

# **The effects of deforestation on tropical freshwater streams: A comparison of stream geomorphology and coarser clastic particles distribution between Kasekera watershed (forested) and Mtanga watershed (deforested), Lake Tanganyika, East Africa**

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## **Introduction**

Streams alter the Earth's landscape through the movement of water. Streams are powerful erosive agents moving material from their bed and banks. In mountainous regions, stream erosion often produces deep channels and canyons. Streams also deposit vast amounts of sediments on the terrestrial landscape and within the lake basin. The size and flow of streams are directly related to their watershed area and geology. Other factors which affect channel size and stream flow are land use, soil type, topography and climate. The geomorphology of the channel reflects all of these factors.

This study involves two small freshwater streams located on the northeastern coast of Lake Tanganyika in western Tanzania. The Mtanga and the Kasekera streams were chosen for this study because of their similarity in nearly all factors that affect watershed erosion and streambed deposition other than current forest cover status. The two streams are similar in size (the Mtanga watershed is 3km<sup>2</sup> and the Kasekera is 3km<sup>2</sup>) and the bedrock in the area of both watersheds is the Kigoma Quartzite. The main difference between the two watersheds is vegetation cover. The Kasekera lies within Gombe Stream National Park and its vegetation cover is tropical forest. The Mtanga stream lies to the south of Gombe Stream National Park and has been settled by humans and most of the original vegetation has been removed and the area is largely devoid of trees, mostly the result of local fires. This study will attempt to determine the effect deforestation has on the erosional processes in the watersheds by comparing bedrock geology, stream geomorphology and clastic particles distribution between the two streams.

## **Research Objectives**

- To assess the impacts of land use of watersheds on the geomorphology and clastic sediments distribution on the two contrasting streams (forested and deforested);
- To establish the role of geology of the watersheds on the geomorphology and clastic sediments distribution on the two contrasting streams (forested and deforested).

## **Hypothesis**

- The geomorphology of the streams and clastic sediments distribution are affected by land use of the watersheds.
- The geomorphology of the streams and clastic sediments distribution are controlled by the geology of the watersheds.

## **Methodology**

### *Stream geomorphology mapping*

We mapped the watersheds, particularly along the streams using a handheld GPS unit to continually locate and track position. We took coordinates and elevation at three points across a stream, on

its northern bank, south bank and in the central part of the channel, with recordings going upstream every 50m starting from stream mouth up to 500m, then every 100m up to 1000m upstream. Observations about the bedrock lithology and geomorphological constraints on sedimentation within the stream were made. A tape measure was used to estimate stream width and depth at every 50m upstream from river mouth up to 500m from the shore inland, then every 100m up to 1000m.

*Gravelometer*

The US SAH-97™ hand-held gravelometer-particle size analyzer was used to sort the size of individual gravel and cobble particles into ½ phi size classes. An advantage of the gravelometer over sieving or using calipers is its reduction of error in measurement by eliminating incorrect identification and measurement of the intermediate particle axis, a common problem in measurement and classification using traditional calipers. During mapping, the streambed was sampled every 50m interval upstream. At each point of the stream was selected along which unbiased selection of a representative particles occurred. Particles are counted and tallied by the smallest hole in the gravelometer, which they pass through. Approximately 5 to 10 particles were counted at each point according to stream width (the wider the stream, the more particles were sampled). Finally the graphs of relationship between distance upstream and grain shape for both streams were plotted.

*Steel Stick test: Sediment Penetration Measurements/Compaction Estimation*

This test was used for determination of thickness of loose sediments, with measurements made every 50m starting from stream mouth (0m). At each sampling site a steel rod was hammered into the loose sediments on the north and south banks as well as in the active stream channel, across a stream at particular point. The extent of penetration into loose sediments was measured by a tape measure.

