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Assessment of Geomorphologic Impacts of Channel Erosion in River Tisa Basin in Ambasel District, Northeastern Ethiopia

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Abstract
The geomorphological impacts of channel erosion in streams that flank from Ambasel ridge of Mile drainage basin(which is one of the upstream of Awash river) were examined. Data were generated through direct field measurement and observation of some geomorphological variables of the cross sectional channel width and channel depth dimensions. The basic equipment employed for data generation is the tape, a piece of tie rod and ranging poles. The data generated were analyzed and processed by descriptive statistics such as the mean, standard deviation, range and simple percentages while the Student's't' and Snedecor's F tests were also used as the basic inferential statistics for testing the hypothesis generated. The result of the analysis showed that the geomorphological impacts of erosion in the Ambasel ridge and its low-lying area varied spatially both across and along the profiles of the streams. However, such impacts were more pronounced in the upstream of the drainage basin. The study uncovered further impact of channel erosion to include channel bank collapse and in-caving, destruction of habitat structure, degradation of farmlands in the low-lying areas by sediment invasion over the farm lands. The way forward is land use zoning agriculture and channelization tracing the natural sinuosity of the river as some of the measures for controlling the undesirable effect of channel erosion in the drainage basin.
Keywords: Spatial Analysis, Geomorphic Impacts, Channel Erosion, Ambasel District

1. INTRODUCTION

Raindrops, sheet, rill and gully flows do some of the work of running water. The larger part is done by stream erosion, because the water in them is deeper and faster flowing. They have greater erosive and transporting power that result in distinct landforms along their course and banks. Channel erosion is the removal of soil from stream banks and soil movement in the channel (Payne, 1997).

In this vein, stream valleys are actively eroded by channel deepening, widening and channel extension through the processes of mechanical abrasion, corrosion and potholing (Arohunsoro, 2011). According to Cooke and Doorn Kamp (1974) and Strahler and Strahler (1977), channel erosion is one of the three interrelated geologic activities taking place within a river. Other two geologic processes are channel bed and channel bank Erosion River impacts on land surface forms by carving their channels and wearing away the earth surface through the process of fluvial erosion. A drainage basin is the area of land from which a river system derives water and rock wastes. A river system constitutes the area of land which channel water and debris into and out of the main river and its valley; as well as its tributary rivers and their valley (Chup, 2005). The various fluvial erosion processes operating in the drainage basin can impact on the surface land forms of a drainage basin. These impacts many be expressed through aggradations and degradation of the basin's terrains (Chup, 2005;Arohunsoro, 2011)

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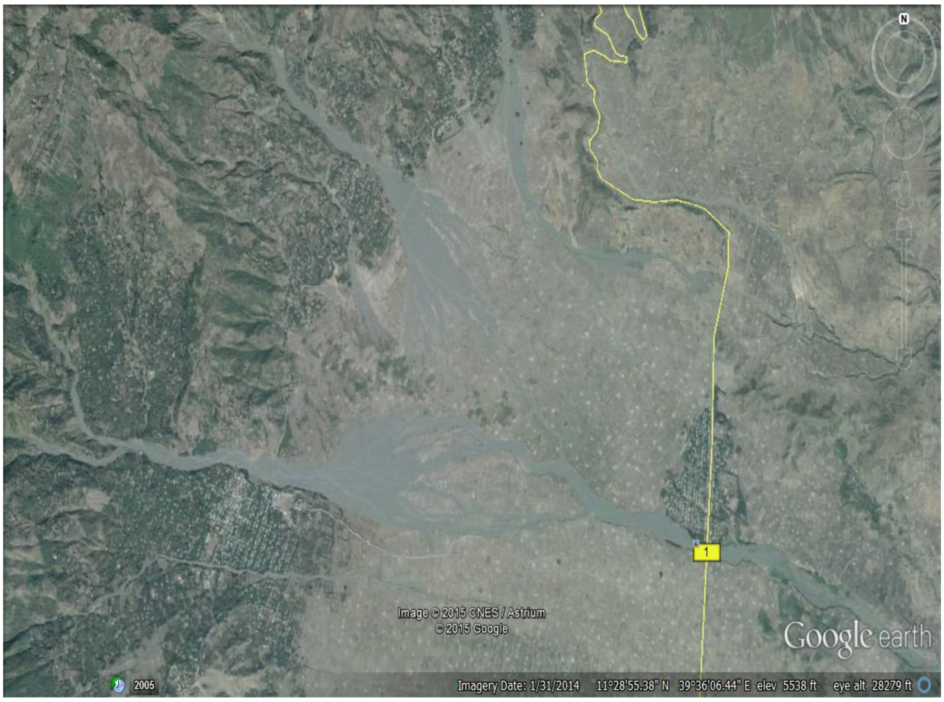
River Robit is the trunk flow of the Ambasel ridge drainage basin in Ambasel district. Following the incising of the Ambasel ridge south west of Wuchale(the town of Ambasel district), and the subsequent widening, deepening and retraining of its main course downstream, it has generated a number of impacts on the geomorphological relations of the basin. Such impacts seemed to have become more pronounced in the face of the increasing tempo of agricultural land in the low-lying area. In order to entrench a sustain ably liveably agricultural activity by protecting it from the wasting consequences of erosion there is need to understand the dynamics of the geomorphic processes operating in drainage basin particularly in a river traversing the plain fertile and productive agricultural land.

