SUMMARY

Land degradation is a serious problem world-wide and millions of hectares of arable land are already lost and this poses a great threat to sustainable agricultural production. Human-induced soil erosion is a major cause of land and water degradations in South Africa due to unsustainable agricultural land practices. It is estimated that soil erosion by water in South Africa has already affected about 6.1 million hectares of cultivatable and 10.9 million hectares of grazing land. The most affected areas are resource-poor farmers in the rural areas where lack of knowledge and available agricultural land leads to bad agricultural practices and inappropriate land uses. Severe conditions of soil erosion are often found in the semi-arid and arid climates, and large areas of South Africa can be classified as semi-arid and arid.

The problems of soil erosion by water relates to soil loss and sediment yield due to processes of detachment, entrainment, transportation of soil particles from an area of a landscape and deposition on other areas such as backwaters, impoundments, irrigation canals and streams. These processes cause problems of flooding at lower areas and maintenance of soil fertility, irrigation canals, reduced capacity of reservoir and clean water. Sometimes the effects of soil erosion could not be seen but felt such as reduction in soil fertility and soil profile depth. Therefore, it is important to identify the influences such as rainfall, soil topography and vegetation cover and human impact and, type of erosion such as rill, interrill and gully erosion that occurs to combat soil erosion.

To combat land degradation by soil erosion, a LandCare program, which is a community-based natural resources management program, was launched in South Africa. The impact of LandCare projects to combat erosion-induced land degradation requires evaluation tools such as erosion models that can be applied to evaluate the extent of erosion on an area by evaluating and monitoring the impact of land management practices on soil erosion. This could be done through Participatory Monitoring and Evaluation (PM&E) framework implemented in LandCare projects.

Erosion models have been developed under different conditions and applied for a variety of purposes. These models range from soil loss models and field assessment methods of erosion to physically based sediment yield models. Soil loss models apply empirical and statistical techniques to predict soil loss. Whilst, sediment yield models uses sediment-runoff and continuity equations to predict soil erosion by water. Therefore, it is important to know the principles on which they are based, as well as their limitations to select the most appropriate model for a specific set of conditions to avoid wrong results and speculation.

A study was undertaken to evaluate available erosion models and field assessment methods tools to evaluate the impact of land management practices on soil erosion in LandCare projects. The main objectives of this study were:

(a) To theoretically evaluate the suitability of erosion prediction models and field assessment methods as soil erosion tools for use in Participatory Monitoring and Evaluation;

(b) To select suitable prediction model(s) and field assessment method(s) for evaluating and monitoring erosion under communal land management practices;

(c) To apply the selected prediction model(s) and field assessment method(s) in a prediction scenario using data emanating from LandCare project to test their suitability as erosion tools in participatory monitoring and evaluation.

The study was conducted in the Potshini catchment that fall within Highland sourveld (moist) bio-climatic region of KwaZulu-Natal Province of South Africa and is underlain by sandstone and mudstone of the Escourt and Tarkastad formations. The area was chosen since it shown significant signs of erosion and has unsustainable communal livestock grazing and subsistence-based cropping practices targeted by a LandCare project.

Major land uses on the hillslopes were rangeland utilised as communal grazing and cropland utilised mostly for dry-land maize cultivation. Other crops such as *Canibus sativa* were also planted either as intercrops or for crop rotation. The upper slopes of the study area is characterised by rock outcrops, soils of the Mispah and Glenrosa soil forms and high slope gradients. Tillage and grazing practices are carried-out on these slopes that are not suitable for sustainable farming practices.

Potential erosion models and field assessment methods were theoretically evaluated to select appropriate models or methods using scientific criteria of model selection and also other requirements such as the availability of data inputs; applicability under South African conditions; relative ease of data file preparation and selection of inputs. Therefore, soil loss prediction models, SLEMSA (Soil Loss Estimator for Southern Africa) and RUSLE (Revised Universal Soil Loss Equation), and field assessment method ACED (Assessment of Current Erosion Damage), were selected to test their suitability as erosion evaluation tools to be applied during the monitoring and evaluation process of a LandCare project. The selected models and assessment method were applied in a LandCare project to simulate the effect of land management practices on the rate and severity of soil erosion.

