Soil Conservation Perspectives of Road Infrastructure within a Development Context in South Africa

H.R. Beckedahl*, T.R. Hill and M. Moodley

INTRODUCTION

The soil resource of South Africa is recognized to be declining at an alarming and accelerating rate resulting in severe environmental degradation. This paper argues that solutions will not be readily forthcoming or implemented until such time as there is a true dialogue between the ‘experts’ and the people most closely associated and affected by soil loss – the rural communities. We need to bridge the chasm between the ‘expert’ planners and developers and those closest to the associated results – the rural communities. A number of South African studies (Pile, 1996; Watson, 1996; Watson and Ramokgopa, 1997) have recognized the need to determine whether or not rural communities' perception of soil erosion equates with that of the so-called ‘experts’. Results show that there is recognition of and concern for soil loss but that it is often perceived as a purely physical phenomenon and the more intricate class distinctions between various erosional features are not acknowledged. This paper sets out to describe the state of the rural environment as a consequence of the existing road infrastructure, the erosional processes in operation as a result thereof and makes a call for community involvement in the management process of future road development within the rural areas. The authors suggest that this final point can be partly achieved through co-construction of the perceived issues, which could be developed through recognized techniques, such as participatory rural appraisal (PRA), thus empowering rural communities within the management process.

Given the economic challenges facing many developing regions, including South Africa, it is probable that technologically advanced road construction will not extend into many of the more inaccessible rural areas in the near future. Access of vehicles to individual homesteads nevertheless remains an important priority and effective management of existing infrastructure and careful planning of future development is necessary to limit environmental degradation. Several researchers (Duck, 1985; Megahan and Ketcheson, 1996) have recognised access roads as the principal source of sediment production within watersheds. In an environment where strong dependence is made upon subsistence agriculture and natural watercourses as a source of potable water, failure to effectively manage the infrastructure can have far reaching consequences.

Since soil erosion is essentially a two phase process consisting of the detachment of individual particles from the soil mass and transport by erosive agents (Morgan, 1986), encouragement of conditions that favour either phase will lead to enhanced sediment production. Under purely natural conditions most geomorphological systems are characterised by negative feedback mechanisms that act as regulators against inherent increases in entropy. With disturbance of

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these systems through road construction positive feedback may well be initiated, which implies that change will continue until dynamic equilibrium is once more established. The concept of effective management therefore necessitates an understanding of the mechanisms, stimuli and feedbacks that influence the utilisation of access roads.

**Road Infrastructure Erosional Processes**

Essentially three broad classes of access road systems serving rural areas may be recognised namely formal, low cost formal and informal road systems (Table 1). Formal roads have a compacted foundation onto which is added a surface seal such as bitumen, concrete or compacted gravel. In low cost formal systems the roadbed is created by excavating a given tract of land to form a quasi-planar surface, often exposing the subsoil horizon. Informal road systems, the most prevalent forms existing in developing areas, are formed through successive wheeled traffic across a given transect. In the latter case the passage of the vehicle results in the transmission of a shear stress from the ground downwards through the soil profile. The magnitude of the stress is not as important as the reaction of the underlying material to the stresses imposed. The effect of these stresses is two-fold, namely compaction of the surface where bulk density and soil strength increases and by smoothing natural obstructions that would otherwise act as important energy sinks. Allied to this is the rapid denudation of vegetation through mechanical dislodgement or damage that under virgin conditions would act as efficient dissipaters of erosive energy (Webb, 1983).

It is pertinent to differentiate between on-site and off-site damage, where the former refers to degradation of the road surface proper and the latter to soil instability arising as a consequence of road construction. On-site damage is particularly pronounced on low cost formal and informal road systems that present a lower shear resistance to the action of water flowing across it. Three dominant soil erosional forms are recognised within these systems namely sheetwash, rilling and gullying. Water flowing across a soil surface generates tractive forces, which result in the detachment and subsequent transport of eroded sediment through entrainment processes. On road surfaces the efficiency of sheetwash erosion is enhanced through the mechanical dislodgement of soil particles by the vehicle’s wheels. Moreover, the associated reduction in hydraulic roughness reduces the energy losses due to friction between the sediment charged flow of water and the bare soil surface. Erosion is then limited only by the capacity of overland flow to entrain the detached sediment (Hinckley et al., 1983). Sheetwash activity is easily recognised by the lag of coarser sized sediment on the road surface with tailings of fine material deposited on the downslope end of the road surface camber and represents the early stages of road surface degradation.

