



Environmental Guidelines for Small-Scale Activities in Africa (EGSSAA)
Chapter 14: Rural Roads
(EXCERPT)

Table 1: Environmental Mitigation and Monitoring Issues for Rural Roads Projects

Activity	Impact <i>The activity may. . .</i>	Mitigation Note: Mitigations apply to specified project phase: <i>Planning and Design (P&D), Construction (C), or Operation and Maintenance (O&M)</i>
Planning and Design in General (New and Existing Roads)		
Identification and weighing of alternatives		<ul style="list-style-type: none"> Identify known and potential areas of ecological, archeological, paleontological, historic, religious or cultural significance and ecologically sensitive areas such as tropical forests, wetlands, and other areas of high biodiversity or threatened species along possible routes (P&D)
Establishing design standards	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and paleontological resources Change local culture and society Cause soil erosion Degrade water quality and/or alter hydrology Mar scenic views Lead to injury, disease, or death of workers, and local residents	<ul style="list-style-type: none"> Choose or develop design standards for each facet of construction and related activities, e.g., road bed, road surface drainage, culvert installation, erosion control, revegetation, stream crossing, sensitive areas, steep slopes, material extraction, transport and storage, construction camps, decommissioning, etc. (P&D) Provide plans to identify and protect sensitive habitats (P&D) Take patterns of local weather and natural phenomena into account, e.g., fog, flooding, earthquakes, heavy rain, mudslides, drought, etc. (P&D) Develop an Erosion Control Plan for all projects (P&D)

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Planning route	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and paleontological resources Change local culture and society Cause soil erosion Degrade water quality Alter hydrology Contribute to deforestation Mar scenic views	<ul style="list-style-type: none"> • Have a multidisciplinary team involved in planning new routes. Ideally the team will include an ecologist, geotechnical and road engineer, soil scientist, hydrologist and other relevant professionals, such as an archeologist or tourism specialist (P&D) • Avoid routing road through sites of known paleontological, archeological, historic, religious or cultural significance (P&D) • Avoid routing across agriculturally productive soils (P&D) • Take problem areas involving soil and slope stability into account. Note seasonal and long-term (50- and 100-year) flooding patterns (P&D) • Whenever possible, site roads to follow hill contours (P&D, C) • Avoid creating road grades of greater than 10% as well as long straight downhill stretches (P&D) (C) • Identify sites for temporary/permanent storage of excavated material and construction materials. If excavated material will not be reused, decide how it will be disposed of or shaped (P&D) (C) • Keep the route a safe distance from river and stream banks (P&D) • Avoid environmentally sensitive areas, such as wetlands, and places near protected areas or relatively undegraded forests. Explore possible "compromise" alternatives such as building a narrow, improved trail across protected area lands to provide access on foot, bicycle or motorcycle, with construction of main access roads around these areas (P&D) (C) • Avoid constructing roads through forest areas, especially tropical forest, if possible. If clearing is unavoidable, protect or restore forests elsewhere within the drainage basin as close as possible to those that were lost (P&D) • Minimize impacts on viewsheds (scenic landscapes) by avoiding planning roads that cut long straight paths across valleys and plains. Instead, hide roads beneath forest cover to minimize aesthetic damage, and provide meanders where feasible (P&D) • Avoid siting roads where they may disturb animal behavior such as feeding, mating, and migration patterns (P&D) • If sensitive areas cannot be avoided, involve ecologists and engineers in designing road, construction camp, quarries and other areas. (P&D) (C)

