Introduction

Land and water management comprises of activities at the local level which maintain or enhance the productive capacity of the soil in erosion prone areas through prevention or reduction of erosion, conservation of soil moisture, and maintenance or improvement in soil fertility. A Land and water management Technology consists of single or combined measures belonging to the following categories: Agronomic (e.g. intercropping, contour cultivation, mulching) Vegetative (e.g. tree planting, hedge barriers, grass strips) Structural (e.g. graded banks or bunds, level terraces) Management (e.g. land use change, area closure, rotational grazing) Combinations (e.g. where two or more technologies are used together and enhance each other) (Van Lynden et al., 2001).

A land and water management approach comprises the ways and means that are used to realize and support a land and water management Technology in achieving more sustainable soil and water use. Elements of a soil and water management Approach are as follows: All participants (policy makers, administrators, specialists, technicians, land users, i.e. actors at all levels), inputs and means (financial, material, legislative, etc.), and know-how (technical, scientific, practical). An approach may include different levels of intervention, from the individual farm, through the community level, the extension system, the regional or national administration, or the policy level to the international framework.

The need for land and water conservation arises from five land degradation problems namely, soil erosion, soil fertility decline, soil water deficit, soil cover deterioration and siltation of reservoirs. Soil erosion by water has been the main focus of attention but currently increasing attention is being paid to the improvement of soil fertility, water harvesting, and the maintenance of vegetative cover. Soil erosion by wind has only been identified as a significant problem in some areas, especially due to inappropriate land use. The siltation of reservoirs is a major problem affecting both the supply of water to urban areas and the generation of hydropower.

Soil and water conservation in Kenya.

Kenya has a long history of state intervention in both soil and water conservation and land management. Early approaches focused on providing cash payments to encourage farmers to construct the labour-intensive measures such as cut-off drains and artificial waterways. But by the end of the 1980s, it had become clear that the conventional approach to soil and water conservation was unable to meet the prevailing environmental challenge. The Government of Kenya recognized that the only way to achieve widespread conservation coverage was to mobilize people to embrace soil and water conserving practices on their own terms. All financial subsidies were stopped, and resources allocated instead to participatory processes, extension, training, tools and farmer trips.
It adopted in 1989 the Catchment (or Area of Concentration) Approach. This was seen as a way of concentrating resources and efforts within a specified catchment (typically 200-500 hectares) for a limited period of time (generally one year), during which all farms were laid out and conserved with full community participation. Small adjustments and maintenance would then be carried out by the community members themselves with the support of local extension agents.

Participatory methods implied shifts of initiative, responsibility and action to rural people themselves. Interdisciplinary teams drawn from various government departments worked together in the catchment. These teams often included officers from ministry of Agriculture, as well as those from other departments and ministries, including Education, Environment, Livestock and Fisheries, Forestry, Public Works, Water Development and Irrigation and Health. They also included staff of local and international NGOs who are actively working in the catchment.

The Catchment Approach brought significant benefits over the individual farmer approach. The number of farms fully conserved every year in Kenya with various soil and water conservation measures rose with the Catchment Approach from 59,450 in 1988 to some 100,000 in the mid-1990s. The process of implementation of the Catchment Approach itself varied according to the human resources available and differing interpretations of the degree of participation necessary to mobilize the Catchment community (Pretty et al, 1995).

In order to guide improvements in delivery of extension services, the Ministry of Agriculture and Rural Development (MoARD) formulated the National Agricultural Extension Policy (NAEP) over several years in the late 1990s. With the broad goals of increasing agricultural production, incomes and standards of living, the policy recognised the need to diversify, decentralise and strengthen the provision of extension services to increase their sustainability and relevance to farmers. To operationalise the NAEP, the Ministry developed an Implementation Framework (IF) for NAEP in the form of a National Agriculture and Livestock Extension Programme (NALEP). The NAEP and the NALEP-IF also referred as NIF were launched in 2001. These were meant to form the basis for all extension work within the MoARD and in its interactions with other stakeholders in agricultural research and development. After subdivision of the MoARD, the Ministry of Agriculture (MoA) and the Ministry of Livestock and Fisheries Development (MoLFD) have continued collaborating in implementing NALEP (NALEP,2005). (NALEP,2005).