In the light of the above broader framework, the study is aimed at the assessment of the impact of channel erosion (bank, bed and head ward erosion) on the terrains of Ambasel ridge drainage basin and in the low-lying farming areas. In consonance with this, the paper has the following specific objectives to achieve in relation to the drainage basin;(a) examine the spatial pattern of channel erosion in streams drainage basin.(b) discuss the impacts of channel erosion on the low-lying farm lands.

2. STUDY AREA

Streams in the Robit drainage basin are located in Ambasel district, Ethiopia within latitudes 11^{0}30'19''N to 11^{0}27'59'' N and 39033'17''E to 39037'14'' E and 70381 North. It has a downward sloping from west to east(fig.1).



The streams originate and incise from the Ambasel ridge which is one of the most rugged topography in Ethiopia and the water divide of the Abay basin and Awash The drainage basin enjoys the tropical climate characterized by the rainy and dry seasons. The total annual rainfall varies between 900mm and 1100mm with over 80% of the fall concentrating between June and September. On the average, there are 112 rainy days with between 65 and 85% of the rainfall consisting of the moderate to high intensity type. Temperature has a mean monthly value of between 18^0c and 240 and a small annual range of 4^0c.

The study area underlained by the Precambrian igneous and metamorphic rocks, the predomnant of which is the coarse-grained and the medium-grained basaltic rocks forming about 86% of the total area . The basaltic rock produces weathered regolith characterized by clastic materials of sand and silt with high erodibilty (Jumoh, 1997; Arohunsoro, 2011). Field measurement reveals that, the depth of the weathered mantle can be as much as 20 meters although this depends on the lithology of the parent materials.

The farming system on the sloppy area has generated an upsurge in the spatial extent of sediment fluxes in the low-lying area. This may have implication for instantaneous runoff and resultant impact of erosion in the river channels.

The fast increasing population and the upsurge in physical growth of the environment may have an eventual repercussion on the river's channel, valley and floodplains.

3. RESEARCH METHODOLOGY

Data were collected on cross sectional channel width and cross-sectional channel depth and width. These three geomorphological variables typify fluvial erosion processes within the river channel. This is because a river can expand its channel through vertical dissection or lateral degradation (wasting) and expansion of its banks.

a. Assessing Sediment Flux and channel Erosion

The cross sectional width dimensions of the two streams were measured with the tape. Measurements were taken at every 20 meters along the longitudinal profile of the streams and the mean values were calculated. In addition, the channel depth was measured with a piece of tie rod and a ranging pole. The tie rod was calibrated in centimeters in order to facilitate reading. Measurements were taken at successive points along each transect and the average of such measurements was obtained all the measurement were generated in meters. The measurement of cross sectional channel Depth is expressed as

Average channel depth = d1 + d2 …….d7 ----------- (1)
7 Where d1, d2------d7 are channel depths at successive points.

