SOUTH AFRICA'S SOIL RESOURCES AND SUSTAINABLE DEVELOPMENT

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1. NATURE OF SOUTH AFRICA'S SOIL RESOURCES

South Africa falls within the relatively little known "Third Major Soil Region" of the world. This region covers the mid-latitudes on both sides of the equator, between the humid tropics and the high latitudes. South Africa's soil patterns are somewhat comparable to those of other countries at the same latitudes, such as Australia, the Sahel area and countries around the Mediterranean Sea. They are completely different from those of the developed countries at the high latitudes in the northern hemisphere, including North America (USA, Canada) and Europe (West and East). South Africa's soils also differ from the deep, highly weathered soils of the humid tropics.

The developed countries at the high latitudes in the north are dominated by plains with deep, fertile soils and thus high crop production potential. South Africa is dominated by very shallow soils. This is because the combination of hard rock parent materials and very low, inefficient rainfall seriously limits soil formation. Large parts of the country are covered by sandy soils, with severe inherent limitations. In most parts of the country with between 500 and 700 mm annual rainfall, where crop production could theoretically be important, poor quality, unstable soils prohibit this. The poor quality of these soils is due to the influence of the parent materials from which they formed.

Approximately 35% of South Africa receives enough rain for dryland crop production. However, South Africa has only 13% (about 14 million ha) arable land, i.e. land suitable for crop production. Most of this is marginal for crop production, i.e. it has low production potential. Only 3% is considered to be high potential land. Using the international norm that 0.4 ha arable land is required to feed a person, would mean that South Africa could produce food for only 35 million people on its 14 million ha arable land. Normally over-exploitation and fastly accelerated degradation follows when the human carrying capacity of the land is exceeded. In comparison: The USA has 350 million people, but the arable land to feed 800 million.

South Africa has very limited irrigation potential. It is estimated that a maximum of 1.5 million ha can be irrigated. Limited water availability is the main reason for this, but on some of the southeastern rivers limited irrigable soil is the main factor. Only 10% of the irrigated soils in South Africa have high potential. In comparison: Iran, a country with the same size as South Africa, has the potential to irrigate 7.5 million ha.

A characteristic of most South African soils is that they are extremely vulnerable to various forms of degradation and have low resilience (recovery potential). Thus even small mistakes in land use planning and land management can be devastating, with little chance of recovery once the degradation has been caused. In some cases, e.g. in the Drakensberg-Maluti area, environments are described as being robust against degradation, but having very low resilience once they give in.

2. TYPES, DEGREES AND CAUSES OF SOIL DEGRADATION IN SOUTH AFRICA

2.1 Water erosion

Water erosion is the type of soil degradation with by far the biggest effect on the basis of the area affected. It has been described as South Africa's biggest environmental problem. Many figures are mentioned regarding how much soil is annually lost due to water erosion, but these are difficult to verify. It is estimated that South Africa has lost 25% of its topsoil during the 20th century due to water erosion. One estimate is that the average annual soil loss in South Africa is 2.5 tons per hectare. Although this may not seem much, it far exceeds tolerance levels when compared with an annual soil formation rate of 0.3 tons per hectare. In some catchments soil loss rates of over 100 tons per hectare have been measured. In some areas soil loss rates have dropped sharply because virtually all erodable material has already been removed and there is little or nothing left that can be lost.

Water erosion is serious and extensive in both cropland and rangeland. In cropland inappropriate farming practices play a role, but the most serious cases are where non-arable soils that are extremely vulnerable to erosion have been cultivated. An extreme example is the terrible erosion in cultivated areas in the "betterment schemes" or "rehabilitated" areas in the former homelands, where planners often sited fields for cultivation on extremely highly erodable non-arable soils. These have long ago been abandoned, but recovery is very limited. Many such areas carried some of the country's best rangeland, but these have for all practical purposes been permanently destroyed.

In rangeland used for extensive grazing serious erosion is due to removal of the protective vegetative cover due to poor management. Primarily it is due to removal of the dense grass cover. Overstocking with grazers (especially sheep) led to destruction of the grass cover, leaving the soil barren or leading to bush encroachment or densification. Injudicious exclusion of browsers and/or burning to contain bush encroachment or densification contributed largely to the situation. Some of the worst erosion is found in game reserves, established for ecotourism, with alarming signs even in parts of the Kruger National Park. Rangeland management is more difficult in these than on livestock or game farms, because fencing to protect vulnerable areas is, for aesthetic reasons, unacceptable.

2.2 Wind erosion

It is estimated that 25% of South Africa is covered by soils that are potentially highly susceptible to wind erosion. These include the sandy soils in the western half of the "maize quadrangle" in the Northwest Province and northwestern Free State, the areas that produce most of the country's maize. Annual soil loss of as high as 59 tons per hectare due to wind erosion has been measured in this area. Yet, very little attention has been given to wind erosion, which is in South Africa often seen as a "nuisance" rather than as a source of soil degradation.

