

## Assessment on the Shrinkage and Ecological Importance of Wetlands of Fogera Plain, North West Ethiopia

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### Abstract

This study investigates the shrinkage, carbon sequestration potential and biodiversity richness of wetlands of Fogera plain, North West Ethiopia. Landsat MSS of 1986, Landsat TM of 1994 and Landsat ETM+ 2011 were used to study the change in areas of wetlands over time. Supervised image classification through maximum likelihood classifier algorithm was used. Besides to this, interview and focused group discussion were used for the qualitative study of wetlands shrinkage. Soil samples were taken from three classes of wetlands i.e permanent wetlands (undisturbed wetlands), less disturbed wetlands and temporary wetlands. From each category of wetlands, 23 composite soil samples in three replications at a depth of 0-75 cm were collected. Sample soil organic carbon and organic matter were analyzed in soil laboratory. The result of Landsat images analysis showed that the area of the wetland in Fogera plain is decreasing. It was 25% of the area in 1973, while it shrank in to 19.59% in 2011. For this, sediment deposition, practice of unsustainable farming practices by local farmers and problem of land ownership are the major causes. There is a significant difference ( $p < 0.05$ ) in soil OC and OM content in between different classes of wetlands. The organic carbon content of soils of permanent wetlands where there is sediment deposition is very low. In less disturbed wetlands, there is better carbon content than other state of wetlands. Totally, carbon sequestration potential of these wetlands is very low in comparison with the carbon content of the wetlands of other parts of the world. Because in these wetlands there is high deposition of sediment with high sand content transported from the upstream watersheds by Rib River. This triggers the wetlands to lack their pristine nature. The wetlands of Fogera plain are home for different species of birds and fish. In these wetlands, 207 bird species during the wet and dry seasons were observed. The wetlands are rich in and nursery habitat for *Labeobarbus* and *Clarias gariepinus* fish species. This study recommends a call for wetland conservation and rehabilitation efforts through incorporating wetlands into watershed management plans, better community management system and effective land registration and certification program.

**Key words:** wetland shrinkage, carbon sequestration, sedimentation

### 1. Introduction

Wetlands are important natural resources which provide a range of environmental and socio economic functions (MEA, 2005). More importantly, wetlands are among the strategies of lowering CO<sub>2</sub> emissions to mitigate climate change by sequestering CO<sub>2</sub> from the atmosphere than other natural resources (Lal, 2011). But there are controversies on this regard. For instance, McCarty et al, 2009 research out that there is a rapid C sequestration in wetlands associated with rapid mineral deposition takes place in wetlands. In contrast Minnesota Board of Water and Soil Resources, (2008); Goreau and Mello, (2007) research out wetlands release carbon both through natural and seasonal changes and more drastically when wetlands equilibrium is affected by human interference. Because of these controversies there is a recognized need for additional research on wetland carbon sequestration to assess the state of science on this emerging topic at local level.

