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An overview of the soil erosion and sedimentation problems in Kenya

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Abstract While soil erosion and sedimentation are by products of surface water runoff, they reduce soil fertility and the economic life of reservoirs. Available information from research works indicate that this kind of phenomenon has been experienced in Kenya since the 1930s. The quantitative and qualitative evaluation and assessment of soil erosion and sedimentation problems in Kenya is vital in providing significance insight in the development of water resources in the country. This paper examines the historical and the present trends and status of the problem. It considers all the parameters linked with soil erosion and sedimentation processes and suggests means of combating the problem. Indeed, it is a vital input in the development of water resources in Kenya and provides planners with a tool of making policy matters related to water resources development in the country.

INTRODUCTION

Kenya is basically an agricultural country and three quarters of its estimated 23 million population are engaged in agriculture. Large scale changes in agriculture in the last 75-80 years have occurred. These are linked with changes in methods of cultivation practices (from traditional to modern) and expansion of agricultural lands to the more fragile marginal lands in the arid and semiarid areas. In 1900 many of the presently cultivated areas were mainly heavily forested regions, but are now characterized by intensive cultivation which has led to overgrazing in the marginal areas. This has resulted in accelerated soil erosion rates in many of the agricultural and grazing areas and also high sedimentation rates.

Nationally the areas which experience the highest erosional risk coincide with most productive areas in the country. This includes the Kenya Highlands, the eastern Districts of Machakos, Kitui and Embu, the Lake Victoria basin and some parts of the coastal zone. In the rural areas erosion and sedimentation reduce soil fertility and productivity for the farm owners, in addition to causing siltation of channels, reservoirs and dams and increase turbidity of water supplies. This problem therefore calls for urgent attention, understanding and evaluation of the causes and significance of soil and sedimentation problems to the development and management of the natural (land and water) resources of the country. Thus, the significance and urgency of erosion and sedimentation problems, pose a big challenge to environmental planners in the country. This calls for the need for training and support of a large number of Kenyans in all aspects of water and soil management in related fields of earth sciences.

Historical background of soil erosion in Kenya

Soil erosion in Kenya is mainly due to surface-water runoff from "bare" soil surface. The problem is more pronounced in the marginal lands as a result of intensive cultivation and overstocking. Studies elsewhere, indicate that grass particularly if it is not burnt provides the best protection for the soil and causes a minimum of water loss through runoff. Bare soil, on the other hand is shown to be particularly vulnerable to loss of soil and water. The relationship between slope angle and soil loss in semiarid areas in africa has been shown by Hudson & Jackson (1959) from experiments in Zimbabwe. During six seasons the average soil loss from a plot on a 3.5° slope was more than double that lost from a plot on a 1.5° slope. The effects of differences in soil type, vegetative cover, rainfall intensity and amount, runoff and soil loss were demonstrated by Elwell & Stocking (1975) through field experiments on cropping and grazing lands in Zimbabwe. In Tanzania, soil erosion and sedimentation studies were carried out south and east of Dodoma in the years 1968 to 1974. At Mpwapwa runoff and soil erosion were studied from 1933 to 1954.

The problem of soil erosion has a long history in Kenya and had been identified as a major environmental problem by 1935. The dangers of soil erosion increased in Kenya in the 1960s when the nature of approach to soil conservation changed from enforcement to advisory, which led to a temporary breakdown of soil conservation activities (UNEP, 1987). From the 1970s attention has been focused on land management and conservation practises with a view to reducing the problem of soil erosion. Tracts of degraded land seen in Baringo, Kitui and Machakos Districts are evidence of the seriousness of soil erosion in Kenya. Studies by Dunne & Ongwenyi (1976), Dunne *et al.* (1978), Ongwenyi (1978, 1979), Wain (1983) and Edwards (1979)

Table 1 Soil erosion data from selected catchment areas in Kenya.