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Constructing road surface	Increase sedimentation Cause discomfort to road users	<ul style="list-style-type: none"> • Stabilize the road surface with gravel/murram and other rocky surfacing material (P&D) (C) • Elevate road surface (measure from base of wheel tracks) above side channel water (see figure 3-1.2) (P&D) (C) • Clearly define the type of road surface shape and drainage method—insloped, outsloped, or cambered/crown roadway—to be used for each section of roadway (see figures 3-1.2 - 3-1.5 for examples of cambered roadway) (P&D) (C)
Drainage	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Install drainage structures during construction instead of after construction. Most erosion associated with roads occurs in the first year after construction. Delaying installation of the drainage features greatly increases the extent of erosion and damage during the first year (P&D) (C) • Clearly define the type of road surface shape and drainage method—insloped, outsloped, or crown roadway—to be used for each section of roadway. Use outside ditches to control surface water when necessary, but avoid general use, as they concentrate water flow and require the road to be at least a meter wider. Install frequent structures, such as berms or ditches , to divert water off the road before it directly reaches live stream channels (see figure 3-1.2 and 3-1.4) (P&D) (C) • Install frequent diversion structures, such as cross drains, drivable, rolling dips or water bars, to move water off the road frequently and minimize concentration of water (P&D) (C) • Install drainage crossings to pass water from the uphill to the downhill side. If using culvert pipes, at least roughly design them before or during construction. Use either the Rational Formula or back-calculation using Manning's Formula and high-water mark data to determine the anticipated flow. This will allow you to roughly determine the correct pipe sizes. Where flows are difficult to determine, use structures such as fords, rolling dips, and overflow dips that can accommodate any volume of flow and are not susceptible to plugging (P&D) (C) • Stabilize outlet ditches (inside and outside) with small stone riprap and/ or vegetative barriers placed on contour, to dissipate energy and to prevent the creation or enlargement of gullies (P&D) (C) • Extend runout drains far enough to allow water to dissipate evenly into the ground (P&D) (C) • Visually spot-check for drainage problems by looking for accumulation of water on road surfaces. Do this immediately after first heavy rains and again at the end of the rainy season. Institute appropriate corrective measures as necessary (C)

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Perennial and intermittent rivers and streams	Risk destruction of bridge by 50-or 100-year flood Cause damming and resultant meandering of stream which destroys neighboring sections of roadway, dwellings and/or native flora and fauna	<ul style="list-style-type: none"> • Construct drifts rather than bridges, where feasible and cost-effective. Since periodic replacement or reconstruction of damaged bridges and culverts can be costly, involve hydraulic engineers in bridge designs (P&D) (C) • When constructing a bridge, consider using a design, such as a Bailey Bridge, that can be erected and dismantled so if the waterway meanders, the structure can be moved to another site (P&D) (C) • Try “training” rivers and streams to follow desired channels by selectively removing debris. However, any channel changes should be minimized. Use a combination of hand labor and small machinery. Careful and selective bulldozing may be feasible in some cases. However, bulldozer tracks can easily expose soil to erosion and do more harm than good (P&D) (C)
Wetlands	Degrade wetland, damaging the valuable ecosystems and habitats Alter hydrology	<ul style="list-style-type: none"> • Avoid routing through these areas (see “Planning route” above for additional guidance) (P&D) • Minimize cuts and/or fills and compensate for impact by protecting other wetlands (P&D) (C) • Take special precautions to prevent release or dumping of debris, oil, fuel, sand cement and similar harmful materials (C) • Use elevated porous fills (rockfills) and/or multiple pipes to maintain natural flow patterns of groundwater and near-surface water (C)
Sloped areas and raised roads	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Stabilize slopes by planting vegetation. Work with agronomists to identify native species with the best erosion control properties, root strength, site adaptability, and other socially useful properties. Set up nurseries in project areas to supply necessary plants. Do not use non-native plants. Use soil-stabilizing chemicals or geotextiles (fabrics) where feasible and appropriate (P&D) (C) • Minimize use of vertical road cuts (even though they are easier to construct and require less space than flatter slopes). The majority of road cuts should have no more than a ¾:1 to 1:1 slope to promote plant growth. Vertical cuts are acceptable in rocky material and in well-cemented soils (P&D) (C) • Install drainage ditches or berms on up-hill slope to divert water away from road and into streams (see figure 3-1.4) (P&D) (C) • Install drainage turnouts at more frequent intervals and check dams to reduce ditch erosion (P&D) (C) • If possible, use higher-grade gravel, which is much less prone to erosion (P&D) (C) • If very steep sections cannot be avoided, provide soil stabilizers or surface with asphalt/concrete (P&D) (C)