**Results & Interpretation**

*Stream Geomorphology*

Stream	Status	Slope (°)	Av.width (cm)	Av.bank height (cm)	Lithology	Comments
Mtanga	Deforested	1.89	43.67	93.8	Precambrian sediments, soil, Kigoma quartzite boulders	Erosion is more intense
Kasekera	Forested	4.69	8.79	59.34	Precambrian sediments, soil, Kigoma quartzite boulders and silt stone	Less erosion taking place

Kasekera Stream (Forested) – See fig.5

Located in the heavily forested Gombe Stream National Park, Kasekera is dominated by modern soils and Precambrian sediments. The channel appears to be completely occupied by the current water flow in most places. In other places, gravel and cobble point bars and transverse bars can be found in straighter sections. Samples were taken in the deepest portions of the stream.

Mtanga Stream (Deforested) – See fig.6

Located south of Kasekera and the Gombe Stream National Park, Mtanga is deforested with a village living along its flanks with a population of about 300 people (authors’ field estimation).

*Gravelometer Data*

Gravelometer data supports data from sediments shape analysis that Mtanga (deforested) has more angular sediments than those of Kasekera (forested). The difference between streams is very significant (p>0.0079). One explanation of this result is that angularity is a function of lack of vegetations cover, hence there is less filtration of the water by natural means (roots, leaves, etc...), and higher energy flows during

wet season related events. Also, Kasekera has more rounded sediments compared to Mtanga. The difference between streams is very significant ( $p > 0.005$ ), possibly for the same reasons as particle angularity, although in addition, the furthest possible source of sediments in Kasekera stream is farther than at Mtanga stream. See the illustrations below.

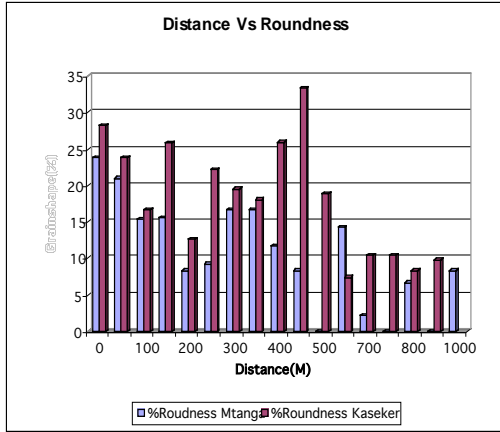


Fig.1.

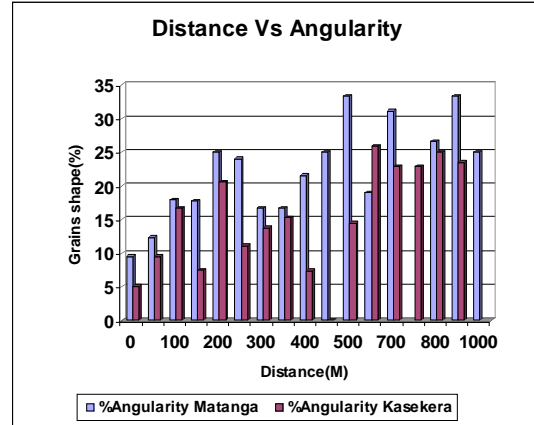


Fig.2

Steel stick data

Steel stick data supports data from the loose sediments analysis that Mtanga stream (deforested) has thicker loose sediments downstream than those of Kasekera stream (forested). However, the difference between streams is not significant ( $p > 0.214$ ). At Kasekera the loose sediments are randomly distributed due to abundant vegetation along the stream corridor provide resistance to erosion and filtering of sediments than Mtanga where most of sediments are deposited down the stream. For more details, refer to the figures below.

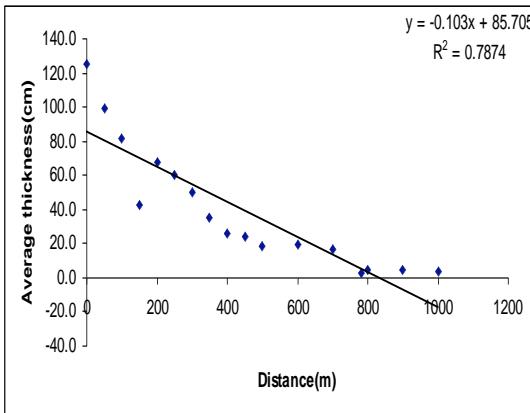


Fig.3; Relationship between thickness of loose sediments and distance from shore to upstream sites at Mtanga.