Drainage basin	Area (km^2)	Total annual sediment production (t)	Area rate of sediment loss (t/km/2yr)	Land use type
Sagana, above Kiganio	501	4 200	8.2	Forest, steep slopes
Sirimon, above Isiolo-Nanyuki Road	62	540	8.6	Forest, steep slopes
Sagana, above Sagawa	2 650	92 000	34	Forest/agriculture/steepslopes
Nzioa, above Broderick Falls	8 500	426 000	50	Forest/agriculture
Tania, above Kamburu Dam 4DE3	9 520	6 068 000	637.4	Agriculture/forestry
Ehania, above Thika	517	82 000	158	Agriculture/forestry
Thiba, above Machanga	1 970	312 000	160	Agriculture/forestry
Tributaries of Athi, Mairobi, Kamburu region, Nairobi	510	110 000	228	Agriculture/forestry
Kambure, Nzoia, below: Tana	1 350	142 000	252	Agriculture/forestry
between Grand Falls and Garissa	15 200	24 000 000	1 560	Grazing
between Kindaruma and Uaso Nyiro	7 700	24 000 000	3 100	Agriculture/grazing
above Archer's	15 300	24 000 000	1 560	Grazing

show high rates of sediment yield and siltation of reservoirs and dams, and in general suggest that soil erosion rates in Kenya are increasing.

Soil erosion and sedimentation

While the problem of soil erosion in Kenya was identified by the year 1935, sediment yield monitoring started between 1948 and 1965. Gauging and sediment monitoring are maintained by the Ministry of Water Development in Kenya. Between 1948 and 1965 the Ministry had established a network for monitoring sediment yields in the drainage areas in the country. These catchment areas are distributed through out a wide range of environment conditions in terms of geology, topography, climate, vegetation and land use types. Sediment yields from these catchments shown in Table 1 for the periods 1948-1965 are calculated from suspended sediment samples and discharge records. They show great variations of erosion between the regions of Kenya. It also indicates a tremendous increase in soil loss between 1985 and 1991. The highest rates of soil loss are encountered in an area of very steep slopes on the eastern sides of Mt Kenya where cultivation is practised in the steep valley slopes in the upper parts and cultivation and grazing are occurring in the gentler but drier hillslopes in the lower marginal parts. On the other hand, in areas of undisturbed forests, soil erosion rates are extremely low. The rates of erosion increases under agricultural conditions and are much greater under grazing and overstocking in semiarid and arid parts of the country.

Soil loss due to running water and wind which is above the permissible amounts (10 tonnes/ha/year) is noticeable in marginal and semi-arid areas due mainly to overstocking by livestock and wildlife. This phenomenon results after overstocking surpasses the carrying capacity of the land. Such soil loss has been reported in parts of Machakos, Kwale, Kilifi, Embu, Kitui, Kajiado, Nakuru, Meru, Samburu, West Pokot, Taita Taveta, Narok, Laikipia, Baringo, Elgeyo Marakwet, and Marsabit. In West Pokot, Kajiado, Nakuru, Taita Taveta, Kitui and Embu soil losses exceed 32 tonnes/ha/year (UNEP, 1987). From Kitui District and the surrounding areas alone, about 200 000 tonnes of topsoil were already lost to the Indian Ocean by 1983.

Sediment production is the main product of soil erosion due to surface water runoff. This is normally deposited in areas along the water courses where the river flow rates are low and the physical conditions are favourable for deposition (i.e. areas of depressions, meanders, dams and dykes,and reservoirs). Thus sediments are produced whenever soil is exposed to rainfall energy and flowing water regardless of whether the location is urban or rural. Sedimentation phenomenon is of great significance to water resources development. It often reduces the economic life of any developed multipurpose reservoirs thus rendering it inefficient for its initial intended use(s).

In general, sediment load is classified into three categories; (i) bed load, (ii) suspended load, and (iii) wash load. In Kenya, suspended load monitoring has been carried out by the Ministry of Water Development (MOWD). The national assessment of soil losses and sedimentation rates commenced in 1969 with studies of flow conditions and sediment yields. The results provide a baseline against which to measure changes in soil erosion with changes in land use and climate. In 1974 a study was commenced to record the suspended sediment transport in the upper Tana River catchment above Kamburu dam. Studies by Consultants for East African Power and

