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The Current State of Riparian Vegetation: The Dabbis River of Ambo Woreda, West Shoa Zone, Oromia Regional State, Ethiopia

Diriba Oljira Gemeda, Habtamu Ashagre, M.I. Zuberi*

Department of Biology, Ambo University, Ambo, Ethiopia

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Key words: Riparian vegetation, River, Habitat degradation, Vegetation cover, Ethiopia.

Abstract

The status of riparian vegetation along the Dabbis River of West Shoa, Ethiopia was assessed in selected plots by examining vegetation types, vegetation change, soil cover, soil quality and water quality. Rapid survey of these indicators and systematic sampling was used to collect data from 72 plots both upstream-downstream and left-right sides of the river. These were compared to determine the less degraded and degraded plots and abundance, diversity and dominance of vegetation were calculated by using Shannon Diversity index to assert these findings. The results indicated about 55 % of the plots were covered mainly by herbs/grasses, about 57.0 % had poor soil, in nearly 55 % of plots water was mucky and dark in colour, whereas in about 90 % of the plots river was shallow. When all the indicators combined about 75 % of the plots, both up- and down-stream and left- and right- sides were found more or less degraded. Laboratory analysis indicated that soil structure, pH and moisture content were different between the less degraded and degraded sites. Evidence indicated that sites away from villages had less plots with bare land and herb (18%) and relatively more trees (5.6%) while river side by the city of Ambo had more plots with herb cover or bare land (22%) and less tree cover (only 1.9%). Though Shannon-Simpson indices and evenness indicated more or less similar diversity between the less degraded and degraded plots, the former were more rich. The main reason of the degradation of the riparian vegetation was identified as cutting trees and removing vegetation for fuel, agricultural field expansion and livestock grazing. The local community, typical farming and natural ecosystem dependent, were found to have knowledge about the degradation of the riparian vegetation and their utility and usefulness. The need of community participation and government involvement for management of riparian vegetation was indicated.

***Corresponding Author:** M.I. Zuberi ✉ iqbal.zuberi@gmail.com

Introduction

Riparian vegetations are ecosystems comprised of streams, rivers, lakes, wetlands, and floodplains that form a complex and interrelated hydrologic system (Verry, 2000). They extend up and down streams and along lakeshores from the bottom of the water table to the top of the vegetation cover, and include all land that is directly affected by surface water. Riparian vegetations are significant in ecology, environmental management and civil engineering because of their role in soil conservation, their rich biodiversity and influence they have on fauna and aquatic ecosystems, including grassland, woodland, wetland (Lugo, 1990).

They are also important natural bio-filters, protecting aquatic environments from excessive sedimentation, polluted surface runoff and erosion (Hughes *et al*., 2001). They supply shelter and provide feed for many aquatic animals and shade that is an important part of stream temperature regulation. Riparian vegetations also provide wildlife habitat, increased biodiversity, and provide wildlife corridors, enabling aquatic and riparian organisms to move along river systems (Fleishman *et al*., 2003).

They can provide forage for wildlife and livestock and maintain native moisture in landscape by augmenting water in soil and by extending seasonal or perennial flows of water. In addition, riparian plants act as sinks, absorbing and storing excess water, nutrients, and pollutants that would otherwise flow into the river reducing water quality (Renofalt *et al*., 2005) One of the most important functions of riparian buffers is enhanced infiltration of surface runoff (Jontos, 2000).

One of the major global concerns is the problem of degrading ecosystems and declining natural resources (Woldeamlak Bewket and Solomon Abebe, 2013) that are being threatened by the rapid human population growth and there is an increasing need to use resources in a sustainable way (MEA, 2005). Therefore, the UN has committed to developing a set of Sustainable Development Goals (SDGs) to build upon the Millennium Development Goals (MDGs), which come to an end in 2015. One of the six proposed SDGs include ensuring 'healthy and productive ecosystems' (UN, 2015). Impacts of climate change are likely to affect the rivers and riparian vegetation most severely in dry and semi-arid parts (MEA, 2005; Perry *et al.,* 2012).