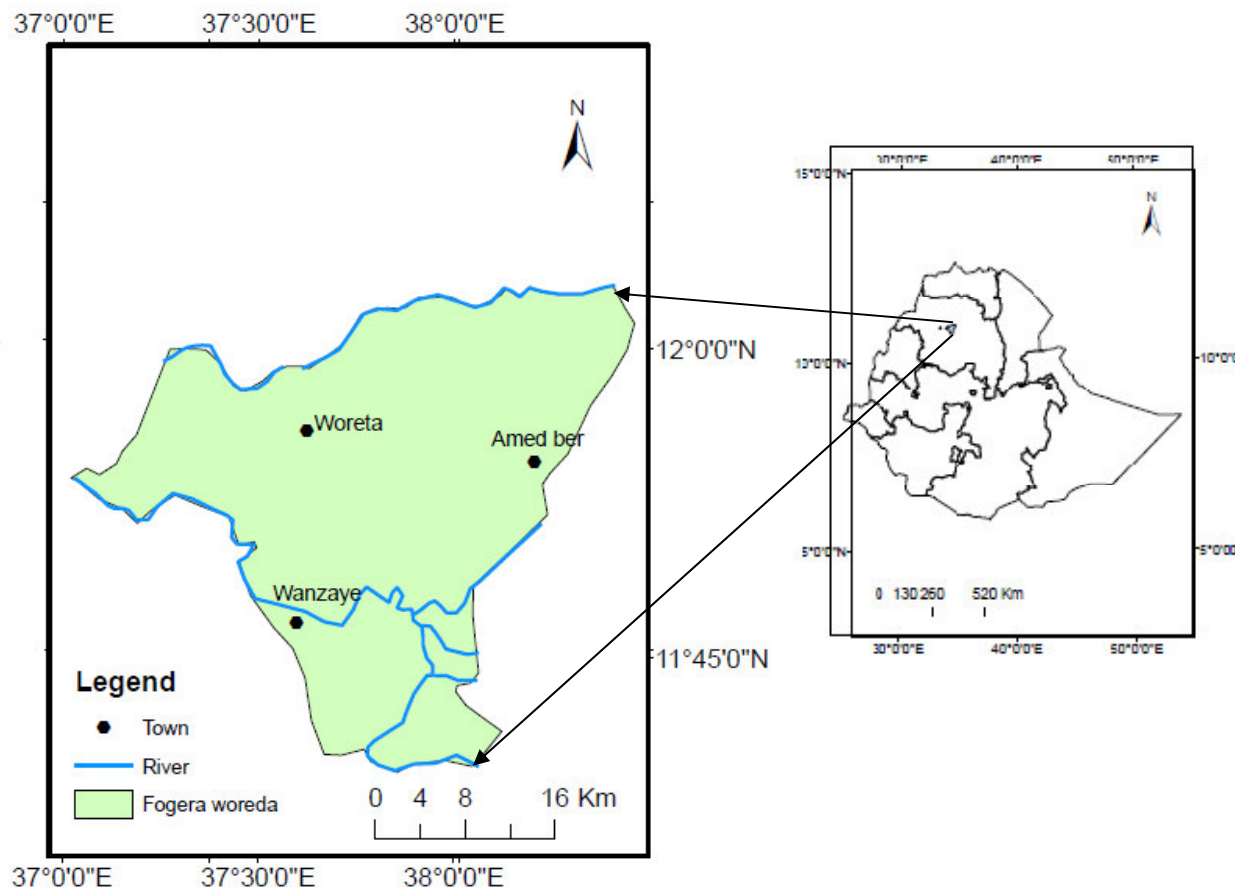
Even though wetlands are critically important ecosystems that provide globally significant environmental, social and economic benefits, they are under serious threat. Miserably the degradation and loss of wetlands is more rapid than that of other ecosystems. For this agricultural land expansion, climate change and sedimentation are the major causes (MEA, 2005). In connection to wetlands degradation it is hardly possible to know how much carbon would be released if wetlands are destroyed. Scientific evidence must be gathered soon that shows carbon storage potential of wetlands. Knowing how much carbon stored in wetland is a means to find a way to combat global warming and rising CO<sub>2</sub> levels in the atmosphere.

Large part of Fogera woreda is floodplain and this woreda is rich in wetlands. But these wetlands are characterized by extensive cultivation. The land for rice production was 6 hectare in 1985/86 E.C while it increases into 15,119 hectare in 2003/2004. In parallel, the production of rice increase from 160 quintal in 1985/86 E.C to 856,794 quintal in 2003/2004 E.C (Government Communication Office, 2011). Sedimentation owing to erosion of the upstream watersheds (Rib and Gumera) is also another major problem. Mainly these problems are observable in the wetlands of Shesher and Welela wetlands. At all there is no practice of sustainable agriculture in the environs of wetlands of Fogera plain. As is identifying change in area and describing ecological character of wetlands is one framework of Ramsar convention, this study has conducted to assess the shrinkage and ecological importance of Wetlands of Fogera Plain.

## 2. Materials methods

### 2.1 Description of Study Area

Fogera plain is found in South Gonder zone, Amhara regional state. Astronomically this woreda is located between  $11^{\circ} 42' - 12^{\circ} 03' N$  latitude and  $37^{\circ} 25' - 37^{\circ} 58' E$  longitudes. This plain is bordered with Lake Tana from the West.



**Figure 1 Map of Fogera Woreda**

The elevation is ranged from 1500- 2500m. Topographically, 11 % is mountainous, 13% undulating and 76% is plain. The woreda has the potential for different crop cultivation mainly for rice and is totally in Weynadege agroecology. The annual rainfall is 1284 mm and annual temperature ranges from  $10.3^{\circ} C$  to  $18.75^{\circ} C$  (Ethio Government Communication Office, 2011). In Fogera plain, different spot wetlands are found. But large area of wetlands is found in the plain of Shesher and Welela. The wetlands of shesher cover the area of Shina, Nabega, Shega and Kidist Hana kebeles of Fogera Woreda. According to Development agents, Land administrator expert and local people, Shesher dries usually in February or March; whereas, Welala dries in April or May. In rainy years, when there is high overflow from Ribb River, Welala never dries throughout the year. The Shesher and Welala wetlands are valuable for the local community. They provide water, grazing for livestock and fish for food.