Lighting Company Limited (now Kenya Power and Lighting Company Limited) and Ongwenyi (1978), Dunne & Ongwenyi (1976) indicate that there has been increased rates of sedimentation of the multipurpose reservoirs constructed along the Tana River. About 12.6 million m^3 of sediment were deposited in Kindaruma reservoir since 1968. After 1971 Kamburu reservoir, above it, trapped almost all the sediment. Thus almost all the sediment in Kindaruma must have accumulated between July 1968 and December 1970. If the sedimentation on the Tana and Thiba rivers have so increased since the dams were planned, generation of electricity at Kindaruma would last less than twenty years. It will destroy the fish and aquatic life of the lake and create flooding upstream. If the rate of sedimentation (1971-1976) continues, the Kamburu reservoir in its turn will be completely filled within 30 or 35 years. Worse, if 1961-1976 weather conditions prevail, and if land use continues to increase in the catchment (Tana), the reservoirs are likely to be filled within 20 to 25 years. This will reduce storage capacity and halt hydropower generation at Kamburu. The new Masinga reservoir will, however, trap most of the sediment and thus reduce the rate of

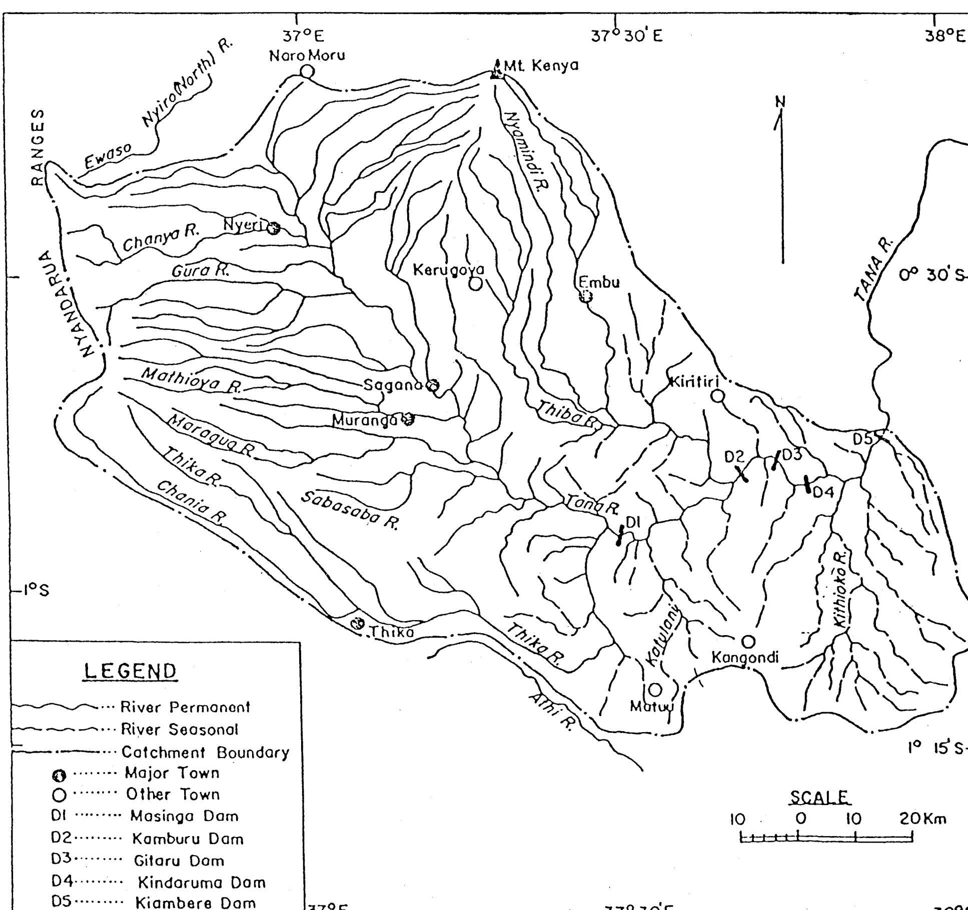

Fig. 1 River network of the upper Tana basin.