Almost all the rivers in Africa near urban areas have become so polluted that they cannot be used for any purpose (Hailu and Legesse, 1997; Alemayehu, 2001; Melaku *et al*., 2007; Devi *et al*., 2008; Abebe Beyene *et al.,* 2009) also, there are conflicts arising for water use (Flintan and Imeru, 2002). Wide scale deforestation also contributed to the decline of rivers, streams and wetland areas, for example in the Awash Valley, degradation of water resources were observed in connection with land use change (Kloos,1982), cattle grazing, clearing of vegetation, construction of dams and irrigation channels. In addition, soil erosion, sedimentation and pollution due to application of agro-chemicals (Hailu and Legesse, 1997), also affected are many other river and wetland systems like in Fincha, Chomen and Amerti in Wellega zone, in Borkena, Meteke, Koffe, and Illubabor (Abebe Beyene *et al.,* 2009). Now, there is growing awareness and concern regarding both of the increased pressure on river and riparian vegetation across the world as a result of human activity (Lemlem Aregu and Fassil Demeke, 2006; Awulachew, 2007). The potential economic and social benefits to be gained from environmentally sensitive sources like rivers should have well planned management based on better understanding of environmental, ecological and hydro-geo-morphological conditions. Many of the African rivers (Sieben, 2000; Bishaw Badege and Abdelkadir Abdu, 2003; Awulachew *et al.,* 2007; Abebe Beyene,*et al.*, 2009), especially those of Ethiopia like the Nile and its tributaries are found to be rich in silt, sediments and other nutrients (Alemayehu, 2001; Devi *et al.,* 2008). There being wide deforestation and land use change in the head-waters and watersheds of these rivers, utilization of river water for hydro-electricity generation has been seen as a big problem (Devi *et al.*, 2008).

There are numerous perennial and intermittent rivers in Ethiopia and these rivers and streams support large numbers of species in relatively dense vegetation.

The riparian vegetation typically support a distinctive flora that differs in structure and function from adjacent terrestrial vegetation (Naiman *et al.*, 1993, 2005; Tang and Montgomery, 1995; Prach and Straskrabova, 1996; Naiman and Décamps, 1997). These riparian vegetation used to be an important source of fodder for livestock during the dry season, and is a source of food for humans, medicinal plants, fuel wood, and wood for utensils and homebuilding, also are home to many bird species and other wild animals (Kemper, 2001; Naiman and Décamps, 1997).

There are many rivers around Ambo town (the Huluka, Dabbis, Aleltu, Taltele and Farisi) and the riparian vegetation here, too, might have suffered widely from the effects of clearing, grazing, sand /boulder extraction, nutrient enrichment and sediment discharge and deposit like many other rivers (Prabu*et al* , 2011).

These rivers are in the Abay/Upper Blue Nile basin and are the source of life for the several hundred million people living in the basin and further downstream. It provides more than 60% of the total Nile water (UNESCO, 2004; Conway, 2005). Also, the largest hydro-power potential sites in Ethiopia are found in the Abay/Upper Blue Nile basin (Kloos and Legesse, 2010). For example, the Grand Ethiopian Renaissance Dam (GERD) located in the Abay/Upper Blue Nile basin, has been started in March 2011 (EEPCO, 2010).

This also makes the riparian vegetation to the management of the watershed and reducing soil erosion very important. Nevertheless, no study has been done in the riparian vegetation in the Ambo area, so the proposed study is expected to provide important base line data on this important ecosystem needed for the sustainable management of the water and land resources along the water bodies.

Materials and methods

The studied riparian vegetation along river and surrounding villages in Ambo ($37^0$48'59" to $37^0$54'15"E Longitude and $8^0$57'54" to $8^0$59'39"N Latitude) is situated in the Oromia Regional State, Western Highlands of Ethiopia (Fig 1).