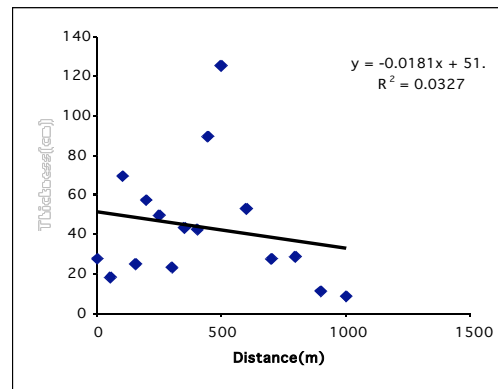


Fig.4; Relationship between thickness of loose sediments and distance from shore to upstream sites at Kasekera.

Discussion

The statistical analyses showed that there is a significant relationship between percent of grain shape (roundness and angularity), width of stream channel and distance upstream for both stream mouths. At Mtanga stream (deforested) thickness of loose sediments, width of channel, sediments roundness as shown on the figures(1,2,3,10,11) were shown to generally decrease with distance upstream whereas the height of banks and angularity of sediments generally increases with distance upstream. At Kasekera all

the parameters studied (stream width, stream channel banks and thickness of loose sediments) except grain shape distribution vary randomly. Decreases in channel width upstream may be due to the nature of the banks, which are controlled by outcrops of quartzites on both sides but lower part of stream only bare soil which is easier to erode during wet seasons. There is also a lack of vegetation along the stream channel in its lower course. Sediment roundness decreases upstream, loose sediment thickness decreases upstream because of the erosive power of the stream which is higher upstream hence erode and transport most of material downstream. The randomness of the parameters at Kasekera may be due to thick nature vegetation along the stream, its highly meandering character, and the fact that the source of stream and sediments are very far from the shoreline (i.e. sediments are traveling for a longer distance before reaching the stream mouth).

## **Conclusions**

This study used multiple stream analyses and field mapping to investigate the relationship between deforestation and stream sediment characteristics and its geomorphology. Combining this multi-analytical approach, we conclude the following:

1. Channel width and stream morphology seem to be related to the extent of deforestation. The impacted watershed displays a wide, eroded channel with more angular sediments, less rounded and little vegetation, whereas the un-impacted watershed had a narrower channel with more rounded and less angular sediments.
2. Variation of particle shape in the deforested stream was much higher, suggesting a lack of filtration of the water by natural means (roots, leaves, etc.), and high energy flows during wet season related events.
3. Destabilization of the stream banks and channel bottom directly by such things as livestock grazing and damaging land management practices.
4. Loose sediments are deposited primarily in the downstream reach.
5. The stream width generally increases in the downstream direction, that is, it is a function of discharge, sediment transport, bed and bank materials, and vegetation along the stream. Vegetation along the stream corridor provides resistance to erosion and filtering of the sediments.

## **Recommendations**

In order to conserve the streams watersheds the following recommendations are important:

- To increase public awareness of the value of natural stream corridors and their beneficial functions;
- To promote acceptance of streams as dynamic systems that inherently flood and meander;
- To affect wide-spread adoption of best management practices in watersheds in order to minimize human impacts on stream ecosystems;
- To protect existing stream resources from unnecessary degradation and restore stream resources where appropriate and feasible;
- To work with the stream in an environmentally sensitive manner consistent with the stream's natural processes;
- To have active citizen involvement in stream monitoring, protection and restoration efforts.

## **Acknowledgements**

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## **References**

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**Håkanson L, & M. Jansson.** Principle of Lake sedimentology. Springer-Verlag: New York, 1983.