### 2.2 Methods and Procedures

#### 2.2.1 Methods and Procedures for Wetlands Shrinkage Study

For this study the shape file of this area was taken from Ethio GIS 1994 and used as a base map. The Landsat satellite images of MSS for the date January 1973, Landsat TM for the date December 1994 and Landsat ETM+ for the date January 2011 which have 58m, 28.5m and 28.5m resolution respectively were acquired. WGS\_1984\_UTM\_Zone\_37N projection was used to georeference and to georectify the images. Satellite images were classified by supervised classification through maximum likelihood classifier algorithm on ERDAS Imagine 8.6. After having the spatial and temporal maps of the wetlands, the accuracy of the classification of wetland maps of 1973, 1986 and 2011 are assessed by error matrix, over all accuracy and Kappa (K) statics. For this method, ground truthing data were collected by guided and transect walks and GPS. Besides to satellite image mapping, focused group discussions and key informant interviews were conducted with the community having different economic status, age and sex group. In this study lands which are covered by water, sedimented

lands and moist lands are classified as wetland.

### 2.2.2 Methods and Procedures for Soil Sampling and Analysis

For this study, biosequential soil sampling approaches was followed. After having these governing soil sampling approach, soil samples were taken from the land which was wetland 20 years ago ( sample site 1), land which was wetland 10 years ago ( sample site 2) and currently undisturbed wetland ( sample 3). A composite soil samples from 0-75 cm were taken in three replication. From one sample site 21 soil samples, totally 63 soil samples were taken. Each soil sample were placed in a plastic zip-lock bag and stored in air drying place. Location of sample points, sedimentation areas, different types of wetlands (disturbed or undisturbed wetlands) and other aspects of wetland were identified on the field during sampling. Finally carbon content of the sample soils was analyzed in laboratory of Oromia Water Works Enterprise in Addis Ababa following ferrous ammonium sulphate using diphenylamine indicator procedure (Schnitzer, 1982).

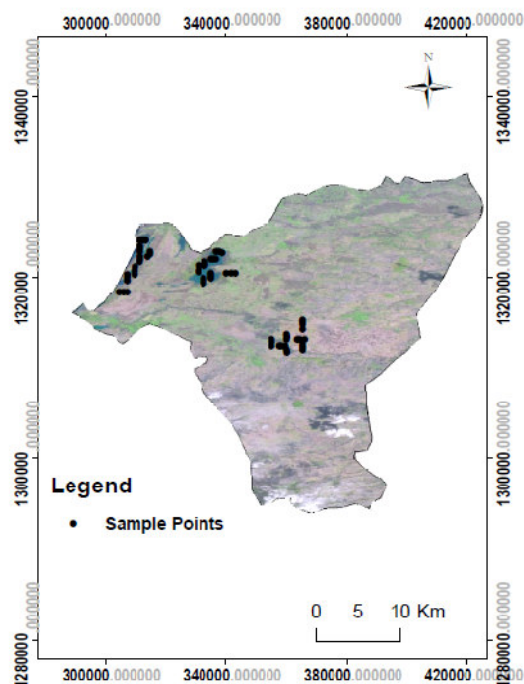


Figure 2 Distributions of Sample Points

After laboratory analysis of carbon content of wetlands, statistical analyses were performed by using ANOVA. Data was analyzed using two groupings. Group 1 is reference site (the current undisturbed wetland) and group two is former wetland sites now under other land uses (disturbed site). Then comparison of the mean carbon content in between different state of wetlands was conducted using ANOVA test.

### 2.2.3 Qualitative Data Collection and Analysis

These are methods to study the causes of wetland shrinkage and qualitative description of the trend of wetland. Focused group Discussion with youth households group, old aged households group and kebele administration group having a group size of six and key informant interview with 28 informants were performed. The key informants were kebele Development Agents, governmental and nongovernmental organizations, social institutions, religious leaders and others concerned to the management of the wetlands of Fogera plain. For qualitative data analysis, content and comparative analysis methods were used. For biodiversity study, field observation, interview and review of other studies were conducted.

## 3. Result and Discussion

### 3.1 Analysis of Wetlands Shrinkage in Fogera Plain

By using field survey and satellite images of Landsat MSS 1973, Landsat TM 1994 and Landsat ETM+2011, cultivated land, settlements, Wetlands, Grazing lands and Forest and bush lands were identified. These land use and land covers have spatial pattern and subject to change over time. Among these land uses, change in area of wetlands is the objective of this study ( see figure 3 and table 1).

