Evaluation of the impacts of soil and water conservation practices on ecosystem services in Sasumua watershed, Kenya, using SWAT model

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ABSTRACT

Degradation of agricultural watersheds reduces the capacity of agro-ecosystems to produce Ecosystem Services such as improving water quality and flood mitigation. Conservation of degraded watersheds can abate water pollution and regulate stream flows by reducing flash floods and increasing base flow as a result of enhanced infiltration. The objective of this study was to evaluate the effect of soil and water conservation practices on hydrology and water quality in Sasumua watershed, Kenya using Soil and Water Assessment Tool (SWAT) model. Vegetative filter strips, contour farming, bench terraces and grassed waterways were the conservation measures assessed. They were represented by adjusting relevant parameters in the model and the resulting effect on sediment yield and stream flow assessed. The width of the filter strip was adjusted to simulate vegetative filter strip, USLE-P and CN were adjusted to simulate contour farming and terraces were simulated by adjusting CN, USLE-P and slope length appropriately. Grassed waterways were simulating by adjusting *CH_N2, CH_EROD* and *CH_COV* parameters in the model. Two additional simulations were also done to compare alternative management scenarios.

It was found that the reduction in sediment yield increased with increase in width of the filter strip but the increase was logarithmic. A 5-meter width was predicted to reduce sediment loading by 38% when simulated in the agricultural part of the sub-watershed. Simulation of contour farming reduced sediment yield for entire Sasumua sub-watershed ($67.44\ Km^2$), from the base simulation value of 32,620 tyr^{-1} to 16,600 tyr^{-1} representing a 49% decrease. Contour farming decreased the surface runoff by 16% from 193 mm for

base simulation to 162 mm and increased base flow from 304 mm to 327 mm an increase of about 7.5%. A combination of 5 meter vegetative filter strip and contour farming were predicted to result in a reduction of 73% of sediment yield. The sediment yield reduced to 8720 tyr^{-1} from the base simulation value 32,620 tyr^{-1}. Simulation of bench terraces reduced sediment load to 4930 tyr^{-1}. This represents 85% decrease. The surface runoff decreased by 22% from 193mm to 151 mm while base flow increased from 304mm to 335mm which is an increase of 10%. Both the contour farming and terraces resulted in only a slight change in total water yield. Grassed waterway simulated for some drainage ditches in the watershed reduced sediment load from 20,600 tyr^{-1} to 12,200 tyr^{-1} at the outlet downstream of the drainage channels that represents a reduction of 41%. For the entire sub-watershed, grassed waterway reduced the sediment yield from 32,600 tyr^{-1} to 25,000 tyr^{-1} which represents a 23.5% decrease. A management scenario that simulated less intensive cultivation in agricultural lands and proper managed grazing in grasslands resulted in a reduction of 34% sediment yield. The sediment yield reduced from 32,620 tyr^{-1} to 21,430 tyr^{-1}. The surface runoff reduced by 28% from 278 mm to 138 mm and the base flow increased by about 14% from 304 mm to 346 mm for this scenario. A management scenario that simulated more intensive cultivation in agricultural lands and overgrazing in grasslands was found to have a 53.6% increase in sediment yield, 44% increase in surface runoff and about 10% decrease in base flow. The sediment yield for this scenario increased from 32,620 tyr^{-1} to 50,100 tyrwhile the surface runoff increased to 278 mm from 193 mm and the base flow reduced from 304 mm to 272 mm.$^{-1}$

Thus all the conservation practices investigated were found to have a positive impact in enhancing the ecosystem services. Soil erosion ‘hotspots’ which should be prioritized in conservation were identified. Bench terraces were found to be the most effective. It is recommended that bench terraces should be constructed in the watershed especially on the soil erosion ‘hotspots’. For the farmers who may not be able to construct the bench terraces due to cost, grass strips should be planted as they would evolve to bench terraces with time. Grassed waterways should also be constructed on the drainage channels that feed Mingotio stream. The Nairobi City Water and Sewerage Company and Water Resources Management Authority should rehabilitate the gauge stations and be collecting stream flow and water quality data. This would be important for better planning and would be of more help in future research work. Further research on the willingness of the farmers to accept to engage in soil and water conservation should be done. The cost of implementing the conservation practices should also be carried out.