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Construction contracts	Cause all types of damage mentioned	<ul style="list-style-type: none"> • Select or develop guidelines and procedures to be applied to each facet of road construction, and incorporate them into contracts with construction companies. These will apply, for example, to site clearing; bed and surface construction; drainage; fuel and materials usage; quarry site management; and procedures for operating construction camp and work site, including procedures addressing worker safety • Include incentives for adhering to guidelines and penalties for violating them
Maintenance agreements	Cause all types of damage mentioned	<ul style="list-style-type: none"> • Finalize maintenance agreements with local communities before beginning construction. All parties must clearly understand and be committed to the terms of the agreement, such as who will do what work, when, how frequently, for what compensation, and within what limits
<i>Planning and Design—Existing Roads (Reconstruction/Repair/Realignment)</i>		
All projects		<ul style="list-style-type: none"> • Use a “clean slate” approach, i.e., consider realigning all existing minimal/informal roads to follow contours and avoid sensitive areas (P&D)
Road surface is below grade of surrounding road	Cause soil erosion Degrade water quality Alter hydrology	<ul style="list-style-type: none"> • Raise road surface with stable fill material. Grade with inslope, outslope or cambered shape. Install sufficient cross-drains, ditches and settling ponds (Figure 3-1.1 and 3-1.2) (P&D) (C) (O&M)
Road is steeply sloped and eroding	Cause soil erosion Degrade water quality Alter hydrology	<ul style="list-style-type: none"> • Consider realigning the road section so that it conforms to preferred design parameters described above. Decommission original road sections after realignment (see “Decommissioning” below) (P&D) (C) (O&M)
Deteriorated road surface	Cause erosion Damage vehicles	<ul style="list-style-type: none"> • Determine cause of deterioration. If the cause is heavy use, either find a means of reducing traffic or upgrade road to a more durable surface (gravel, asphalt, or concrete) (figure 3-1.6) (P&D) (C) (O&M)
Drivers drive at excessively high speeds	Cause injury and death of people and animals	<ul style="list-style-type: none"> • Realign road sections to meander; curving roads deter speeding (P&D) • Add speed bumps in villages or populated areas (C)
Sections have multiple tracks/off-road driving	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Generally caused by either muddy/flooded roadway or highly deteriorated roadway. Maintain or upgrade road so road section no longer floods or becomes muddy (P&D) (O&M) • Raise the road bed or define the roadway with rocks. Realign the road to a better area. Avoid very flat terrain (P&D) (O&M)
Road section must be realigned		<ul style="list-style-type: none"> • Remove surface if necessary and loosen soil of previous track (to accelerate regeneration of vegetation). Block access with rocks, branches, roadblocks and signs. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment. Wider roads may require active planting and reseeding (C) (O&M)

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Construction		
Construction camp and crew	<p>Damage local habitat, compact soil and create erosion via building and occupation of construction camp</p> <p>Contaminate surface water and spread disease via solid waste and feces generated by camp</p> <p>Spread communicable diseases including malaria, tuberculosis, and HIV/AIDS via construction crew members who come from outside the region</p> <p>Introduce alcohol or other socially destructive substances via construction crew</p> <p>Generate trash due to lack of solid waste management</p> <p>Adversely effect local fauna and flora (especially game and fuelwood) via poaching and collection by construction crews</p>	<ul style="list-style-type: none"> • Explore off-site accommodation for crew. Avoid wet, muddy sites (P&D) (C) • Keep camp size to a minimum. Require that crew preserve as much vegetation as possible, e.g., by creating defined foot paths. Define areas of use (with rocks or fencing) (P&D) (C) • Provide potable water for crew (O&M) • Provide temporary sanitation on site, e.g., VIP latrine (assuming the water table is low enough and soil and geology is of appropriate composition) (also consult “Water Supply and Sanitation” in this volume). Where this is not possible, instruct road crews to employ soil mining (digging a pit for human waste and covering with soil immediately after use) (P&D) (C) • Use local or regional labor, if possible. Provide hygiene and public health training to road crews, including information about transmission of HIV/AIDS and other sexually transmitted diseases (P&D) (C) • Collect all solid waste (metal, glass, and burnable materials) from all work and living areas. Dispose of waste in local dump or landfill. If this is not possible, sell recyclables for reuse/recycling, place organic wastes in well-screened waste pits, covering with soil weekly, bury the remainder (excluding toxic materials). (Also consult “Management of solid waste from residential, commercial and industrial facilities” in this volume) • Set guidelines prohibiting the poaching and collection of plants/wood, with meaningful consequences for violation, such as termination of employment. Provide enough food and cooking fuel; both should be of good quality (C) • Restore site through revegetation and similar measures after camp is broken down (C) • Test grade drivers’ ability to follow grade, slope, and contour design standards. Train if necessary (P&D) (C) • Test the ability of bulldozer drivers and other equipment operators to properly maintain drainage structures. Train if necessary (P&D) (C) • Test road crew’s ability to keep roads clear of vegetation with least adverse environmental impacts. Train if necessary (P&D) (C) • Provide workers with appropriate safety equipment, e.g., earplugs or headgear to mute noise from very loud equipment; masks for workers exposed to large amounts of dust; safety glasses for workers doing jobs that may generate sharp projectiles