(i) The cross-sectional channel width in the upper streams of the area was measured with the tape and the tie- rod. The tape was laid across the banks and measurement was taken. However, in the lower reaches the channel width was measured with the aid of ranging poles and surveying equipment following the recommendations of Goudie et al, 1981. Goudie et al (1981) recommends that cross -sectional channel width less than 3metres need not be generated with more sophisticated surveying equipment such as theodolite, rather by the tape and the tie- rod. Thus, since the width is less than three meters measurement was taken by using the tape and the tie- rod.

(ii) The data were analyzed by computing the average values, standard deviation and simple Percentages. The hypothesis was tested with Student't' statistics. All the statistical inferences and conclusions were carried out at 95% probability.

b. Investigating sediment invasion on the low-lying areas

In addition to field measurement, many studies show that local communities are well informed and have ample experience on changes of their individual farms, landscape and agro-ecological level (Maitima et al, 2004).
Seen in this way, the use of various sources of data and methods of data collection (interview, FGD and observation) ensures the necessary rigor and reliability to the finding of the study. In essence, some of the Participatory Research Approach (PRA) tools and sources of primary data collection are highlighted as follows.

I. In-depth interview- This is carried out with various segments and members of community, Development Agents, heads of local institutions, and other resource persons were interviewed to generate historical information about sediment invasion to their farm land. All the interviewees will be taken with their own consent.

II. Focus Group Discussion-This is conducted to gather information pertaining to controversial perceptions on practices and constraints as far as status of land degradation, land cover change due to flooding is concerned.. In addition, a focus group discussion has been organized at the district level which is made up of different experts and official for the issue under consideration. Thus, in each group subsequent discussions will be made with the help of checklist prepared and different triangulating issues will be considered. Each group will have a minimum of 6 (seven) members.

III.Field observation-Plot, landscape and agro-ecological level data such as exposure, slope, soil type, and their implications were collected. In addition, the prevailing biophysical and socio-economic contexts at local level in which the issues of the study are embedded will be lenses of the field observation. The study was also flexible enough to accommodate evolution of ideas and refine understanding as the research works proceed. Field observations were backed up by snap shot photographs and informal discussions with the local dwellers.

RESULTS AND DISCUSSION

The variables used for the study comprises cross-sectional channel width and cross-sectional channel depth. For this purpose, a total of 60 observations were recorded for each variable. The result of their descriptive statistics are shown in Table 1.

S/N	No of measurement	Variable		Mean	St. deviation	St. error
1	30	Channel width	Upper segment	3.39	1.92	0.22
			Lower segment	8.17	2.26	
2	30	Channel depth	Upper segment	1.35	0.22	0.26
			Lower segment	8.32	1.06	

Source: Field Measurement.

The result of the data analysis in Table1 shows that there is a spatial variation in the dimensional values of the geomorphological variables of the stream between the upper and the lower segments of the river.

The analysis in Table 1 shows that the cross-sectional width for the entire River Robit drainage basin had a mean of 5.88metres. However the average channel width in the upper segment of the river was 3.39 ± 1.92metres while the average channel width in the lower segment was 8.37 ± 2.26metres. Cross-sectional depth had a mean of 1.51metres in the entire drainage basin. While the mean dimension of cross-sectional depth was

1.35 ± 0.22metres in the upper segment, the corresponding mean value in the lower channel was 8.32 ± 1.06metres. The result of analysis in Table 1 depict clearly that both channel depth and channel width exhibit spatial variation in their dimensional values between the upper and the lower segments of drainage basin.

3.2 SPATIAL PATTERN OF CHANNEL EROSION IN RIVER AMBASEL DRAINAGE BASIN.

The causes of channel erosion in River Robit are both physical and anthropogenic in nature. Qualitatively, the survey conducted in the drainage basin revealed the descriptive causes of channel erosion as farming system in the drainage basin (40%), heavy and frequent rainfall (35.6%), heavy absence of drainage channel (15.8%) and frequent rainfall (10.5%).