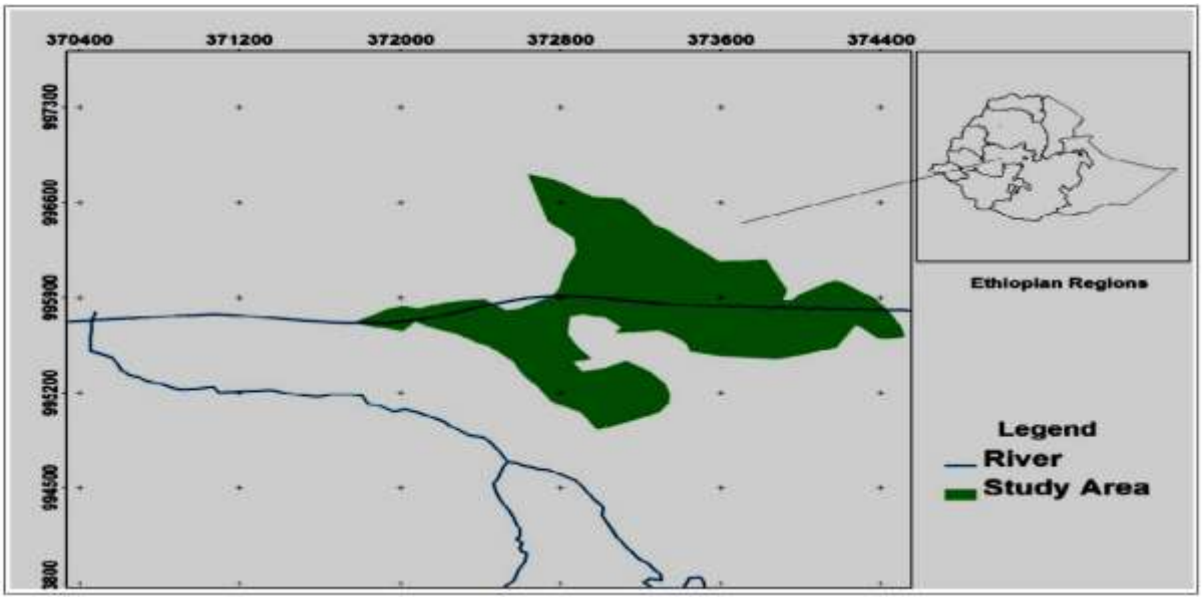


Fig. 1. Location of Ambo in Ethiopia.

The area on an altitude range of 2060 - 2204 m.a.s.l, the landscape is highland mountains with a long dry season of 8 to 9 months (September to May). Meteorological data (National Meteorology Agency, 2007) indicates that Ambo area experiences high rainfall (around 1000mm) between May to September.

The lowest mean temperature over ten years was 8.7°C recorded in December, whereas the highest was 24.6°C recorded in February (National Metrological Agency, 2007). The northwestern part of the District is covered with hilly slopes and mountainous escarpments with clay soils of black, red and intermediate types. Due to high rainfall intensity during rainy season and wide deforestation of the mountain terraces, there is high land degradation and soil erosion. Of the rivers around Ambo area being very similar in phyto-geological nature, the Dabbis River was selected for the study (Fig 2).

Fig. 2. Google map of Ambo area showing the location of the Dabbis (arrow).

One purpose of this study was to rapid screening of the riparian vegetation to establish the level of degradation, by grouping observed plots into two classes 'more degraded' and 'less degraded' through calculating the combined impact of different contributors' impact (indicators) to the present state of riparian vegetation (Jontos *et al.,* 2000). The condition of the assessing factors on the overall vegetation/environmental state of the plots were expressed in four classes: very poor, poor, fair and good which included habitat, ecological, chemical and biological attributes that are related to riparian vegetation health such as:

Vegetation cover: Bare land (poor); sparse ; medium dense; dense.

Age of vegetation: Very young herb; young herb/shrubs; low trees/shrubs; trees.

Soil quality: Very poor no humus; coarse with little humus; medium grey; good - color dark.

but less dirty; clean and clear.

Water depth: Very shallow< 25 cm; shallow ,25 – 50 cm;deep,50 to 75 cm, very deep>75 cm.

Width of water: Very narrow < 3 m; narrow 3 to 5 m; wide, 6 – 8 m; very wide, > 8 m

In the second step randomly selected 'plots' of the two classes and the water besides were compared for different parameters through laboratory and detailed analysis. A composite soil samples were taken from 20-30cm depth from two classes of plots for determination of soil pH, soil organic matter, soil texture and soil color. Particle size distribution (% of sand, silt and clay) were determined. Water samples were collected from the river near the sampling plots as mentioned above and the temperature and pH were determined. Finally comparison of the in-site vegetation were made. Shannon - Wiener (1949) index was applied to quantify species diversity, evenness and richness. This method is one of the most widely used approaches in measuring the diversity of species. Five vegetation layers were distinguished: herbs, low shrubs (height< 2 m), high shrubs (height between 2 and 5 m), understory trees and canopy trees.