2.3 Soil compaction

South African soils are extremely prone to serious soil compaction under intensive mechanized cultivated agriculture, both dryland and irrigated. It is throughout the country a problem and much more widespread and serious than the global norm. For example, about 80% of the area on which maize is produced, is prone to serious compaction. It is becoming an increasingly more widespread problem in small-scale agriculture due to increased mechanization. Because compaction restricts roots to a very shallow soil depth, the growth and yields of crops are seriously limited and drought risk is aggravated because the plants cannot utilize the water stored below the compacted layer.

From the early 1960s soil compaction became a widespread and serious problem in South Africa. Its extent and impact is in many areas presently much less than before, because the farmers have adopted appropriate cultivation practices that combat it effectively. In many areas farmers have not yet adopted these practices, however, and compaction remains a serious problem in those areas.

2.4 Soil crusting (surface sealing)

Large areas of South Africa are covered by soils that are extremely prone to serious crusting. The extent of crusting, as well as awareness of it, has increased sharply during the last approximately 25 years. The increased switching to overhead and micro-irrigation systems and the widespread problems associated with these on crusting soils greatly contributed to this. The lack of recovery of the large areas of bare patches in overgrazed rangeland (including game farms and nature reserves/parks) and abandoned cultivated areas is mainly due to severe soil crusting.

2.5 Waterlogging and salinization/sodification

Waterlogging (the building up of excessive water levels in soils due to over-irrigation) and the resultant salinization or sodification (building up of harmful levels of salts or sodium) is of small extent in South Africa, compared with world trends and with other forms of soil degradation in South Africa. This is because in the past South Africa's irrigation water has generally been of good quality. Some small irrigation schemes have been abandoned due to salinization or sodification, however. The quality of the irrigation water is declining due mainly to pollution from urban, industrial and mining sources.

2.6 Acidification

Human-induced soil acidification is a major problem in South Africa. Its impact is serious, because it affects the scarce arable land, especially high potential land. More than 5 million ha cultivated land have already been seriously acidified, due mainly to injudicious fertilizer practices and inadequate lime applications. This is in addition to the 16 million ha naturally acid soils. In the high potential areas of Mpumalanga opencast and strip coal mining causes soil acidification. Although the contribution of acid rain to soil acidification in this area is relatively small, it has, according to one report, a financial implication of R28 million per annum (at 1992 rates) to farmers.

2.7 Soil fertility degradation

The annual loss of the three main plant nutrients due to soil erosion is estimated at 30 000 t N, 26 400 t P and 363 000 t K. The estimated cost to replace these is R365 million per annum at 1985 prices, and probably up to five times as much at present prices. This does not include all the other nutrients that are lost due to erosion.

Due to various reasons very little fertilizer is applied in small-farmer agricultural systems, leading to exhaustive cropping and soil fertility decline. Because yields are low, the annual amounts of nutrients removed, are small, but the long-term effects are large.

In commercial agriculture there has been a tendency of “nutrient capital building” for some nutrients, especially phosphorus and zinc. In some cases P has even been built up to excessive levels, where it decreases yields. Statistics for the last 20 years indicate that trends in P levels follow two opposite directions: In a significant proportion of fields P levels are declining from adequate to deficient, whereas in other cases it is still being increased from adequate to excessive levels due to over-fertilization.

2.8 Pollution

The total soil area affected by pollution is much smaller than those affected by other types of degradation, but the direct effects of pollution are big, especially on human health. Mines and industries, both manufacturing and processing, are the main sources of pollution. Mining pollution consists mainly of toxic levels of various heavy metals and serious acidification. Industrial pollution consists of toxic metals, excessive levels of sodium or phosphorus and/or organic pollutants. Urban waste, such as sewage sludge, is an important source of pollution.

In various cases liquid wastes, inorganic and organic, are disposed on soils, e.g. bleached sands, which do not have the capacity to retain the pollutants in them. The consequence is pollution of underground water bodies, streams, etc. The same will happen with human excreta when pit latrines are sited on such soils.

2.9 Effects of urbanization, industrialization and mining

Apart from their pollution effects, urbanization, industrialization and mining have several other negative impacts on soil – to such an extent that internationally there is presently often more concern about the impacts of urbanization than erosion or pollution on soils. In South Africa indiscriminate invasion of the scarce prime and unique high potential arable land by urban expansion, industrial development and mining is a major problem. It represents a complete and irreversible form of land degradation. It has always been a problem, but has during the last 10 years escalated due to the fast expansion of informal settlements – often onto prime agricultural land. During the last few years there have also been a number of cases of development of shopping centres and other urban complexes in wetlands – areas in which no type of development should ever be permitted because of their key ecological roles.

