson *et al's* (2003) argument that transport infrastructure is a livelihood asset that provides livelihood opportunities to communities during construction, implementation and sustainability. Local communities are employed during construction and project implementation and some will continue to be employed for the upkeep and maintenance of such structures. Beyond, the direct benefits are the indirect benefits such as access to social services and employment opportunities that emanate from their existence. The use of local labour in terms of the labour based technology and as fully enunciated by the national program of the Expanded Public Works Program [EPWP]; by the DoT is a welcome development. In Mpumalanga, the Department of Roads & Transport has gone a step further and has introduced and is bankrolling the Siyatentela project. These project targets poor rural households to engage in labour based rural road maintenance and construction. Such initiatives should be supported and promoted.

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