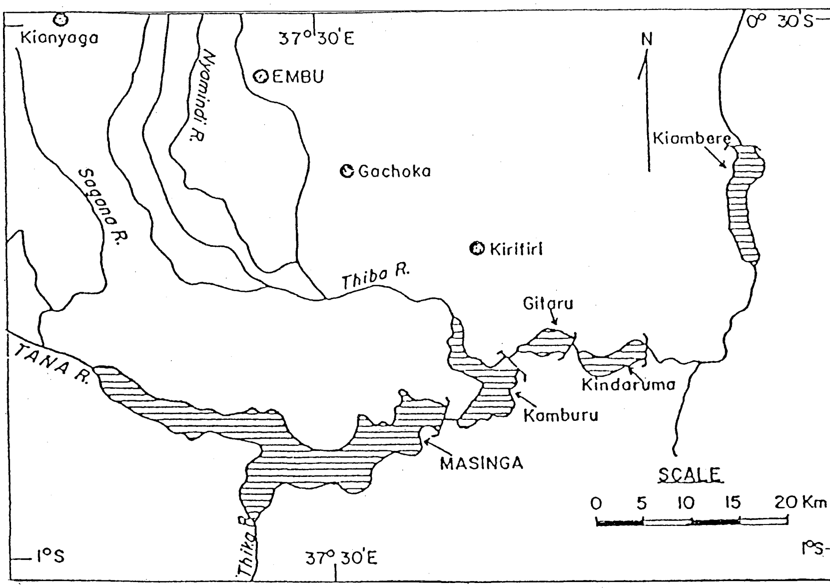

Fig. 2 Upper Tana's five major dams.

sedimentation at Kamburu and extend its life. But the problem will be now transferred to Masinga.

In the Athi River drainage basin sediment transport estimates from 1965 or earlier indicate that this basin lost 55 000 tonnes annually, but current estimates show 2 million tonnes. Soil erosion results from surface runoff in Machakos and Kitui Districts due to destruction of vegetation for charcoal burning, poor cultivation methods and overgrazing. Increased turbidity of the Sabaki waters is evidenced by sediments at Baricho and along the coast. It has resulted in pollution problems at the marine national park and Malindi; a heavy silt load at the water supply intake at Baricho, and the port of Malindi and its value as a tourist resort (Republic of Kenya, 1974).

SOIL EROSION AND SEDIMENTATION EFFECTS AND ABATEMENT MEASURES

Deforestation and land use changes associated with erosion have caused nutrient losses of topsoil and productivity of the land as well as siltation in the reservoirs. The removal of the top soil by erosion reduces soil fertility and water storage capacity of the soil resulting in a decline of crop yield. This is critical because Kenya's population depends of the productivity of the soil for their daily livelihood. Rapid silting of reservoirs and dams which have been built by heavy capital investment reduces the economic life of reservoirs e.g. Kamburu and Kindaruma. Heavy sedimentation rates may affect the biotic life in the reservoirs and interfere with the reservoir's ecosystem. Silting of river channels and other water carrying bodies make them much more liable to flooding. This is presently happening in the Perkera River and the recurring floods in the Kano plains could be attributed to the destruction of forest in parts of the Nandi hills to give way for settlement and cultivation. Heavy deposition of silt at harbour sites