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Use of heavy equipment and hazardous materials	<p>Cause erosion due to machinery tracks, damage to roads, stream banks, etc.</p> <p>Compact soil, changing surface and groundwater flows and adversely affecting future use for agriculture</p> <p>Contaminate ground or surface water when (1) machinery repairs result in spill or dumping of hydraulic oil, motor oil or other harmful mechanical fluids; and (2) hazardous construction materials are spilled or dumped</p> <p>Put workers at risk from exposure to hazardous materials</p>	<ul style="list-style-type: none"> • Minimize use of heavy machinery (P&D) (C) • Set protocols for vehicle maintenance, such as requiring that repairs and fueling occur elsewhere or over an impervious surface such as plastic sheeting. Prevent dumping of hazardous materials. Capture leaks or spills with drop cloths or wood shavings. Burn waste oil if it is not reusable/readily recyclable, does not contain heavy metals and is flammable. Prohibit use of waste oil as cooking fuel (P&D) (C) • Investigate and use less toxic alternative products (P&D) (C) • Prevent fuel tank leaks by (a) monitoring and cross-checking fuel levels deliveries and use, (b) checking pipes and joints for leaks, (c) tightening generator fuel lines, and (d) preventing over-filling of main storage and vehicle tanks (C) <p>(Also consult “Activities with Micro and Small Enterprises (MSEs)” in this volume)</p>
Materials extraction: Quarrying, logging	<p>Damage aquatic ecosystems through erosion and siltation</p> <p>Harm terrestrial ecosystems via harvesting of timber or other natural products</p> <p>Spread vector-borne diseases when stagnant water accumulates in active or abandoned quarries or borrow pits and breeds insect vectors</p> <p>Take land out of other useful production</p> <p>The quarry may become a safety hazard</p>	<ul style="list-style-type: none"> • Identify the most environmentally sound source of materials that is within budget (P&D) (O&M) • Use material from local road cuts first, but only if it produces a fairly suitable, durable aggregate for either embankment fill or surface stabilization material. Local borrow material can be very cost-effective. Upon removal of material, the area should be restored and receive erosion control measures (P&D) (C) • Develop logging, quarrying and borrowing plans that take into account cumulative effects (P&D) • Take photos of site before initiating excavation, so that restoration can match original site characteristics as much as possible (C) (O&M) • Site quarries and gravel pits so that they are not visible to travelers on the roads (P&D) (C) (O&M) • Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M) • Decommission/restore area so it is suitable for sustainable use after extraction is completed (C) • Install drainage structures to direct water away from pit (C) (O&M) • Implement safety protocols to minimize risks from falling rock or debris, collapsing quarry walls, or accidental falls from cliffs (P&D) (C) (O&M) • Develop specific procedures for storing topsoil, as well as for phased closure, reshaping and restoration when extraction has been completed. Include plans for segregating gravel and quarry materials by quality and grade for possible future uses. Where appropriate, include reseeded or revegetation to reduce soil erosion, prevent gulleying and minimize visual impacts (P&D) (C) (O&M) • Discuss with local community the option of retaining quarry pits as water collection ponds for watering cattle, irrigating crops or similar uses. Highlight issues of disease transmission and the need to prohibit its use for drinking, bathing, and clothes washing (P&D) (C) (O&M)