Maps

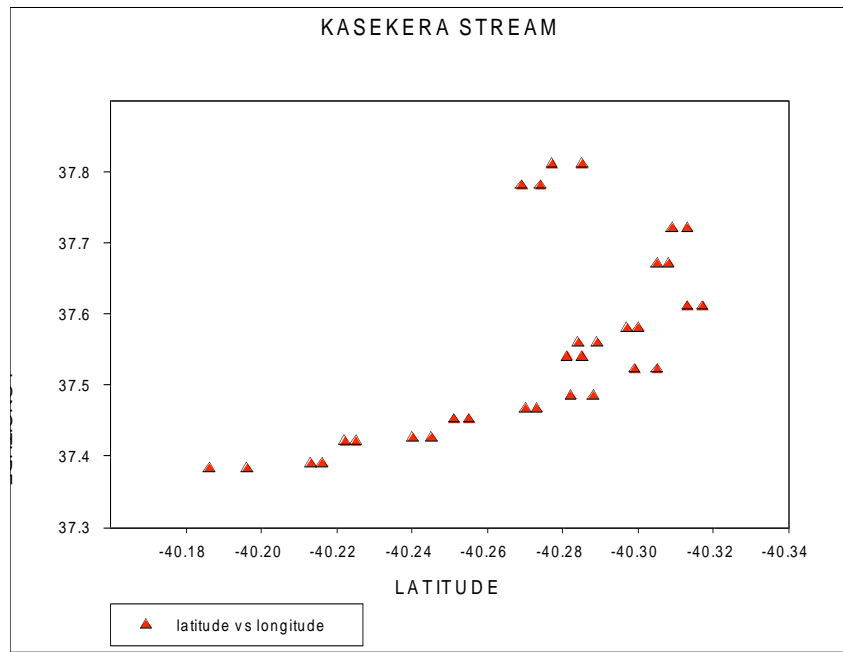
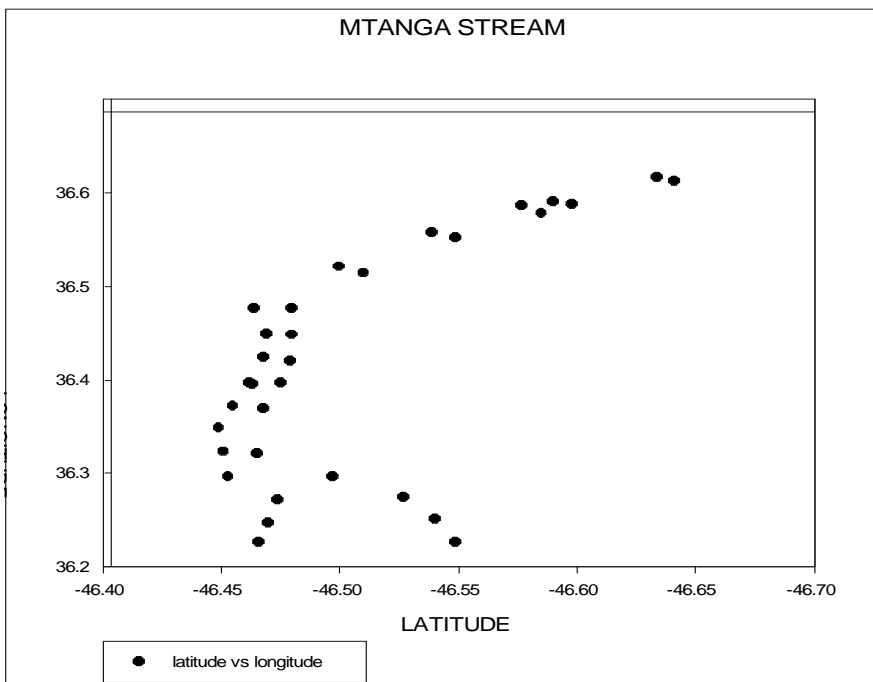