A major donor-supported programme in the public sector that is making an important contribution to implementing the NAEP is the Kenya Agricultural Productivity Programme (KAPP), supported by the World Bank. KAPP officially became effective in late 2004. Key partners are the Kenya Agricultural Research Institute (KARI), MoA, MoLFD and the Kenya National Federation of Agricultural Producers (KENFAP). One objective of the first phase is to “reform the extension system”, especially by promoting stakeholder participation in the research and extension processes. KAPP seeks to encourage replication of successful extension methodologies for faster adoption of appropriate technologies by farmers (NALEP,2005).
Overview of technologies and approaches used in soil and water conservation

Agronomic measures

Double digging involves digging soil to a greater depth than usual to break up hard pans and improve infiltration. It is normally combined with the application of compost and the results in crop growth are usually very good though how much of the effect can be attributed to digging and how much to compost is not clear. Double-dug beds are commonly used for vegetables in kitchen gardens. Yields of maize of up to 40% in maize have been reported. Double digging can be combined with runoff harvesting creating the Mandala garden. (Thomas et al. 2003)

Mulching is a process that involves the use of organic materials to cover the ground surface. There are various methods of mulching: (i)Normal (stubble mulching) which involves the use of dead plant residues as a cover over the ground. The crop residue decreases rain drop erosion, slows down the water flows and increases the infiltration rate, (ii)Trash farming – this involves ploughing in crop residues and (iii)Green manuring which involves ploughing in of young growing plants into the soil.

Rotation should be practiced so that those plants that give soil a good crumb such as grass can be allowed to grow. Contour Farming means planting, tillage and other operations along the contour. In contour farming, ridges reduce surface runoff thus preventing rill erosion. Ridging reduces the speed of runoff thus increasing infiltration. Tied ridges are appropriate for semiarid areas. Strip cropping the practice of growing alternate strips of different crops in the same field. It is quite often used in conjunction with terracing. Strip cropping is not carried out as a single practice, but as a combination of several good farming practices particularly crop rotation contour farming and cover cropping and may include conservation tillage operations and stubble mulching. Contour strip cropping: crops are arranged in strips or bands on the contour at right angles to the natural slope of the land usually the strips are cropped in a definite rotational sequence.(Wenner, 1981)

Conservation Tillage is practiced on a number of large scale, wheat farms that are using a variety of mechanized equipment in conjunction with herbicides. One system is to use disk harrow to break up the crop residues and a deep tined cultivator to loosened the ground and undercut weeds. Zai Basins have potential for semi-arid areas of Kenya as they have proved effective in other dry parts of Africa such as Mali, and Bukina Faso.

In the more humid areas the pattern is changing from routine soil conservation measures to new aspects of soil fertility management. This has been due declining yields in these areas, despite to the SWC measures. The use of simple techniques such as rock phosphate and *Tithonia diversifolia* are being encouraged. Very good results have been obtained by some farmers who are using compost made from manure, crop residues, hedge trimmings such as *Tithonia diversifolia* and *Lantana camara*. Stubble mulch farming and conservation tillage are also practised to an increasing extent

Vegetative measures

Grass strips have been promoted since the start of the National soil and Water Conservation Programme in 1974, as a measure which assists in the control of erosion
and leads naturally to the development of terraces with minimal labour. The most commonly used grass is Napier grass though others such as signal grass are also being used. Vetiver grass system is also emerging as technology with high potential for soil and water conservation. The Vetiver System is a low cost simple and effective technology which uses a unique plant Vetiver grass (*Vetiveria zizanioides* reclassified *Chrysopogon zizanioides*). The Vetiver system is used in agricultural fields and watersheds for soil and water conservation, pollution control, bioremediation, water treatment and wetlands rehabilitation. The Vetiver system can be used to enhance agricultural production through soil and water conservation, pest control and provision of fodder for livestock. It can also be used to improve the rural livelihood through provision of material for handicraft, thatching, site slope stabilization, medicinal application and so on. It can also improve wildlife biodiversity through wetlands and wasteland rehabilitation and maintenance, pollution control and wastewater treatment. It is able to do all these because of its remarkable characteristics which permit it to survive where other plants cannot. Vetiver grass often acts as a pioneer plant, establishing itself in hostile conditions and creating micro-climates that permit a variety of other indigenous plants to prosper (Truong and Loch, 2004).

Vetiver is not weedy or invasive and hedges are propagated and established vegetatively. Analyses show that recommended cultivars of *Chrysopogon zizanioides* (South India type) are sterile and are not invasive. Vetiver’s deep, massive fibrous root system can reach down to two to three meters in the first year. This massive root system is likened to “living nails”, binding the soil together. The measured maximum resistance of vetiver roots in soils is equivalent to one-sixth that of mild steel (75 Mpa); stronger than most tree roots; improves soil shear strength by as much as 39% The fibrous mat of roots strengthens earthen structures and removes many contaminants from soil and soil water. Closely planted slips grow into dense hedgerows with a deep, tough root systems. They can withstand inundation, and effectively reduce flow velocities, forming excellent filters that prevent soil loss.

