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# Suspended Sediment Content

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**Abstract**
Kilimanjaro ecosystem, which is of local and global significance, is experiencing an extensive degradation and deforestation which include completely deforested patches and enormous soil-erosion gullies. Soil loss as a result of erosion is of concern for different reasons like socio-economic and ecological activities. The Government of Tanzania, with support from the Global Environment Facility (GEF) through UNDP is implementing a 4-year project aimed at reducing land degradation on the highlands of the Kilimanjaro Region. Activities carried out include rehabilitation of gullies, agro forestry, soil and water conservation measures (terracing and soil-fertility management). This paper also includes measurement of suspended sediment content within the Pangani River Basin at two gauging stations; Kikuletwa River (1DD1) and Ruvu River (1DC2A). These measurements (suspended sediment) data allows for the estimation of sediment yields.Observation of sediment concentration data (secondary data) of years 2005-2006 in August at 1DD1 ranges from 9.8 to 1136.5 mg/L while primary data of year 2014 in August at 1DD1 ranges from 9.333 to 33.667 mg/L. This reveals sediment yield in 2005-2006 are higher than in 2014. The same observed at 1DC2A where secondary data ranges from 0.2 to 13.0 ton/day while primary data ranges from 5.879 to 7.400 ton/day. Although the two sets (collected in August) differ in sample sizes due to limited resources, gives credence to the comparisons, particularly that it is averages that are being compared. Therefore the findings with limited information show that the sediment loading rate for the two rivers, Kikuletwa and Ruvu is declining.
**Keywords:** Pangani river basin, kikuletwa, ruvu, sustainable land management, suspended sediment content

## INTRODUCTION

The Government of Tanzania, with support from the Global Environment Facility (GEF) through UNDP is implementing a 4-year project aimed at reducing land degradation on the highlands of the Kilimanjaro Region, which has 7 administrative councils, namely Rombo, Hai, Moshi Rural, Moshi Municipality, Siha, Mwanga and Same. The project is in response to the extensive degradation and deforestation that the Kilimanjaro ecosystem, which is of local and global significance, is experiencing. Examples include completely deforested patches and enormous soil-erosion gullies. Soil loss as a result of erosion is of concern for different reasons, e.g., socio-economic, and ecological. The Project is covering 40,000 ha, across six watersheds in three mountain blocks of Kilimanjaro, North Pare, and South Pare. Activities include rehabilitation of gullies, agro forestry, soil and water conservation measures such as terracing, soil-fertility management, etc. With such measures it is expected that degraded land could be recovering. As such, one indicator of the project's performance is about reduction of silt in the Pangani River system at least by 10%. This paper, therefore, set out to measure the suspended sediment content within the Pangani River Basin. Measurement of suspended sediment data allows for the estimation of sediment yields. This information will not only to contribute to the development and prioritization of land management strategies, but also assess if activities of the project are contributing to sustainable land management. This paper describes the current methods used as part of the basin suspended sediment monitoring programme, with results collected prior to August 2014 included.

## METHODS

Two 2 monitoring sites used are from Kikuletwa and Ruvu Rivers in Pangani River Basin (Fig. 1, Table 1). These sites include 2 manual gauging stations and 1 automatic station called ISCO (but currently not operating due to a technical problem).