All the sampling and data collection including the vegetation survey started in January, 2015, an array of upstream sites 15 km from a selected spot (the intersection of the road from Ambo to Odessa, a village opposite) and 15 km to the downstream were included. This sampling represented right bank close to and left way from the city. Samples were drawn along transects line at every 5 km established running parallel to the river. A total of 27 plots upstream and 27 plots downstream measuring 10 × 10 m for tree and subplots of 5×5m for shrubs and 2×2m for herbs and grass nested in the bigger plot were established.
The community living near the riparian vegetation were selected by simple random sampling for interview because of their local knowledge to identify past state of riparian vegetation along Dabbis River.

Results and discussion

Differences in habitat characters

The Dabbis (and other rivers around Ambo) being characterized by the mountainous landscape, rapid fluctuations of water levels is very common (Fig 3). The vegetation of the Dabbis River banks was found to be dominated by mainly herbs/grasses (55.8%), there were only 12.9% of large trees, whereas about 37.0% of vegetation along the river were very young growth of herbs and grasses, indicating their annual nature, few older shrubs and trees, about 40% of the area was covered by juvenile shrubs, only 9.3% of the vegetation was covered by older vegetation including low trees and high shrubs (Table 1).

Table 1. Summary of the indicator performance in 54 sites from both sides of the Dabbis.

	Indicators	Very Poor Score 1		Poor Score 2		Fair Score 3		Good Score 4	
		n*	%	n	%	n	%	n	%
1	Present vegetation cover	23	42.6	19	35.2	8	14.8	4	7.4
2	Age of vegetation	20	37.0	22	40.7	7	13.0	5	9.3
3	Soil quality	31	57.4	15	27.8	8	14.8	-	-
4	Water color	32	59.3	14	25.9	5	9.3	3	5.5
5	Width of water from bank to bank	13	24.0	24	44.4	12	22.3	5	9.3
6	Width of water body	22	40.7	17	31.5	8	14.8	7	13.0
7	Water depth	27	50.0	19	35.2	6	11.1	2	3.7

*number of plots.

Riparian soils of the studied area were very poorly developed because of the rocky substratum and dynamic environment near rivers, soils often washed away during rains and floods and it is mainly the sand, rocks and boulders that remain in the poorly covered sites (Fig 3).

There were about 57.0 % of the sites where the soil was very poor, dry and loose with grey color while in only 14.8% sites where soil was good (Table1). Also in 59 % of the 54 sites water was mucky and dark (poor), while about 30 % it was less brown (fair) and only about 15 % it was good (Table 1). As the rivers of mountain area, data on water depth indicated about 90 % of the sites the river was shallow (below 0.5 m) and rocky (Figs 3 and 4), also the water marks in the river bed indicated that the depth being very variable, and this variability resulted from the cycle of precipitation and infiltration or runoff. In about 44.0% of riparian sites water width was narrow and about 41 % had very narrow water body; this because the river runs through mountain edge with rocks and boulders as substratum.

Table 2. Left vs Right and Upstream vs Downstream comparison of riparian vegetation.

% Cover of	Sites (no)			
Vegetation	Left side	Right side	Upstream	Downstream
Very Poor	19	24	20	23
Poor	19	22	21	20
Fair	12	6	10	8
Good	4	2	3	3

Table 3. List of plant species in the riparian vegetation of the Dabbis river.