Where surface runoff becomes channelled due either to natural obstructions such as coarser sized sediment or early rut development resulting from excessive soil compaction beneath the centre-line of the vehicle wheels, rills may develop. The development of rills on roads is often accentuated at gradients in excess of 3 degrees (Govers, 1987) The existence of rills represents a more drastic erosive mechanism of sediment removal and therefore a higher rate of road surface degradation may be expected. Where rills form directly within the compacted rut these are rapidly removed through vehicle traffic. The eroded sediment is then deposited and re-entrained during subsequent rainfall episodes with a consequent deepening of the rill or rut. Sediment transfer can then be described as sequences of deposition and entrainment events before removal from the road system. Rill development on low cost formal road systems are usually precursors to the formation of gullies and, although clearly dependant on variables of soil type, gradient and rainfall intensity, rills have been shown to develop at volumetrically derived rates varying between 4 and 20 Mg ha⁻¹ yr⁻¹ (Beckedahl and Slade, 1993; Beckedahl, 1998).

Gullies on road surfaces (i.e. wash-aways with a depth of more than 0.30 m and a width:depth ratio less than one) represent an advanced stage of physical degradation and usually a threat to the functionality of the road system. The combined effect of soil compaction and smoothening of surface roughness elements results in the preferential flow of water within the continuous micro-depressions or ruts. Infiltration is also substantially lowered due to an increase in bulk density. Once overland flow becomes concentrated runoff power increases significantly such that higher kinetic energy is available for the scour and entrainment of sediment (Iverson, 1980). In consequence, these forms develop rapidly in informal roads particularly where they are sited parallel to the slope. Once the sediment is entrained within the flow its weight and frictional forces ensure its eventual deposition either on or off the road itself. Deposition is typically in a fan deposit at a change in topographic gradient; at breaks in topography or, in the case of degraded systems of more than 0.5 m depth, along the gully sidewall. Gully sidewall enlargement is either through the process of undercutting or from above by mechanical dislodgement due to vehicle traffic. Where gully development has advanced such that ‘bottoming’ of the vehicle occurs as contact between the suspension and inter-rut area is encountered the former track may be abandoned and a new track adjacent to the former created.

The significance of multi-track development is that theoretically, additional concentrated paths for the flow of water are created and therefore a potentially increased sediment load results. A further consequence of ‘bottoming’ is that large quantities of sediment are mechanically dislodged from the inter-rut area, further contributing to problems of siltation elsewhere. In advanced stages of degradation sediment removal from the inter-rut area is enhanced leading to a wide U shaped gully.

**Soil Conservation and Infrastructure Management**

Recognition of physical factors contributing to accelerated soil erosion is only a component of effective
management. Soil conservation methods of the past have tended to have a top-down positivistic attitude of addressing the physical causes and consequences of soil erosion with few techniques beginning to recognize and incorporate the ideas of participation and dialogue. More recently the trend has been towards addressing the ills from the causal aspect of socio-economic and political perspectives (Lal & Pierce, 1991). This is particularly pertinent in South Africa with the social geography of the past and urgent need for rural upliftment to alleviate the high levels of poverty and unemployment.

Despite the recognition of soil erosion by rural people, the burden thereof should not be borne by them alone. The stark reality is that it often comes down to a choice of starvation now or starvation in the future. Or, in the case of resettlement or land redistribution, poor land is perceived as better than no land at all. The issues surrounding land redistribution have been recognized by Watson and Ramokgopa (1997) who write, “since the 1930’s numerous government directed attempts to arrest gully erosion commonly involving entire communities have failed” (pp. 33). The forced ‘resettlement’ of many rural people onto already degraded land has culminated in the general apathy and lack of conviction regarding the effectiveness of conventional soil conservation measures. This results in what Blaikie (1985) describes as the ‘reproduction squeeze’ in which rural peasantry may be caught between maintaining current livelihoods and looking after soil conservation measures – livelihood will usually take preference.

There is a strong need to overcome the two opposing, often antagonistic, attitudes of conservation or produce, and create an integrated approach in which both views can be housed. Land husbandry (Stocking, 1995a,b) is one such approach in which soil conservation is perceived as an integral part of agricultural production and environmental management. This approach involves ‘grass-root’ integration, viz; taking into consideration total production cycle, land uses, constraints and opportunities, access to land, labor, capital and gender issues, as well as the technical appropriateness of suggested solutions. Such an approach can only truly be implemented if it is carried out with, and under the auspices of, the community directly involved and will, in turn, only succeed if the community has been involved in the process in its entirety and not just paid lip service to as the process unfolds.