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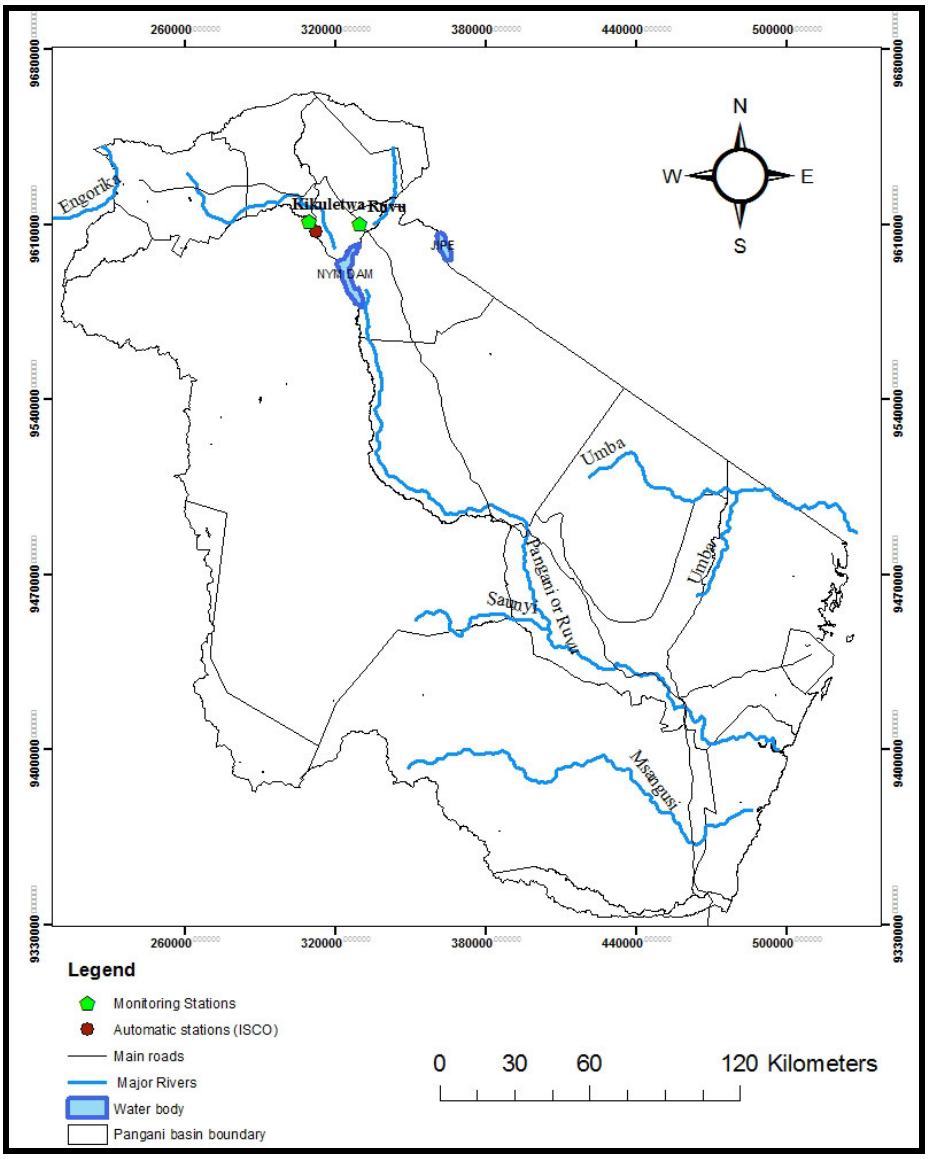


**Figure 2: Pangani Basin showing manual and automated (ISCO) gauging sites**

**Table 3: Manual gauging and automated (ISCO) site**

| Reference Number | Site Name | Sources | Location |
|---|---|---|---|
| 1DC2A | Ruvu | Ruvu River | Kifaru |
| 1DD1* | Kikuletwa | Kikuletwa River | TPC |

*Include manual and automated sediment monitoring (ISCO site).

A wide range of techniques are available for sampling suspended sediment in rivers. The appropriateness of each technique is determined by the flow and sediment dynamics; sample and data requirements; and resources available. The sampling techniques described herein can be broadly classified as: (i) manual and, (ii) automatic. Manual sampling is the most effective and direct means of obtaining suspended sediment sample of the river while automated Sampling is an alternative to manually sampling the river by deploying apparatus capable of automatically collecting a sample without a field operator being present.

**Data collection**

**Flow measurement**

First flow measurements were carried out at each station (Kikuletwa River and Ruvu River) by current meter method (wading). Flow calculations and analysis were done within Pangani Basin Water Board.

 