	Tree	Shrub	Herb
	Scientific Name	Scientific Name	Scientific Name
1	*Ficus thonningii*	*Vernonia auriculifera*	*Urtica simensis*
2	*Salix mucronata*	*Phytolacca dodecandra*	*Pavonia glechomifolia*
3	*Ficus capensis*	*Maytenus gracilipes*	*Pennisetum riparium*
4	*Myrica salicifolia*	*Euclea divinorum*	*Cynodon dactylon*
5	*Albizia schimperiana*	*Pterolobium stellatum*	*Solanum anguivi*
6	*Bersama abyssinica*	*Premnas chimperi*	*Datura stramonium*
7	*Teclea nobilis*	*Rytigynia neglecta*	*Cyathula uncinulata*
8	*Crotonmacrostachyas*	*Carisa edulis*	*Hypoestes forskaolii*
9	*Myrsine melanophloeos*	*Clausena anisata*	*Justicia ladanoides*
10	*Vernonia amygdalina*	*Myrsine africana*	*Leucas martinicensis*
11	*Podocarpusflactus*	*Phoenix reclinata*	*Guizotia schimperi*
12	*Calpurnia aurea*	*Maesalanceolata*	*Hyparrhenia dregeana*
13	*Euphorbia ampliphylla*	*Acanthus polystachius*	*Panicum monticola*
14	*Maytenus arbutifolia*	*Grewia ferruginea*	*Sporobolus africanus*
15	*Syzygium guineese*	*Lippia adoensis*	*Echinops kebericho*
16	*Acacia abyssinica*	*Vernonia bipontini*	
17	*Cordia african*	*Solanum incanum*	
18	*Dombeya torrida*	*Dodonia miscosa*	
19	*Medicago polymorpha*	*Ricinus communis*	
20	*Brucea antidysenterica*	*Dalbergia lactea*	
21		*Rumex nervosus*	
22		*Rubus steudneri*	

Differences between sites

To examine whether there is any difference between (a) two sides- left and right and (b) up- stream and downstream of the river in respect to the state of the riparian vegetation, survey data were compared. These comparisons have some significance in term of human interference: the right side of the river is next to Ambo town while the left side towards the village. Also the upstream is away from the human settlement while the downstream nearer to human habitation.

The results (Table 2) indicated that the percentage of vegetation cover were better on the left side and downstream of the river, though the differences were statistically non-significant (Contingency Chi-square

= 1.46, and less). However, from field observation and local community information, a decline of the riparian vegetation along the river due to anthropogenic activities like cutting of vegetation for fuel wood and other purposes, also for income has been indicated. Similar trends were reported by Larsen *et al.* (1998), also there was indication of another factor responsible for removal of riparian vegetation, livestock grazing around the river (Fig 5). Grazing and other interferences can potentially influence the riparian vegetation in various ways (Woldeamlak Bewket and Solomon Abebe, 2013).

Table 4. Richness (R), Shannon Diversity Index (SDI), Simpson Index (SI) and Evenness (E).

	Less Degraded Riparian Sites				Degraded Riparian Sites			
	Richness	Shannon Diversity Index	Simpson Index	Evenness	Richness	Shannon Index	Diversity Simpson Index	Evenness
Range	12 - 24	2.21-3.06	20.0-7 .4	0.82-0.98	6 - 13	1.7 – 2.4	4.7 – 9.7	0.98– .66
Mean	15.0	2.757	14.045	0.950	10.19	2.265	7.629	0.944

Table 5. Results of ANOVA for Shannon Diversity Index (SDI), Simpson Index (SI), Evenness (E) and Richness (R) for 'less degraded' (RV) and 'less deghraded' (DRV).

		SDI	SI	E	R
Source	df	Mean square	Mean square	Mean square	Mean Square
Between	1	4.80 ***	1001.17 ***	0.0051 ns	415.68 ***
Error	70	0.04	5.31	0.0025	10.14

*** = highly significant ns = non significant.

The data on soil cover (Fig 6) indicated differences in herb, shrub and tree cover in the 'less degraded' (RV) and 'more degraded' sites, the tree cover around 'less degraded' riparian sites along the Dabbis River were higher, whereas herb and grass were more in the 'more degraded' sites. As mentioned earlier, the decline of the riparian vegetation along the river (Fig 7) was due to anthropogenic activities like cutting of vegetation for fuel wood, similar trends also reported by Hession *et al.* (2003).

Table 6. Summary of use of the Dabbis riparian vegetation by local communities.

Use of vegetation	Frequency	Percentage
Fuel wood for own use	19	47.5
Construction Wood	8	20.0
Timber production	3	7.5
Medicinal use	1	2.5
Selling fuel wood	9	22.5
Total	40	100

Further differences from laboratory tests

The average moisture content of soil sample taken from less degraded (RV) sites was 11.37% while that of degraded (DRV) sites was 3.10%. Analysis of variance showed a significant difference (P<0.001), the results indicated a difference in soil water content (Fig 8).