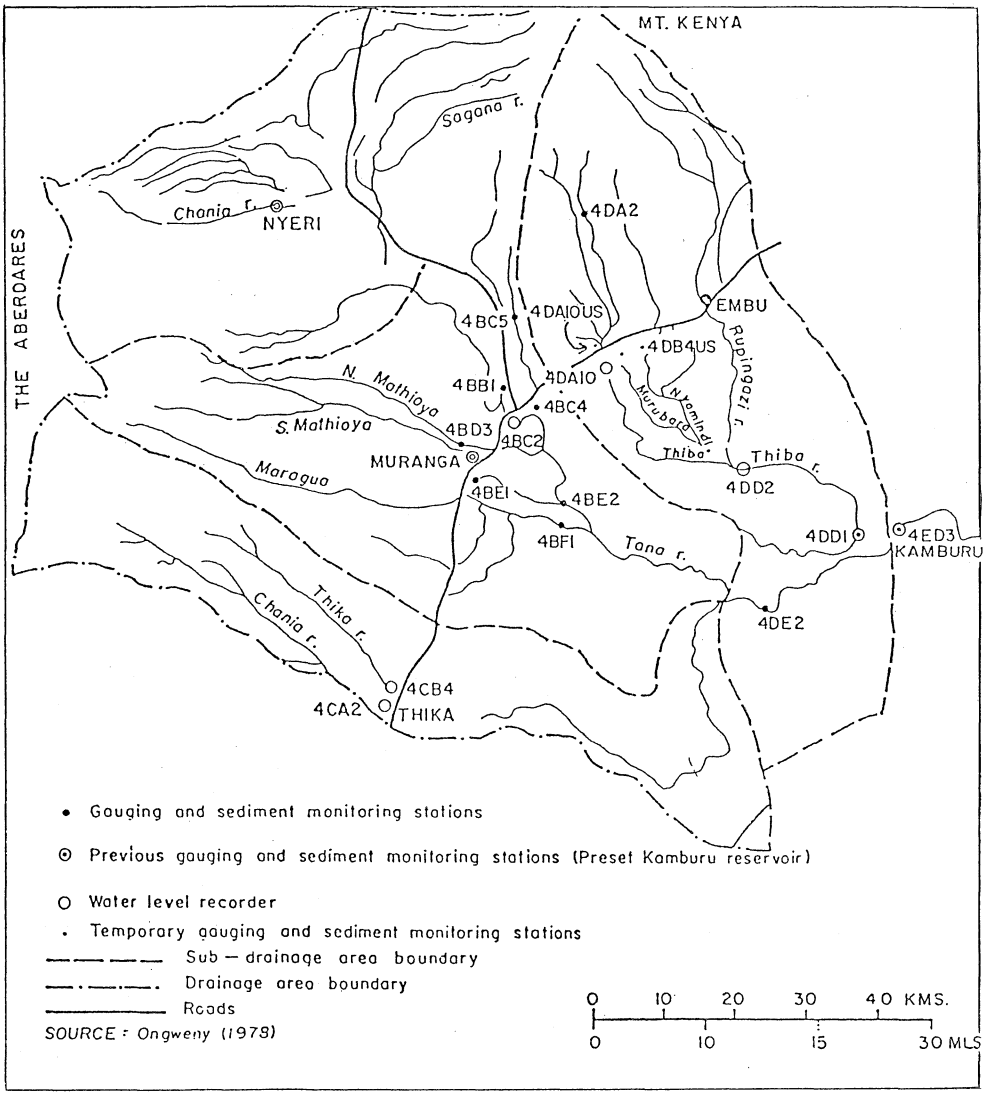

Fig. 3 Drainage, gauging and sediment monitoring stations of the upper Tana catchment.

may have great economic effects on the country. The present sedimentary load of Sabaki River which is being deposited in Malindi has had a remarkable effect not only the development of Malindi as a tourist resort but also on the development and utilization of the Sabaki water for municipal and public water supply in parts of the coast province. Thus, in conclusion the flow of erosion products from grazing lands, cultivated lands, forests and mines threatens the storage capacity of reservoirs by silting and reduces recreational activity and fishing by increasing turbidity.

Soil or land degradation, if left unchecked can reach disastrous proportions. Soil erosion occurs as sheet, rill and gully erosion which are caused by two natural agents namely; wind in the dry season and surface water runoff in the wet season. These

processes are accelerated by poor land management practices such as:
(a) continued overstocking resulting in overgrazing of pastures;
(b) indiscriminate slashing, cutting and burning of natural vegetation;
(c) poor traditional shifting cultivation practices;
(d) population pressure which leads to greater areas of land being opened up for cultivation.

Thus, there is need to take appropriate and most suitable land management and conservation measures. The kinds of soil conservation measures needed to minimize erosion from e.g. roads are very different from those required for cultivated fields. Some attention needed to be given to the management and construction of rural roads in order to develop technology for minimizing soil loss from roads and construction sites because it is a separate problem. Recent efforts of building terraces, benches and dams to conserve soil and water in Machakos and Kitui Districts should be strengthened and extended to other areas e.g. Baringo, Kajiado etc. to reduce surface runoff. "Wanachi" should also be educated on the importance of soil conservation measures and for the use of proper cultivation practices. There is also a dire need for formulation of policy matters relating to water resources development and management. These should include proper evaluation and conservation of all drainage basin's water resources in the country. Researchers and scientist should be encouraged to formulate land-water-people conservation strategies which are similar to the traditional methods of water conservation methods. This is because use of expensive technology for water development and conservation to compensate for shortage may strain other inadequate resources.

In conclusion, there is a need for an evaluation of the economic impact of soil erosion and sedimentation in all reservoirs built or planned for in any drainage basin taking into account environmental implications. Regular and uniform sediment monitoring should commence immediately. There is also a need for training and support of a large number of Kenyans in all aspects of water and soil management in related fields such as agriculture, forestry and water management and conservation. It is also worth noting that the future sedimentation problems cannot be adequately assessed merely by measuring sediment in the river channel at the site of the planned reservoir. Realistic evaluation must be based upon a thorough understanding of hydrologic and geomorphic processes as they relate to land use on the entire catchment.

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