Vetiver grass occurs in several locations in Kenya where it was earlier used mainly as an ornamental or in marking boundaries. Use of Vetiver System for soil and water conservation in Kenya started in early 1990s. Some work on Vetiver grass was done in Embu district under the E.M.I. soil conservation project. The International Centre for Research in Agroforestry (ICRAF) and the Tea Research Foundation of Kenya has also been carrying out some studies on Vetiver grass in Kenya. In Taita Taveta district (Sagalla area) a number of farmers have established Vetiver grass nurseries where they have it available for sale (Owino, 2003). Vetiver grass is being tried in many other places in Kenya but not much information is available concerning the progress.

A Study in India showed that Vetiver grass contour hedges reduced runoff from 23.3% (control) to 15.5%, soil loss from 14.4 t/ha to 3.9 t/ha and sorghum yield increased from 2.52 t/ha to 2.88 t/ha over a four year period. At the International Crops Research Institute for the Semi-Arid Tropics Vetiver hedges gave more effective runoff and soil loss control than lemon grass or stone bunds. Runoff from the Vetiver plots was only 44% of that of the control plots on 2.8% slope and 16% on 0.6% slope. Relative to control plots, average reductions of 69% in runoff and 76% in soil loss were recorded from Vetiver plots (Rao *et al*. 1992). In Nigeria, vetiver strips were established on 6% slopes for three growing seasons to assess effects of Vetiver
grass on soil and water loss, soil moisture retention and crop yields. Results showed that crop yields were increased by a range 11 – 26% for cowpea and by about 50% for maize under Vetiver management. Soil loss and runoff water at the end of 20m runoff plots were 70% and 130% higher respectively in non-Vetiver plots than Vetiver plots. Vetiver strips increased soil moisture storage by a range of 1.9% to 50.1% at various soil depths. Eroded soils on non-Vetiver plots were consistently richer in nutrient contents than on Vetiver plots. Nitrogen use efficiency was enhanced by about 40% (Babola et al. 2003). In Kenya vetiver was able to reduce runoff and soil loss by 28% and 79% respectively after only 16 months. Even though the above results clearly demonstrate the effectiveness of the Vetiver system in enhancing crop productivity, it is important to also take into consideration factors such as the agro-ecological conditions and the age of the barrier when assessing the performance of the Vetiver system (Owino, 2002).

A number of studies have shown that Vetiver grass can be used in an integrated pest management programme. The results of a study by Van den Berg et al., (2003) showed that Vetiver grass had the potential as a trap crop component in an overall “push-pull” strategy in the control of stem borer (Chilo partellus) in maize and rice production. A farmer in Louisiana reported that in a plot of crop where Vetiver was used as mulch, no insects of any kind ever came near. It has also been found that the tops of Vetiver, in the same formation of mixture with the residue of the roots, will make an absolute repellent for the insects that may damage strawberries grown in southern U.S. (Grimshaw, 2002). Studies by Panichpol et al., 1996, Pingxiang Liu et al., 2003 and many others have shown that the forage value of freshly cut Vetiver leaves is comparable to other grasses. They also found that they contained insignificant amount of toxic substances, thus not harmful to the livestock. Vetiver is probably the only grass that provides any feed value at all during drought period because of its ability to survive under drought conditions.
Table 1: Nutritional values of Vetiver, Rhodes and Kikuyu grasses

<table>
<thead>
<tr>
<th>Analytes</th>
<th>Units</th>
<th>Vetiver grass</th>
<th>Rhodes</th>
<th>Kikuyu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Young</td>
<td>Mature</td>
<td>Old</td>
</tr>
<tr>
<td>Energy (Ruminant)</td>
<td>kCal/kg</td>
<td>522</td>
<td>706</td>
<td>969</td>
</tr>
<tr>
<td>Digestibility</td>
<td>%</td>
<td>51</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Protein</td>
<td>%</td>
<td>13.1</td>
<td>7.93</td>
<td>6.66</td>
</tr>
<tr>
<td>Fat</td>
<td>%</td>
<td>3.05</td>
<td>1.30</td>
<td>1.40</td>
</tr>
<tr>
<td>Calcium</td>
<td>%</td>
<td>0.33</td>
<td>0.24</td>
<td>0.31</td>
</tr>
<tr>
<td>Magnesium</td>
<td>%</td>
<td>0.19</td>
<td>0.13</td>
<td>0.16</td>
</tr>
<tr>
<td>Sodium</td>
<td>%</td>
<td>0.12</td>
<td>0.16</td>
<td>0.14</td>
</tr>
<tr>
<td>Potassium</td>
<td>%</td>
<td>1.51</td>
<td>1.36</td>
<td>1.48</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>%</td>
<td>0.12</td>
<td>0.06</td>
<td>0.10</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/kg</td>
<td>186</td>
<td>99</td>
<td>81.40</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/kg</td>
<td>16.5</td>
<td>4.0</td>
<td>10.90</td>
</tr>
<tr>
<td>Manganese</td>
<td>mg/kg</td>
<td>637</td>
<td>532</td>
<td>348</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>26.5</td>
<td>17.5</td>
<td>27.80</td>
</tr>
</tbody>
</table>