Fig.5; Schematic map of Kasekera Stream sampling points - FORESTED (Gombe Stream National Park)



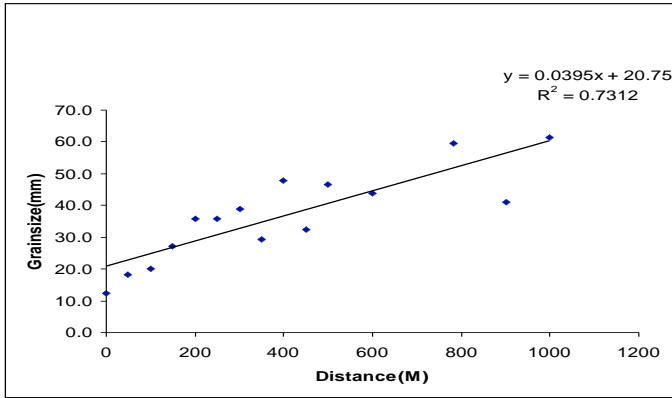


Fig.7; Relationship between average gravelometer grainsize and distance from shoreline at Mtanga stream.

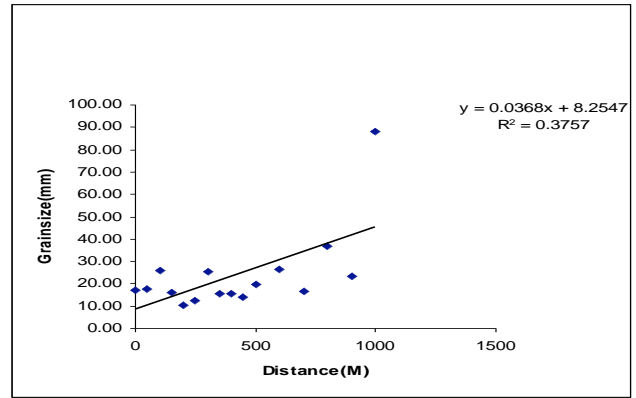


Fig.8; Relationship between average gravelometer grain size and distance from shoreline at Kasekera stream.

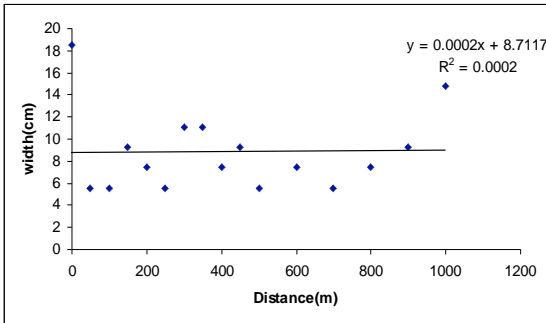


Fig.9; Relationship between distance upstream and width of stream channel for Kasekera stream.

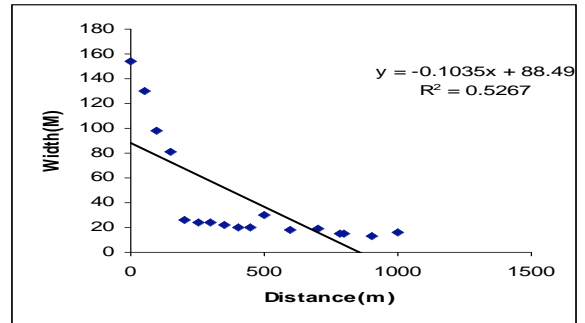


Fig.10; Relationship between distance upstream and width of stream channel for Mtanga stream.