See Table 2

Segment of the river		Causes of Channel Erosion					
		heavy and high frequency rainfall (precipitation	**Farming in the flood plains**	**Absence of drainage channel**	**Farming in the sloppy area**	**Clearing of vegetation**	**Total**
Upstream	**Count**	12	14	2	2	5	33
	Percentage	15.4%	18.1%	3.4%	1.3%	6.7%	45.0%
Downstream	**count**	8	20	3	0	10	41
	Percentage	10.1%	27.5%	.4%%	0.00%	14.1%	55.0%
Total	**count**	19	34	5	1	15	74
	Percentage	25.5%	45.6%	6.7%	1.3%	20.8%	100.0%

Source: Fieldwork, 2015.

Channel erosion was highest in the lower segment of the basin where the impact of illegal dumping of refuses was more prevalent (27.5%). The effect of refuse becomes obvious in its inducement of lateral migration of channel flow which resultantly promotes lateral migration of the area vulnerable to erosion. Heavy and frequent high rainfall was also a factor of channel erosion in the basin. The annual rainfall total of 1100-1200mm, the 95 average rainy days per annum and the characteristic high average intensity of the rainfall over the drainage basin contribute to erosion in the rover channels. For instance, during stormy rainfall surface runoffs are not usually properly co-coordinated and channeled into the drainages. Even where there are drainages they are narrow and most of them perform sub-optimally having efficiency of low performance as 21.1%.

Channel erosion the drainage basin varies spatially across and along the profiles of the river.

Factors causing these variations are the variable morphometric properties of the river. The disparities in the channel morphometry between the upper and lower channels generate variation in the occurrence and intensity of channel erosion valley side slope also contributes to spatial variation in channel erosion in the basin. The ANOVA F value of 209.93 for channel width was significant at 0.05 levels indicating a significant result.

Table 3: **Analysis of Variance of the Effect of Valley Side Slope on Channel Width Erosion in River Ambasel Drainage Basin**

Variable		**Sum of Squares**	**df**	**Mean square**	**F**	**Sig.**
Channel width	Between Groups	926.333	1	926.333	209.925	***.000
	Within Groups	653.078	74	4.413		
	Total	1579.412	74			

Note: ***significant at .05 alpha levels
Source: Computer Analysis

The implication of this is that valley slope contributes to channel erosion in the drainage basin and cause spatial variation in channel erosion. Anthropogenic activities through overgrazing and farming across the farmlands also generate spatial variation in channel erosion across the basin space.

Table 4: Analysis of Variance of the Contribution of Anthropogenic Factors to Channel Width Erosion in Ambasel River Drainage Basin

Variable		**Sum of Squares**	**df**	**Mean square**	**F**	**Sig.**
Channel width	Between Groups	994.130	1	994.130	209.925	***.000
	Within Groups	660.704	73	4.464		
	Total	1654.834	74			
Percentage of farming Activities	Between Groups	30033.375	1	30033.375	209.925	***.000
	Within Groups	.000	73	.000		
	Total	30033.375	74			

Note: ***significant at .05 alpha level
Source: Computer Analysis

The factors of erosion discussed above have generated wide disparities in the incidence of channel erosion between the upper and the lower segments of the drainage basin. The hypothesis testing showed that the calculated‘t’ of 14.213 exceeds the critical value of 1.96 at 95% probability (Table 5).

Table 5: t-test of the Channel Width Erosion in the Upper and Lower Segments of Ambasel Drainage Basin

Variable		**Sum of Squares**	**df**	**Mean square**	**F**	**Sig.**
width of Channel erosion	Upper segment	926.333	1	926.333	209.925	***.000
	Lower segment	653.078	73	4.413		
	Total	1579.412	74			

Note: ***significant at .05 alpha level
Source: Computer Analysis

This led to the rejection of the null hypothesis implying that there is a significant difference in channel erosion between the upper and the lower segment of channel zeal segments of the Ambasel drainage basin. The mean channel width erosion was 3.39±1.92 in the upper segments compare to 8.37±2.26 meters in the lower reaches.