GAUGING STATION RUVU RIVER AT KIFARU No. 1DC2A SHEET No. 1/2

DATE 12/08/2014 MEAN GAUGE HEIGHT 1.05M

| Distance from initial point | Sounded depth | Angle | Revised depth | Unrevised depth of obs. | Revised depth of obs. | Revs. | Time | Velocity: Vel. at point | Velocity: Multiplier | Velocity: Mean vel. in vert. | Mean vel. in section | Area of section | Discharge in section | Discharge accum. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | W/E | ~~R.B~~ | L. R.B | G.H | 1.05M | Time 09:52 A.M | | | | | | | |
| 1.00 | 0.33 | | | | 0.198 | 18 | 40 | 0.124 | | 0.124 | 0.083 | 0.165 | 0.014 | 0.014 |
| 2.00 | 0.68 | | | | 0.408 | 32 | 40 | 0.213 | | 0.213 | 0.169 | 0.505 | 0.085 | 0.098 |
| 3.00 | 0.69 | | | | 0.414 | 74 | 40 | 0.484 | | 0.484 | 0.349 | 0.685 | 0.239 | 0.338 |
| 4.00 | 0.78 | | | | 0.468 | 116 | 40 | 0.757 | | 0.757 | 0.621 | 0.735 | 0.456 | 0.794 |
| 5.00 | 0.81 | | | | 0.486 | 122 | 40 | 0.796 | | 0.796 | 0.777 | 0.795 | 0.618 | 1.412 |
| 6.00 | 0.74 | | | | 0.444 | 88 | 40 | 0.575 | | 0.575 | 0.686 | 0.775 | 0.532 | 1.944 |
| 7.00 | 0.65 | | | | 0.390 | 100 | 40 | 0.653 | | 0.653 | 0.614 | 0.695 | 0.427 | 2.371 |
| 8.00 | 0.67 | | | | 0.402 | 103 | 40 | 0.673 | | 0.673 | 0.663 | 0.660 | 0.438 | 2.809 |
| Totals | | | | | | | | | | | | | | |

Computed By Elijah.S Bachuba Date 12/08/2014 Checked by PAUL DAMIAN Date 13/08/2014

**Figure 2: Filled form showing flow measurement and analysis**

**Suspended Sediment Load**

Later suspended sediment load sampling performed along the river cross section which divided into 3 sections (left, middle and right) where three samples collected for analysis by using DH-48 sediment sampler. In total 15 samples collected into labeled containers for laboratory analysis. Filtration of water samples for suspended solids was done by using vacuum pressure-pump fitted with glass fiber 0.45 µm diameter membrane filters which were initially treated in the oven at $70^0$C for 24 hours. Before being used the original weight in grams of the filter membranes was taken by using a sensitive weight balance and then recorded. Water sample was filtered, and then the wet filters were dried in an oven at $103^0$C - $105^0$C for 1 hour. The weights in grams of the filters with dried residue were measured. The amount of suspended solids in each sample was calculated using the following formula;

$$\text{Total suspended solids in (mg/L)} = \frac{F_R - F_D}{V_S} \times 1000$$

Where;

$F_R$ = Weight of filter with dry residue in (mg)
$F_D$ = Weight of dry filter in (mg)
$V_S$ = Sample volume in (mL)

 

**NGURDOTO DEFLUORIDATION RESEARCH WATER LABORATORY**

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Analysis Requested by: **PANGANI BASIN WATER OFFICE**

Region: **KIIMANJARO**

Date Sample received: **17/08/2014**

**WATER ANALYSIS REPORT**

| S/NO | DATE | STATION NAME | SEDMENTS CONCETRATIONS (mg/l) |
|---|---|---|---|
| 1 | 12/08/2014 | RUVU RIVER | 34 |
| 2 | | | 6 |
| 3 | | | 33 |
| 4 | 14/08/2014 | RUVU RIVER | 38 |
| 5 | | | 16 |
| 6 | | | 5 |
| 7 | 11/08/2014 | KIKULETWA RIVER | 46 |
| 8 | | | 16 |
| 9 | | | 39 |
| 10 | 13/08/2014 | KIKULETWA RIVER | 11 |
| 11 | | | 3 |
| 12 | | | 14 |
| 13 | 15/08/2014 | KIKULETWA RIVER | 3 |
| 14 | | | 8 |
| 15 | | | 20 |

Masumbuko Godwin Msongo
Reporting officer
20/08/2014

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**Figure 3: Laboratory results of sediment samples**

## RESULTS AND DISCUSSION

The primary data was obtained from the laboratory analysis of the sediment samples collected from the two

 

gauging stations; Kikuletwa River (1DD1) and Ruvu River (1DC2A) from 12/08/2014 to 15/08/2014 and the results are as shown Table 2. The secondary data was collected from previous studies done in August for the years 2005-2006. The latter provided a basis for comparison to detect changes in sediment yield.