The result of texture analysis of the soil samples (Fig 9) indicated that the soil texture of 'more degraded' sites had higher percentage of sand (44.5%) than 'less degraded' (22.5%). The average clay percentage of soil samples taken from 'less degraded' sites was 77.3%, while in the 'more degraded' it was 55.5%. No silt was observed.

The SOM contents of the samples taken from 'less degraded' (LDRV) and 'more degraded' (DRV) sites were 6.0 ± 1.88 and 2.2 ± 1.15, respectively (Fig 10), this difference was significant ($p<0.05$).

Results of vegetation survey – causes of vegetation depletion

Vegetation survey indicated 20 tree, 22 shrub and 15 herb/grass species (excluding some of the grasses) dominating the study sites (Table 3), tree species like *Salix mucronata Thunb. (S. subserrata Willd.), Albizia schimperiana* Oliv., *Bersama abyssinica* Fresen., *Myrsine melanophloeos* (L.) R. Br., *Calpurnia aurea* (Ait.) Benth., and *Medicago polymorpha* (Hochst.) Bak. subsp. *Milletia ferruginea* were common. The major shrub species include *Vernonia auriculifera* Hiern., *Maytenus gracilipes* (Welw. ex Oliv.), *Euclea divinorum* Hiern, *Premnas chimperi* Engl., *Clausena anisata* (Willd.) Benth., *Acanthus polystachius* Delile, and *Solanum incanum* L.; herbs like *Urtica simensis* Steudel, *Cynodon dactylon* (L.) Pers., *Solanum anguivi* Lam., *Leucas martinicensis* (Jacq.) R. Br.,and *Panicum monticola* Hook.f. were recorded as major species.

Table 7. Mitigation measures of riparian vegetation suggested by local community.

HoH HSteps	Frequency	Percent
Creating awareness	27	67.5
Control livestock grazing	9	22.5
Fencing riparian vegetation	4	10.0
Total	40	100

Table 8. Opinion of local community about protection of riparian vegetation along Dabbis River.

	Frequency	Percent
Every one's concern	26	65
Only concern of community around the river	7	17.5
Protection supported by government	7	17.5
Total	40	100

The diversity indices given in Table 4 indicated that the richness and diversity indices were higher in 'less-degraded' than the 'degraded plots'. Also degraded plots were more 'even' indicating lower diversity. Results of ANOVA showed that there was significant differences in Shannon Diversity Index, Simpson Index and Richness between 'less degraded' and 'more degraded' sites of riparian vegetation along the Dabbis River (Table 5).

Fig. 3. The river through mountain valley.

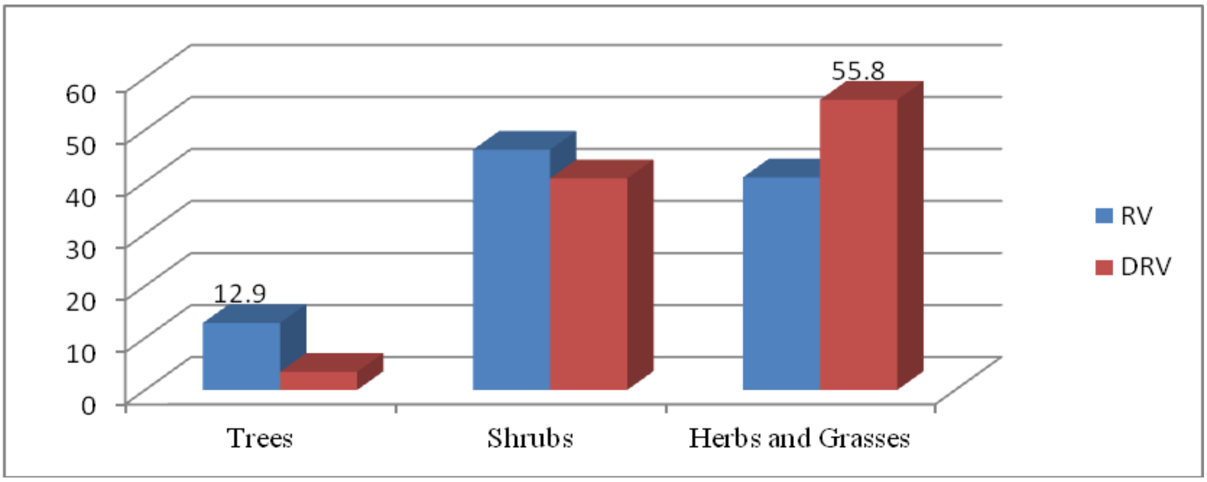
Sampled from a rather small area (30 km) of similar geographical character, there should be a little difference in these vegetation characters between the plots, the observed differences thus indicate significant human interference with the riparian vegetation, like cutting of trees (Fig 11).