Vetiver grass (Vetiveria zizanioides) which has been in existence in the tropics for several years has recently become the subject of intense study and experimentation as an alternative measure for soil and water conservation. Whereas the Vetiver grass system has been shown to have enormous potential for environmental and economic advantages in various parts of the world, in some places the technology has met with resistance from government agencies and research institutions. The adoption of the technology in Kenya has been quite slow and very little has been done towards its promotion since 1990 when it was first tried in the country for soil conservation purpose. It has been tried in various parts of the country with limited success especially in the high altitude areas where some of the reasons given for its poor rate of adoption by farmers include slow growth rate and low palatability as fodder for livestock. In a survey study carried in all the eight provinces of Kenya, 94 % of the agricultural extension staff interviewed indicted that the adoption of the Vetiver system by farmers was very slow. The survey also showed that lack of knowledge about Vetiver was the most important factor affecting its adoption, followed by availability of planting material, and then its palatability to livestock and that climatic condition had the least effect.
Fig. 1: Factors affecting adoption of Vetiver grass system by farmers

Structural measures
Cut off drains have been widely used to intercept runoff and discharge it safely to a convenient point. They are also referred to as diversion ditches and the main function is to reduce the risk of soil erosion by water and in particular to control gully erosion. A cut off drain requires a substantial amount of labour in construction and maintenance. It is appropriate in areas of high rainfall with deep soils and the possibility of discharge to a waterway. Retention ditches are common in humid areas to prevent erosion and in sem-arid areas to harvest runoff and increase moisture storage. Retention ditches are constructed level from end to end.

Fanya juu terraces are constructed by digging a trench and throwing the soil uphill to form a bund. Runoff and sediment accumulate on the upper side and after some years, the fanya juu terraces may become a forward sloping bench terrace.

Stone bunds are common on sloping land in those areas which are particularly stony such as some of the escarpments in the Rift Valley. They may be constructed deliberately but they may also arise from the need to remove stones in order to cultivate the land. They impede runoff, increase infiltration and reduce erosion.

Brushwood barriers are used on very steep slopes in some areas, especially on some escarpments of the Rift Valley where slopes up to 80% or more are used for cultivating finger millet. The brushwood barriers are held in place with stakes and provide a temporary measure to reduce the risk of soil erosion.

Negarims were originally developed in Israel for establishing trees in desert areas. They are V shaped structures laid out along the contour and concentrating runoff at
the lowest corner. Negarims are used to increase soil moisture for fruit tree planting in semi-arid areas. They also assist in erosion control to a small extent.

Conclusion

The systems of Soil and Water conservation have changed in several ways over time in Kenya. The subdivision of the larger scale farms resulted in the removal of the predominantly structural measures that were originally in place. In the small holder areas, there has been greater emphasis on agronomic and vegetative measures and a noticeable increase in the planting of fodder grass in contour strips and along roadsides. The use of fanya juu terraces has increased in the humid and sub-humid areas, but do not exceed the use in the semi-humid and semi-arid areas. In the more humid areas, the new aspects of soil management are emerging with emphasis being directed towards soil fertility improvement. The use of techniques such as rock phosphate and Tithonia diversifolia are being promoted. The use of vetiver system is another approach that has a high potential in soil and water conservation in Kenya. There is need to enhance the adoption of emerging technologies in Soil and Water management through agricultural knowledge and innovation systems, introducing multi-stakeholder methodologies, improved communication, facilitation of bottom-up planning, networking, participatory technology development and use of pro-poor extension methods.

REFERENCES

Grimshaw R. 2002. Vetiver as mulch material. In: Vetiver Network Discussion Board,<dickgrimshaw@vetiver.org>, 1 Feb. 02