Hillslopes showing visible erosion damages were identified and four hillslopes were selected using transact walks. The hillslopes were demarcated into various land facets according morphological appearance, vegetation variation and land use. The South African Soil Classification System and soil augering were used to classify soils and an inclinometer and length-measuring wheel were used to determine slope length, width and gradient. The rills and gullies were measured using a measuring tape and length-measuring wheel. Representative soil samples were collected for the determination of particle-size distribution (Pipette method) and percentage carbon content (Walkley-Black method). Vegetation was described as percentage canopy (vegetation cover above 5cm) and ground cover (vegetation cover up to 5cm) as described in the RUSLE model. The percentage vegetation cover was determined in the field using a square-meter block. Rainfall data collected from Glensila rainfall station indicate that the area is characterised by rainfall intensity of approximately 32 mm.day^{-1} and erosivity of between 11 578 and 16 700 J/m^2/yr.

The soil loss expression units for RUSLE and SLEMSA prediction results are different to that of ACED method due to the different approaches used. Soil loss by ACED is based on the size of the land facet and visibly damaged areas at that particular time. Predicted soil loss by SLEMSA and RUSLE is based on important erosion factors at the time and averaged over a hectare per year irrespective of the size of the land facet. Therefore, the results of the prediction models and a field assessment method were not comparable.

It was found in previous studies that SLEMSA is highly sensitive to rainfall kinetic energy, E and other factors such as topography. The use of predetermined annual E values in original SLEMSA version as applied in Zimbabwe may not yield reliable soil loss results. Therefore, the original and modified versions of SLEMSA were evaluated in terms of kinetic energy value. The modified SLEMSA version was found more reliable to predict soil loss in the study area compared to the original version of SLEMSA. The modified SLEMSA relates to its application in the key areas of the South Africa's Drakensberg mountains in KwaZulu-Natal Province and is based on calculating annual kinetic energy value using the following regression equation that is applicable to the study area,

$$E = 15{,}16\ MAP - 1\ 517{,}\ 67,$$

Where, MAP = Mean annual precipitation.

To evaluate the success of LandCare projects in combating soil erosion, model parameter inputs on vegetation and land management practices were varied during a scenario prediction study to demonstrate the impacts of the various management practices on soil loss. Only SLEMSA and RUSLE were applied for the scenario prediction since the ACED method could not use land management practices or vegetation to demonstrate reduction in soil loss.

In general, it was established that the study area is naturally susceptible to erosion due to the erosivity of the rainfall, steep topography and erodible nature of the soils. The susceptibility of the study area is exacerbated by poor land management practices such as land abandonment and communal grazing. The rangeland was more damaged due to permanent rills and gullies than cropland areas. Although gullies occupy a relatively small area, the magnitude of the damage was high. The abandonment of land formerly under cultivation, particularly on the high slopes with no erosion control or conservation strategy, could worsen the erosion damage and lead to desertification as shown by extensive rill damage and loss of topsoil on hillslope 4.

From the results, ACED indicated that the absence of rills or visible erosion damage on the land facets, such as land facet 6 at hillslope 1, is considered as zero soil loss. ACED assumed that no erosion took place. In contrast, RUSLE and SLEMSA predicted soil losses on the same land facets affected by interrill erosion. By ignoring the effect of interrill erosion indicated that ACED can only be applied to critical areas with visible erosion features. Therefore, it cannot be applied to monitor and evaluate the effect of land management practices on soil loss. On the other hand, SLEMSA considered inherent erodibility of the soil as the most important cause of soil loss and ignored the interaction of other factors such as slope stability and vegetation cover to prevent soil loss. This was illustrated by comparison of SLEMSA and RUSLE predictions of soil loss on land facet 14 on hillslope 3.

The results of the scenario prediction study illustrated that improving vegetation cover without influencing vegetation cover index in SLEMSA does not affect predicted soil loss. RUSLE illustrated more changes in the predicted soil loss than SLEMSA by varying vegetation cover and land management practices. This was because RUSLE was able to predict soil loss from most of the land management practices evaluated in the LandCare project. Also, unlike SLEMSA, RUSLE applies the effect of ground cover to predict soil loss. It is, however, recommended that the reliability of SLEMSA and RUSLE should be verified with measured data from erosion plots.

It was concluded that the ACED could be applied as a participatory erosion learning tool in LandCare projects to identify and assess critical areas of erosion. SLEMSA and RUSLE were considered as valuable erosion tools for monitoring and evaluation of soil loss on a farmland. Therefore, SLEMSA and RUSLE are suitable for decision-making in the management and use of the natural resources. Furthermore, RUSLE was regarded as a more suitable erosion tool for the monitoring and evaluation of soil loss and decision-making than SLEMSA as RUSLE was able to predict soil loss from most of the land management practices evaluated in the LandCare project.

The application of soil erosion models such as RUSLE during the monitoring and evaluation process in LandCare projects would be of great importance for three reasons:

1. To benefit research and technology development;
2. To improve community-based natural resources management; and
3. To provide a framework for sustainable development environment and integrated land use policies.