Fig. 4. Stone and pebble laid river bed with low water level in the Dabbis.

Fig. 5. Cattle grazing in the riparian vegetation around the Dabbis River.

When a questionnaire survey was conducted with respondents (n=40) living around the river for more than 30 years, they reported that most of the large trees had been removed and also shrubs/herbs were removed periodically by the local people (Table 6).

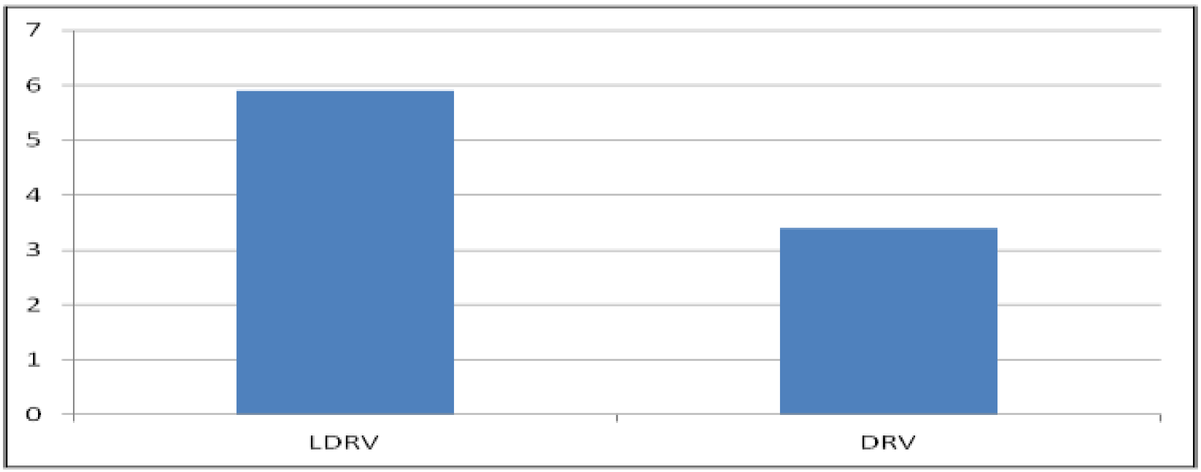
As the Dabbis riparian vegetation has been affected mostly by the anthropogenic activities it is important to know local community perception and opinion about this important ecosystem. All agreed that there is a change in the past and present state of riparian vegetation along Dabbis River, that human activities had transformed the environment, which can have a long lasting impact on the capability of vegetation to survive and function (Clark, 1998).



[Fig 6...at the end of manuscript]

Fig. 6. Plant Cover (%) in the less degraded (RV) and more degraded (DRV) sites along Dabbis River.

Fig. 7. Deforestation of the Dabbis river due to anthropogenic interference.



[fig 8] [Fig 8 at the end of manuscript]

Fig. 8. Percentage of moisture content of soil sample (Bars followed by different letter significantly different at $p < 0.05$ level).

Local community expressed concern over maintaining the sustainability of riparian vegetation along the Dabbis river and suggested different measures (Table 7) including creating awareness.

When asked about the responsibility regarding protection and conservation of the riparian vegetation along Dabbis River the community considered it as every one's concern including local community and the government (Table 8).