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Storing materials	Deplete water resources Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Pre-wet gravel when water is more available (i.e., not during dry season) and store gravel in a way that will keep it wet, e.g., covered with plastic sheeting (P&D) (C) • When siting storage areas, avoid using sensitive areas or sites that drain directly into a sensitive area (P&D) (C)
Site clearing and/or leveling	Damage or destroy sensitive terrestrial ecosystems Produce areas of bare soil which cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems	<ul style="list-style-type: none"> • Minimize disturbance of native flora (vegetation) during construction. Minimize the amount of clearing. Clear small areas for active work one at a time (P&D) (C) • Avoid use of herbicides. Any use should follow health and safety procedures to protect people and the environment. At a minimum, herbicides should be used according to manufacturer's specifications (C) • Where possible, remove large plants and turf without destroying them, and preserve them for replanting in temporary nurseries (P&D) (C) • Move earth and remove vegetation only during dry periods. Store topsoil for resspreading. If vegetation must be removed during wet periods, disturb ground only just before actual construction (P&D) (C) • Install temporary erosion control features when permanent ones will be delayed. Use erosion control measures such as hay bales, berms, straw or fabric barriers (C) • Revegetate with recovered plants and other appropriate local flora immediately after equipment is removed from a section of the site (C)
Excavation	Cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems when excavated soil is piled inappropriately Expose inhabitants and crew to risk of falls and injuries in excavation pits Deprive down-gradient populations and ecosystems of water if upper regions of aquifer are blocked	<ul style="list-style-type: none"> • Cover pile with plastic sheeting; prevent run off with hay bales, or similar measures (P&D) (C) • Place fence around excavation (P&D) (C) • Investigate alternatives, such as shallower excavation and no excavation (P&D) • Have construction crews and supervisors be alert for buried historic, religious and cultural objects and provide them with procedures to follow if such objects are discovered. Provide incentives for recovery of objects and disincentives for their destruction or theft.(P&D) (C) • Ensure that excavation is accompanied by well-engineered drainage (P&D) (C)
Filling	Block water courses when fill is inappropriately placed Destroy valuable ecosystems when fill is inappropriately placed Cause later land subsidence or landslides when fill is inappropriately placed, causing injuries and damages.	<ul style="list-style-type: none"> • Do not fill the flow line of a watershed. Even in arid areas, occasional rains may create strong water flows in channels. A culvert may not supply adequate capacity for rare high-volume events(P&D) • Design so that filling will not be necessary. Transplant as much vegetation and turf as possible (P&D) (C) • Use good engineering practices. For example, do not use soil alone; first lay a bed of rock and gravel (P&D) (C) • Balance the cuts and fills (to minimize earthwork movement) whenever possible.

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Cutting and filling	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Test grade driver's ability to follow design standards for grades, slopes, and contours. Train if necessary (P&D) (C)
Compacting to improve road materials performance	Deplete freshwater resources	<ul style="list-style-type: none"> • Water the road immediately before compacting it to strengthen the road surface. (Otherwise, traffic will soon beat back the road surface to pre-bladed condition) (P&D) (C) • When possible, delay compaction activities until the beginning of the wet season or when water becomes more available (P&D) (C)
Blasting	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Minimize blasting (P&D) (C) • Take safety precautions to protect workers and others from being injured by flying or falling rock and avalanches (P&D) (C)
Design verification Quality control		<ul style="list-style-type: none"> • Conduct independent inspections of work periodically to see that it conforms to original plan and design specifications. Provide incentives and disincentives to ensure conformance (C) • Drive roads after moderate rains to identify areas that collect or gully water. Mark and redesign/rehabilitate as necessary (C)
<i>Operation and Maintenance</i>		
Road maintenance to remove ruts, potholes, washboarding, standing water and materials blocking road	Create gulleys and standing pools Create mud holes, potholes Breed disease vectors in settling basins and retention ponds	<ul style="list-style-type: none"> • Monitor and maintain drainage structures and ditches, including culverts. Clean out culverts and side channels/runout (leadoff ditches) when they begin to fill with sediment and lose their effectiveness (O&M) • Fill mud holes and potholes with good quality gravel; remove downed trees and limbs obscuring roadways (O&M) • Use water from settling basins and retention ponds for road maintenance (O&M)
Construction camp and crew	(See "Construction camp and crew" above)	<ul style="list-style-type: none"> • (See "Construction camp and crew" above)
Use and maintenance of equipment	(See "Use of heavy equipment and hazardous materials" above)	<ul style="list-style-type: none"> • (See "Use of heavy equipment and hazardous materials" above) • Install concrete pads, drains and oil/water separators in areas where vehicle and equipment maintenance and fueling will occur regularly

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<i>Decommissioning</i>		
Decommissioning	Cause soil erosion Degrade water quality Damage valuable ecosystems and habitats	<ul style="list-style-type: none"> • Break up old road surface and soil. Remove and dispose of surfacing material (e.g., asphalt) if necessary, and loosen soil of previous track (to accelerate regeneration of vegetation) • Reshape eroded or culled surfaces with outsloping, or add cross-drains or water bars so that water will no longer follow the course of the roadway (See fig. 3-1.1) • Revegetate as needed. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment. Wider roads may require active planting and reseeding (O&M) • Block access with rocks, branches, roadblocks, waterbars and signs.