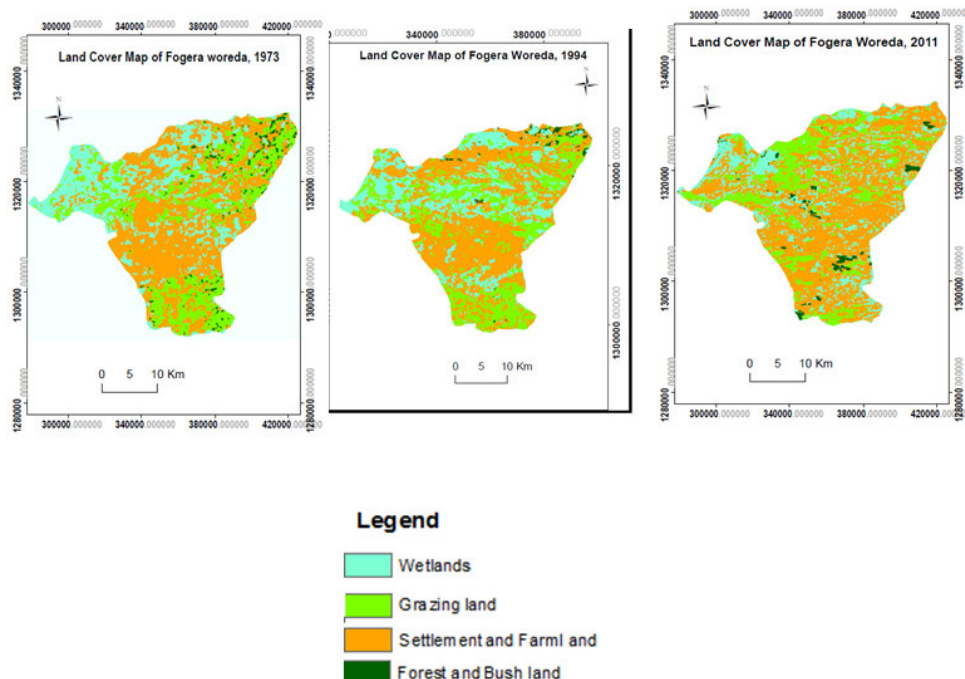


Figure 3 Land cover map of Fogera Woreda in 1973, 1994 and 2011

**Table 1. Area of wetlands in 1973, 1994 and 2011**

Land use and land cover types	Area in ha			Area in percentage		Change in area in ha
	1973	1994	2011	1973	2011	1973-2011
Wetland	25254.56	24981.87	19235.4	25.73	19.59	-5246.26
Settlement and Farmland	46502	49709.19	55615.4	47.35	56.64	+9113.4
Grazing land	24254.1	22337.29	20704.4	24.7	21.08	-3550.1
Forest and Bush land	2179.34	1162	1861	2.22	1.89	-318.34
<b>Total area</b>	<b>98190</b>	<b>98190</b>	<b>98190</b>	<b>100</b>	<b>100</b>	

The wetlands of Fogera plain showed a significant difference in area from the 1970s to the present. In 1973, 25.73% of the area was wetland while in 2011 it reduces in to 19.59% of the area. In contrast the area of agricultural land and settlement showed an increasing trend. In 1973, the land of agricultural land and settlement was 47.35% while it increases in to 56.64% of the area.

The result of the satellite image analyses described above is also confirmed by the local community. The farmers themselves notice the shrinkage of wetlands. The farmers clearly describe that there is shrinkage of wetlands. The farmers of Shina kebele of Shesher said;

“The area of the land covered by water is decreasing from time to time and this is a good fortune for us to plough. Before 20 years ago, there was a grass grown on the wetlands and that grass was used for cattle forage. During that time diary farming was the main stay. But following the retreat of the wetland water, we plough the wetland. Owing to this, we change the former milk cows. Because these cows by nature are big and require more grass. Since 1990s we are practicing farming on this wetland. We drain the water of these wetlands to plough and pump water for irrigation”.

There are diverse causes for the shrinkage of wetlands. Among these, the sediment deposition on Shesher wetland which is transported by river Rib is one. This river carried sediment from the upstream areas and deposits it to the wetlands of Shesher. Following sediment the wetland lacks its pristine nature and following this farmers plough. Due to unsustainable farming activities by local farmers, the existence of these floodplain wetlands and associated ecological services as well as socioeconomic importance is under threat. It was observed that the local farmers were draining and pumping the water to expand cereal crops cultivation. Now these wetland are under extensive cultivation of Teff (*wukro teff*), *Guaya*, *Shinbira*, *Rice*, *Misir*, and *Suf*.