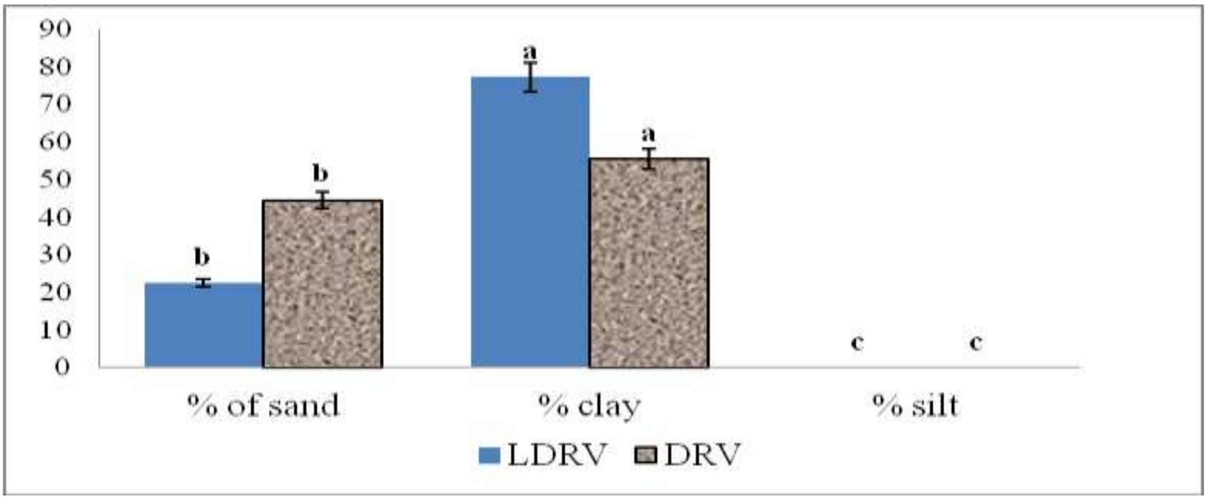


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Fig. 9. Textural classes of 'less degraded' (RV) & 'more degraded" (DRV) sites (Bars followed by different letters are significantly different at $p < 0.05$ level).

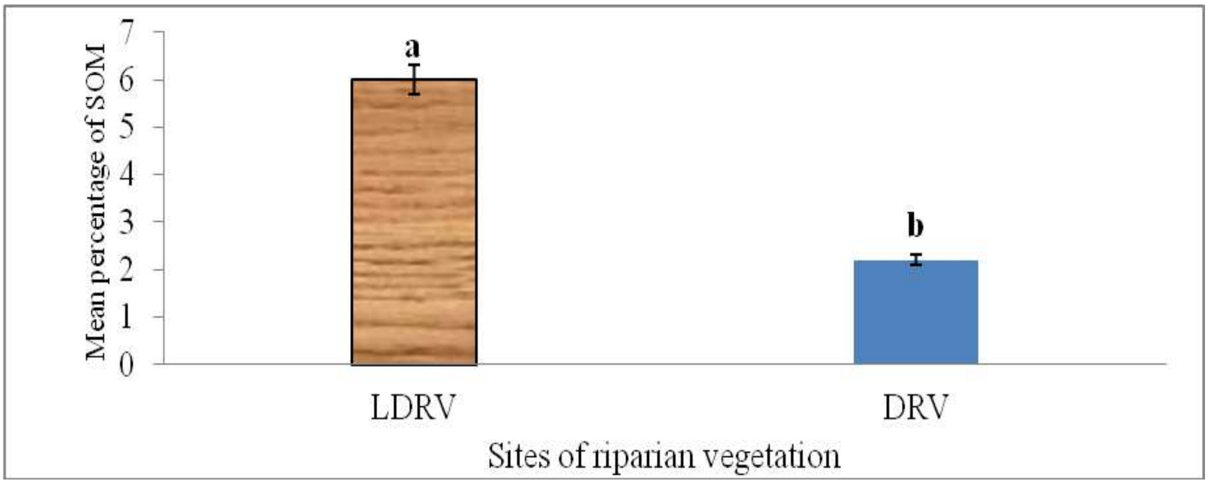

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Fig. 10. SOM content (%) of 'less degraded' (LDRV) and 'more degraded' (DRV) sites (Bars followed by different letters significantly different at $p < 0.05$ level).

Evidences coming from the rapid survey of the Dabbis riparian vegetation, laboratory and vegetation analysis data as well as the local community perception all indicated that the riparian ecosystem has been highly degraded due mostly to anthropogenic interference and to check the condition a rapid awareness building about management of riparian vegetation and ensuring community based management has been indicated.

Fig. 11. Fuel wood collection from vegetation around Dabbis River.

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