POLICY BRIEF

October 2019
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Soil erosion and sediment dynamics in farming and forestry systems

Natural ecosystems provide key functions for the sustainable economic development of societies. However, in many regions of the world, in particular, in developing countries, such landscapes have suffered extensive degradation with consequential negative implications for ecosystems health, potentially jeopardising the capacity of ecosystems to deliver various life-supporting services. A research project funded by the Water Research Commission (WRC) has provided insights on soil erosion and the nutrient loss associated with sediment transportation in selected catchments of South Africa.

Background

Land degradation resulting from soil erosion causes the loss of ecosystem services that are essential for human well-being and agricultural productivity. For example, soil erosion reduces crop yield over time due to the removal of topsoil and the associated loss of nutrients and organic matter, which enrich the soil and maintain its structure and water-holding capacity. The loss of topsoil therefore not only affects plant growth, but also reduces infiltration of water into the soil and increases runoff.

In addition, soil erosion leads to high sediment loads in rivers, which reduces water quality and increases the cost of treatment to drinking water standard; causes sedimentation of dams and hence lowers the quantity of water that can be supplied; and results in a range of ecological impacts through reduced light penetration in the water column and smothering of aquatic organisms.

Causes and types of soil erosion

Soil erosion is a natural process, but is accelerated by changes in land use, particularly those that reduce plant cover, as this increases exposure to erosive wind and water. Poor farming practices such as overgrazing, planting crops on steep slopes, and burning land too frequently cause erosion problems on a wide scale in parts of South Africa. Population growth will inevitably increase pressure on land, while climate change, with the predicted increase in extreme weather events, will exacerbate these problems.

Water is the dominant erosive agent in South Africa. At the smallest scale, raindrops hitting the soil surface cause splash erosion by loosening and detaching soil particles. Surface runoff in the form of shallow overland flow results in sheet erosion, which is a uniform removal of soil. Where water flow is concentrated into small channels, rill erosion occurs. At its most severe, soil erosion leads to the formation of deep gullies.

The rate at which soil erosion occurs is influenced by rainfall intensity and amount of runoff, soil erodibility, topography (slope steepness and length), vegetation cover, soil management practises and conservation measures. In South Africa, soil erosion is most prevalent along the eastern side of the country, in the Eastern Cape, KwaZulu-Natal and Limpopo provinces.

Assessing soil erosion

The project team on site.

The research project was conducted at three KwaZulu-Natal study sites, all of which have been used in previous WRC projects.

- The Two Streams sub-catchment near Greytown, in the Mvoti catchment, has existing research infrastructure in the form of a gauging weir, automatic weather station and boreholes. The land cover is primarily commercial timber plantation and sugar cane, and the plantation owners (MONDI) co-operated with the project team by conforming to different management plans in terms of harvesting, clearing, planting and burning.
- Fountainhill Estate is a private farm near Wartburg in the eastern parts of the uMgeni catchment. It was selected due to an ongoing research relationship with UKZN, and land use that includes subsistence agriculture (till and non-till maize) and grasslands (natural and pasture).
- Okhombe is located near Bergville in the northern Drakensberg. It lies within a rural sourveld area in the upper Thukela catchment, and the land use is communal grazing.

The assessment of soil erosion at the landscape scale is notoriously difficult. While small plots can be used to collect information on sediment mobilisation due to rainfall, they can significantly overestimate or underestimate the overall soil erosion.

The current project therefore used a multi-scale approach that incorporated 1 m x 1 m micro-plots and 5 m x 2 m runoff plots at Two Streams and Fountainhill Estate so that both splash erosion and sheet erosion could be assessed, as well as an ISCO sampler installed at a gauging weir outlet of the 34 ha Two Streams catchment. Water samples were collected at these different spatial scales and analysed for sediments and nutrients (nitrate, phosphate, dissolved organic carbon, and particulate carbon and nitrogen).

In addition, erosion and sediment yield modelling was conducted, using data collected during previous research in the region and the current project. The MIKE SHE model was set up and run at the Two Streams study site, with a focus on compiling input data for a hydrological model that could be used for more detailed sediment modelling studies. The ArcSWAT model (ArcGIS extension for the Soil and Water Assessment Tool) was set up and run at both Two Streams and Fountainhill Estate, allowing a comparison between land use types and land management practices.

The Okhombe site was used for a number of rainfall simulation experiments to study cattle path erosion in the degraded grassland. A workshop and demonstration was held for the community members as an empowerment and capacity-building initiative.

Key findings

The research project's findings concur with previous studies that the key driver of soil erosion and sediment yield is rainfall. Measurements of runoff, sediment, nutrient concentrations and particulate organic carbon yields from different sized plots in the respective study sites were similar, demonstrating that rain splash and runoff have comparable impacts on sediment and nutrient detachment and mobilisation. At a larger scale, overall sediment yield is typically relatively lower due to deposition within the catchment.

High-intensity rainfall events resulted in significant loss of sediment and particulate organic carbon, and, by association, nutrients, although measured nutrient concentrations were lower when runoff was high because of the dilution effect.

The results confirmed the value of vegetation cover in reducing soil erosion, both through canopy cover intercepting the rainfall before it hits the ground, and litter cover on the ground reducing the volume of runoff. For example, while commercial forestry has a relatively low rate of erosion prior to harvesting, soil disturbance by heavy machinery during harvesting, together with the loss of canopy cover and litter, will increase erosion. Likewise, harvesting, ploughing and burning of sugar cane fields will reduce vegetation cover, disturb the soil and alter its physical properties, resulting in increased erosion and runoff. Areas under maize tillage and overgrazed grassland were found to have high rates of erosion.

The MIKE SHE modelling exercise for the Two Streams sub-catchment provided insight into the dominant hydrological processes in operation and the overall water use of the hydrological system. Results from the ArcSWAT modelling exercise were compared to previous simulations conducted with other models, which showed that the ArcSWAT model simulated flows well and with greater complexity. This confirmed that the model is suitable for examining the impacts of different land uses in catchments in South Africa, and can provide high-resolution temporal and spatial output data.

Recommendations

Research involving data collection over longer time periods, thereby encompassing more wet and dry seasons, is needed to accurately reflect erosion response to agriculture practices in South Africa. Nevertheless, data

from the current study can be used to update and develop erosion models to improve management techniques and prediction of erosion in catchments with commercial crop plantations, while farmers can use the available information to inform mitigation measures such as strip cropping, green harvesting, mulching, minimum tillage and buffer crops. The project also highlighted the importance of maintaining existing long-term research sites and, where possible, installing new automatic weather stations and making the data accessible to all researchers.

Further reading:

To order the report, ***Assessing the impact of erosion and sediment yield from farming and forestry systems in selected catchment of South Africa*** (**Report No. TT 788/19**), contact Publications at Tel: (012) 761-9300, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.