The lack of empowerment and control of development experienced by rural communities in South Africa is particularly acute. This stems largely from the enforced racial discrimination and autocratic control of all aspects of life in the country under the previous political apartheid system. As has been noted by Blaikie (1985) soil erosion has both a social and political aspect. Furthermore, it can be viewed as both a consequence of underdevelopment and a cause of underdevelopment leading to a contributing factor in the decline of agricultural production for a region. This is exacerbated in marginal lands such as many of the densely populated, former Homelands, of rural South Africa.

The aesthetic effects of soil erosion are obvious for all to see in the marginal rural areas of South Africa with gullies dissecting once productive subsistence-farmed fields; expanses of bare, sheet-washed, top-soil denuded soils and heavily eroded vehicle tracks and footpaths which constitute a large proportion of the informal transportation network of the rural areas. However, the less obvious consequences of soil erosion are the social and economic aspects such as farm abandonment, rural migration, increased debt and poverty of many of the subsistence-based rural farmers (Scoones et al., 1996). This is a pattern likely to be grossly exacerbated by the need for vehicular access to remote rural communities unless the position and orientation of informal access routes can be carefully located using participatory approaches.

**DISCUSSION AND CONCLUSIONS**

It is widely acknowledged that past rural development strategies have failed to raise living standards significantly in African rural communities (Binns, 1995). They have typically adopted centrally driven, top-down approaches, often failing to appreciate the skills, perceptions, knowledge and aspirations of those whom the programs are designed to assist. The key reasons for the failure of many rural development schemes stems from the fact that they are derived from inappropriate methodologies which have failed to fully comprehend the dynamics of rural life. More specifically, these methodologies have failed to understand the complexities of the socio-economic and cultural contexts in which indigenous livelihood and production systems function. Such limitations have sometimes arisen through the utilization of methodologies with a strong econometric bias (Hill, 1986) and an obsession with the search for universal solutions, rather than trying to identify appropriate strategies for the particular local context. In addition, a lack of empathy and developers’ inability to communicate with the supposed beneficiaries of development have sometimes led to antagonism and frustration by both parties involved.

Where communities are not fully involved or committed to the process of development the results seldom meet expectations.

There is a need to devise schemes that allow for integrated community – land development but, at the same time, take cognizance not to alienate the local government or ‘experts’. This could be achieved through the process of participatory rural appraisal (PRA), providing a vital approach in appreciating the perceptions and skills, including indigenous technical knowledge, of rural people and in formulating locally appropriate, site-specific, conservation/development strategies. This approach has been recognized and implemented in a number of rural African environments, although under other guises depending on the rhetoric of the time and recorder. For example, the implementation of integrated rural development and adaptive rural development strategies in West Africa leading to sustainability and the recognized need for socio-economic factors to be incorporated in the development of appropriate soil conservation technologies in Zimbabwe (Hagmann & Murwirwa, 1996). PRA is developing in South Africa (Binns et al., 1997; Nel and Hill, 2000) and is perceived as a process, which could be used as
a vehicle for co-constructing a shared knowledge base and identifying tangible steps to achieve rural upliftment. Furthermore, it allows for ‘expert’ and community knowledge to be successfully integrated.

The authors concur with Stocking (1995a,b) and regard soil erosion and land degradation as an ongoing process of negotiation between culture and the land. Many soil conservation measures of the past have failed, as they have been top-down and tended to have a technocratic approach instead of integrating socio-economic aspects into the adopted measures. There is a difference between the recognition and perception of a problem and the attitude towards the issue. Peoples’ attitude to soil erosion and possible conservation measures can be altered via education, economic incentives or constraints and/or law enforcement. However, we believe that a more pro-active strategy needs to be in place. PRA allows one to adopt community-initiated and led schemes, which consequently promotes community-empowerment and, more importantly, community-ownership of the process. For soil conservation measures to be successfully implemented and sustained in the South African rural environment the authors see it as imperative that a strategy which involves the people as active partners in all aspects of the development process be applied. It is only through a co-construction of the perceptions, problems and solutions that both parties will be fully committed to attempting to combat soil erosion and implement soil conservation measures, leading to the community taking heed of possible detrimental effects of unplanned infrastructure development within the region (Falloux & Talbot, 1993).

The environmental burdens are severely felt by the rural communities and although the processes leading to these conditions are not always fully perceived, recognized or understood, the resultant loss surely is. Therefore, although development infrastructure such as roads are essential for economic development and growth of rural areas, cognizance, and a fuller understanding, must be taken of the fact that insensitive or misplaced infrastructure development can lead to severe environmental degradation through soil erosion and loss resulting in devastating socio-economic and ultimately political instability of a region. Hence, this is a call for a more integrated program design to identify and address the needs of both development for the sake of the economy and development for the sake of those that have to pay the socio-economic and environmental price – the rural communities.

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