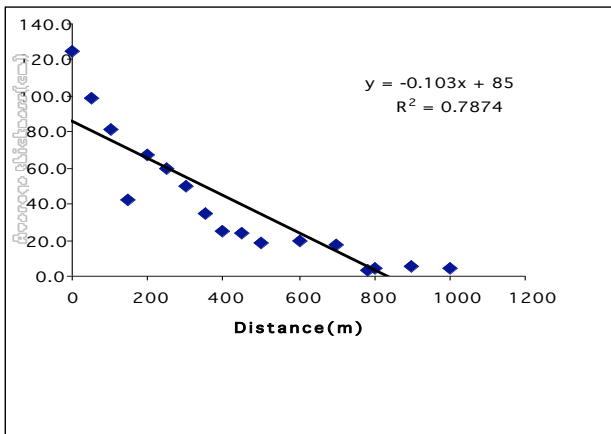


Fig.11; Relationship between distances upstream vs. average loose sediments thickness for Mtanga stream

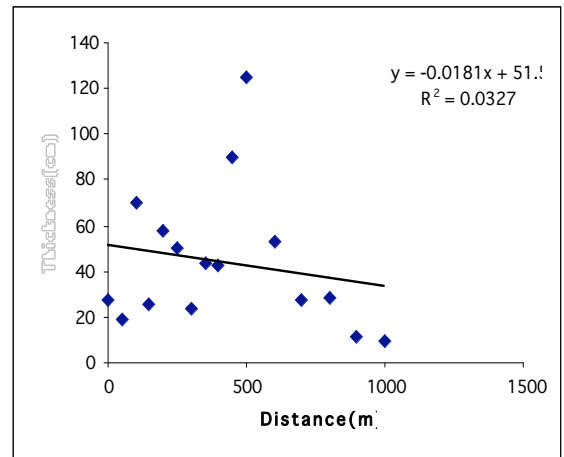


Fig.12; Relationship between distances upstream vs. average loose sediments thickness for Kasekera stream

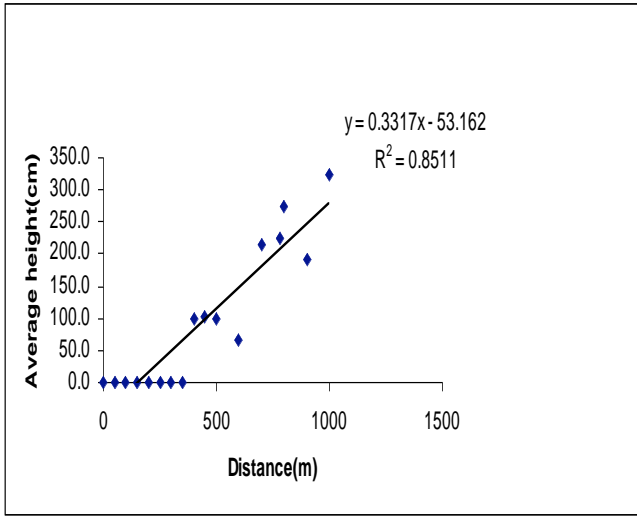


Fig.13; Relationship between distances upstream vs. average bank height for Mtanga stream

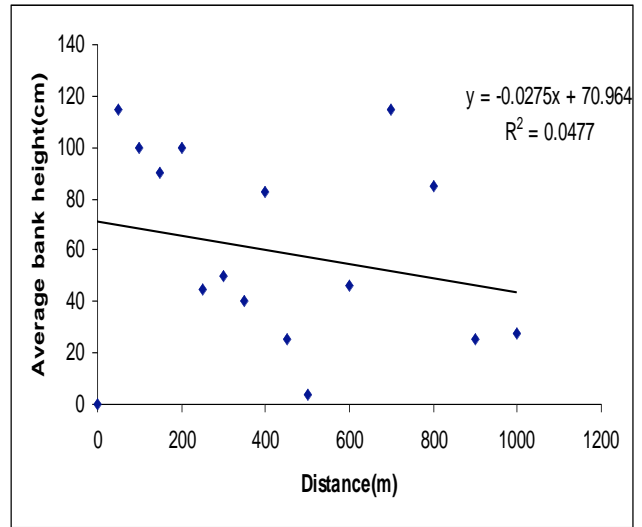


Fig.14; Relationship between distances upstream vs. average bank height for Kasekera stream