3. PROGNOSIS FOR FUTURE SUSTAINABILITY

From a soil point there are various aspects that will determine whether ecological, socio-economic and economic sustainability will be achieved and maintained in future. These include, *inter alia*:

a. It must be realized that South Africa is part of the "Third major soil region of the world", of which the nature and quality of the soil resources differ vastly from those of the soils of the developed countries of the northern high latitudes. This soil region is characterized by serious constraints that create special management requirements. Thus one must be very circumspect when trying to transfer technologies from the northern developed countries to South Africa and/or trying to use experts from those countries. It must be realized that any technology is specific to the physical, social, and economic environment in which it was developed and, in order to succeed elsewhere it must be modified and adapted to local conditions. It has been stressed that Africa (also South Africa) needs **locally** trained soil scientists and experts and leader farmers with local experience to guide land use and management.
b. Because of the wide range of environmental and socio-economic conditions, location specific technical solutions are required, blanket solutions do not work. It is often best to start from indigenous knowledge and technologies and to improve these for a specific area.
c. It must be realized that the resilience (recovery potential) of most South African soils is very poor. Once they have been degraded it is very difficult or impossible to get them back into a productive state again. Thus, it is very important that degradation of areas that are still in good condition should be prevented. This is especially true in regard to soil erosion.
d. Sustainable land use can only be achieved and degradation avoided if land use and management planning is based on correct land suitability evaluation. It should be realized that the American eight class land capability evaluation system and its clones are not suitable for achieving the latter. One should use and further develop South Africanized versions of the FAO's land suitability evaluation framework and guidelines.
e. Correct land suitability evaluation is possible only if it is based on high quality physical-biological resource information, including soil maps and soil survey reports. Government should give much more support for surveys to collect this detailed resource information and its safe storage as national asset of very high value. It should be available to the national and provincial governments and local authorities when land use decisions and planning have to be made. This does not refer to agriculture only, but to all types of land use.
f. From a soil point, it is very important to have well-qualified soil scientists to conduct the required soil surveys and research and to be part of the multi-disciplinary teams that are needed to do efficient land suitability evaluations. Unfortunately there is a

tendency to believe that quasi-soil scientists, i.e. people with limited soil science training or training only in somewhat related fields can fulfill this role. Due to South Africa's very difficult and complicated soil scenario, this only leads to big planning errors and eventually unsustainability.

g. Reclamation of already degraded areas poses big challenges and new thinking. Regarding water erosion the emphasis has in the past been on expensive engineering works – building concrete structures across dongas, etc. These are basically traps to collect eroded soil, but they do not combat erosion at its source. Actual erosion control by farmers has been disappointingly limited. Promising successes with community-based soil and water conservation approaches, based on models from the Sahel, have recently been achieved in the Eastern Cape. These could serve as blueprints for future efforts in this regard.
h. In regard to soil compaction, the required knowledge to identify vulnerable soils and to successfully manage it is available from local research. It is important to get farmers in Mpumalanga and Limpopo, who have not done so, to adopt appropriate management systems. The best way could be by farmer-to-farmer extension visits to the Northwest Province and the northwestern Free State.
i. In regard to soil crusting, the required knowledge to identify vulnerable areas and to adapt management systems is also available from local research. Unfortunately this knowledge is seldom used, especially in irrigation planning. The most extreme present situation prevails in Limpopo province where from provincial government side all future irrigation schemes are apparently prescribed to be based on overhead irrigation. For many soils in the province these are not suitable systems. Furthermore, there are small-scale farmers in the province who have for decades been using very successful short furrow irrigation systems – which are the ideal systems for such soils. This type of approach from government side will seriously jeopardize socio-economic and economic sustainability. Similarly, inappropriate approaches can also jeopardize sustainability in regard to other factors.
j. It has been found that soil acidification due to inadequate lime application by farmers is mainly because the cost-benefit squeeze force them to cut on inputs. The high costs to apply lime are not due to high lime prices, but the consequence of excessive transport costs. Adequate lime applications will not be possible without subsidies for lime transport. Inadequate lime applications lead to large yield decreases and both ecological and economic unsustainability.
k. Strict laws to protect prime and unique agricultural land from being invaded by other uses, especially urban development, and the political will to enforce these, are essential for maintaining sustainable resource use. Likewise effective laws against injudicious subdivision of agricultural land into uneconomic units and strict enforcement of them is required to achieve ecological, socio-economic and economic sustainability.

In the end the prognosis for achieving and maintaining ecological, socio-economic and economic sustainability over the next 20 years will depend on a sound knowledge of the country's resources and the political will to implement appropriate land use planning principles and management practices.