**Table 2: Summary sediment yield and concentration data as at August 2014**

| S/No | Date (DDMMYY) | Station name | Flow, Q ($m^3/s$) | Suspended Sediment Concentration, SS (mg/L) | Average, SS (Mg/L) | Sediment Load, Qs = 0.0864*Q*SS (Ton/day) |
|---|---|---|---|---|---|---|
| 1 | 12/08/2014 | Ruvu River at Kifaru (1DC2A) | 3.520 | 34 | 24.333 | 7.400 |
| 2 | | | | 06 | | |
| 3 | | | | 33 | | |
| 4 | 14/08/2014 | Ruvu River at Kifaru (1DC2A) | 3.460 | 38 | 19.667 | 5.879 |
| 5 | | | | 16 | | |
| 6 | | | | 05 | | |
| 7 | 11/08/2014 | Kikuletwa River at TPC (1DD1) | 11.531 | 46 | 33.667 | 33.541 |
| 8 | | | | 16 | | |
| 9 | | | | 39 | | |
| 10 | 13/08/2014 | Kikuletwa River at TPC (1DD1) | 13.796 | 11 | 9.333 | 11.125 |
| 11 | | | | 03 | | |
| 12 | | | | 14 | | |
| 13 | 15/08/2014 | Kikuletwa River at TPC (1DD1) | 13.014 | 03 | 10.333 | 11.618 |
| 14 | | | | 08 | | |
| 15 | | | | 20 | | |

**Comparison between the collected secondary and primary data**

The observation of the sediment concentration data (secondary data – 35 samples) of August for the years 2005-2006 of 1DD1 shows that the sediment concentration ranges between 9.8 and 1136.5 mg/L. The primary data obtained from laboratory analysis of the sediment sample collected from 1DD1 ranges between 9.333 and 33.667 mg/L. The comparison reveals that the sediment yield in 2014 was lower than in 2006 as shown in Table 3. In the case of 1DC2A, the observation of the secondary data (37 samples) of August for the years 2005-2006 shows that the sediment load ranged between 0.2 and 13.0 ton/day while the data obtained from laboratory analysis (2014) of the sediment load ranged between 5.879 and 7.400 ton/day

**Table 3: Comparison of sediment yield at two sampling sites**

| Site | Parameter | Amount by Year | | Difference |
|---|---|---|---|---|
| | | 2014 | 2005-06 | |
| 1DD1 (Kikuletwa River at TPC) | highest average daily yield (ton/day | 33.541 | 1132.3 | -1098.76 |
| | lowest average daily yield (ton/day) | 11.125 | 11.7 | -0.575 |
| | highest mean concentration (mg/l) | 33.667 | 1136.5 | -1102.83 |
| | lowest mean concentration (mg/l) | 9.333 | 9.8 | -0.467 |
| 1DC2A (Ruvu River at Kifaru) | highest average daily yield (ton/day | 7.4 | 13.0 | -5.6 |
| | lowest average daily yield (ton/day) | 5.879 | 0.2 | 5.679 |
| | highest mean concentration (mg/l) | 24.333 | 42.8 | -18.467 |
| | lowest mean concentration (mg/l) | 19.667 | 0.8 | 18.867 |

Also at 1DD1, the observation of the secondary data of August for the years 2005-2006 shows that the sediment load ranged between 11.7 and 1132.3 ton/day while the data obtained from laboratory analysis (2014) of the sediment load ranged between 11.125 and 33.541 ton/day. Therefore these results show a decline in sediment yields (see table 3 above). The SLM project may have contributed to the decline of the sediment yield, but it is unlikely, however, that it is only reason. Other factors are programs such as Water Sector Development Progrms (WSDP, 2006-2025) which has component emphasize water sources protection and conservation by prohibiting human practices near water sources might also contribute to the decline of sediment load.

## CONCLUSION

A total of 72 samples were collected in 2005-2006 (for month August), including 35 sampled by ISCO (at 1DD1) compared with 15 samples collected in 2014 (for the same i.e. August). Although these two sets are not equal in sample sizes but collected in the same month (i.e., August) gives credence to the comparisons, particularly that it is averages that are being compared. Also due to limited resources, time and life span of the project, fifteen (15) sample sizes collected slightly seemed worth to be compared. Therefore the findings of this assignment, albeit with limited data/information, show that the sediment loading rate for the two rivers, Kikuletwa and Ruvu is

 

declining.

**ACKNOWLEDGEMENTS**

The results presented represent part of a larger project of reducing land degradation on the highlands of the Kilimanjaro Region, which has 7 administrative councils, namely Rombo, Hai, Moshi Rural, Moshi Municipality, Siha, Mwanga and Same within the framework of Sustainable Land Management (SLM) Project. The authors gratefully acknowledge the assistance of Pangani Basin Water Board's staff in data collection from the field and reviewing comments of the paper.

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