The wide contrast was due in part to the geological stricture of the upper segment which yields increased volume of floodwater in the lower segment. Because geological structure and character of an area is the dominant factor the affect the hydraulic as well as the edaphic behavior of areas that have their own repercussion on the rate and the kind of landform development by different processes. Here, the fact that the lower reaches was alluviated and erodible, and also that the geology and soils yields non-plastic and incoherent weathered mantles, the channel becomes more vulnerable to degradation. In this vein, collapse of channel bank due to lateral erosion, which leads to channel widening, is very common in the lower segment of the channel, (see the diagram above)

Geomorphological impact of channel erosion channel erosion in River Robit drainage basin has generated a number of ramifications on the terrains of the drainage basin. The study has shown that channel erosion causes needless degradation of land areas around the channel banks thus causing channel collapse, in-caving and slumping of soil mass of the precipitous slopes of the deeply incised channels. This process was brought about by the fluvial erosion created by increased storm flow particularly in the lower alluvial reaches of the basin.

The geomorphological impact is more conspicuous at the Tisa , and the lower part of the drainage basin . Fluvial wasting of the adjacent land areas of the river channels were more pronounced in this area. Also, the rock-floored nature/characteristic of some reaches of River Robit channel at lower segment promotes lateral migration of channel storm flow, thus extending the erosion processes of the channel on the surrounding area.

Lateral shifting of channel banks and boundaries reduces the spatial extent of riparian vegetation,

reduces floodplain width and extension of the alluvial segment deposition. The poor substrate quality of the alluvial deposits is a loss to proportion of land area for agricultural developments. This is because crops grown such deposits may eventually become vulnerable to indentation. In the face of increasing population of study area and the concomitant upsurge in the demand for agricultural land, such 'problematic' or shifting soils may be a loss and unavailable to the people, the cost of developing such a terrain maybe prohibitive.

Again, channel erosion impacts on the drainage basin land form through sedimentation of the basis of residential houses. This process causes aggradations of quaternary deposits of mud and clay at the upper segment of the drainage basin.

Water spilling the channel causes deposition of sediment of clay and mud which create nauseate sites around houses in the drainage. This deposition produces difficult situation and slippery terrains which impedes easy mobility.

Another geomorphological impact of channel erosion in the drainage basin is the hazard posed to residential buildings erected in the minor and major valleys the study area. The hazard is particularly a feature of the lower reaches of the river at Tisa, where the fast rate of channel banks erosion is gradually causing the channel degradation to encroach on the areas of human habitation.

Summary and Conclusion

The paper examined channel erosion in Ambasel drainage basin. Channel erosion is a fluvial process which entails removal of soil from stream banks and beds. Channel erosion in the Ambasel drainage basin is caused by both natural and human oriented activities. The basic factors of channel erosion in the basin are refusing in channel, intensive rainfall, and human occupation of floodplains. Channel erosion exhibit spatial variation across the basin space. Factors causing the spatial variation of channel erosion in the basin are variable morphometric properties of the river, valley side slope and anthropogenic activities.

Geomorphological impacts of channel erosion in the drainage basin are degradation of channel bank areas, channel collapse and channel in-caving. Other impacts of the channel erosion in the basin include lateral shifting of the channel banks, sedimentation of residential buildings and other hazard posed to the safety and sustainability of residential buildings.

Erosion remains a global basic environmental issue in the contemporary world particularly in areas where rugged topography and torrential rainfall are found in combination. It is useful to adopt measures to combat the hazard of channel erosion in rural watersheds. It is expected that adoption of the necessary measures of environmental management will help to curb the geomorphological impacts of channel erosion in our environment.

Recommendations

The following measures could be adopted to combat the geomorphological impact of channel erosion in Ambasel drainage basin.

(i) Riparian vegetation along the Ambasel channel banks should be allowed to flourish and protected from illegal dry season bush burning and indiscriminate degradation. Appropriate sanctions must accompany such acts.

(ii) Farming of in the floodplains and valleys of should not be allowed henceforth. Cases of erring landlords should be handled legally.

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