The lands in these wetlands have a problem of ownership. That means some farmers have not land book, they are not registered and even they didn't pay tax for this lands. Since 2011, the government tried to protect these wetlands from intrusion and ploughing. By the year 2012, the government aimed to construct boundary for

communal grazing lands and wetlands, control free grazing and identify the farmers who have no title book for the land they are ploughing. Astonishingly the farmers accept the government strategy of control grazing but not ploughing. There are also measures taken for the conservation of the up land to trim down sedimentation. Ethio Wetlands and Natural Resources Association intended to reduce sedimentation from the uplands by taking mainly biological conservation measures.

The result of wetland shrinkage and its causes in this study is in agreement with other studies conducted in Ethiopia and abroad. For example Schuyt, 2005; Morton et al, 2003; Tariku Mekonnen and Ababayehu Aticho, 2011; Afework Hailu, 2009 and Legesse, 2007. In contrast there are studies disclose the rate of wetland loss was decreased since the 1970s (example (Good 2000, Christy 2004).

### 3.2 Carbon Content of Wetlands of Fogera Plain

Sample soils were collected from natural undisturbed wetlands, sedimented wetlands, semi disturbed wetlands and from agricultural land. Undisturbed wetlands are currently in the pristine state mainly found in the shore of Lake Tana. The wetlands which are termed as sedimented are currently covered by sediments transported from the upstream watersheds by Rib River and are undisturbed. These kinds of wetlands are found in the shore of Lake Tana.

There is a significant difference on the carbon content among natural, sedimented, semi disturbed wetlands and agricultural land. There is lowest content of carbon on the soils of sedimented wetland followed by semi disturbed wetlands and better content of carbon on the soils of undisturbed wetlands.

Table 2. Organic Carbon and Organic Matter in different state of wetlands ( mean Sd)

Wetland type		OC (%)	OM (%)
Sedimented	Mean	.6569 ± .24207	1.1325 ± .41967
	N	16	16
Undisturbed	Mean	1.3500 ± .59967	2.3310 ± 1.03260
	N	10	10
Semi disturbed	Mean	1.0156 ± .39806	1.8619 ± .62140
	N	16	16
Agricultural land	Mean	1.3138 ± .39171	2.2748 ± .68033
	N	21	21
<b>Total</b>	<b>Mean</b>	<b>1.0770 ± .48140</b>	<b>1.8887 ± .81848</b>
	<b>N</b>	<b>63</b>	<b>63</b>

Table 3. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
OC	Between Groups	4.807	3	1.602	9.889	.000
	Within Groups	9.561	59	.162		
	Total	14.368	62			
OM	Between Groups	14.247	3	4.749	10.268	.000
	Within Groups	27.287	59	.462		
	Total	41.534	62			

In Fogera plain, sediment is transported from the upstream watershed by Rib River and deposited on the wetlands. The top layer of the soil is sediment and the wetland soil is under this layer. Owing this, the pristine nature of wetlands is lacking. On these sedimented wetlands, lower carbon content of soils was identified. In line to this, it is fair to conclude the sediment transported by Rib River is very poor in organic carbon Better soil carbon is found in undisturbed state of wetlands which are found in the shore of lake Tana..

Concurrent to this study, Kayranli et al, 2010; Philip, 2009; Hoffmann et al, 2009 and Mudda et al 2009 conclude that age of wetlands, location, climate and sediments storage are factors regulate carbon content of wetlands soil. Not only has the supply of the sediment, but also the nature of the sediment determined the carbon content of wetlands. Carbon sequestration is variable depending upon the nature of sediments that are building tidal wetlands (Philip, 2009). In contrast Mudd et al, 2009 discover carbon accumulation in wetlands is nonlinearly related to the supply of sediment. Hoffmann et al, 2009 studied soil erosion acts as a transport agent and adding carbon through sediment accumulation to alluvial storage and to the fluvial system.

### 3.3 Biodiversity Importance of Wetlands of Fogera Plain

Through field observation and interview with the local communities, the biodiversity resource of this area was studied. These wetlands are rich in biodiversity especially in bird and fish species. Beside to these there are also wild mammals in this area. On the wetland of this area there are different types of birds. Among these, local communities mentioned some waterfowl with their local name; *Yibra, Sila, Chile, Amora, Mulamilit, Wari, Shimela, Gergesa, Asawagari, Sabisa, Machidie, Gugut, Kok, Erkum, Wardi, Bula, Erigib, Dirchit, Kura, Sila* and *Jiwajibo* are few of them. Even the farmers narrate that there are birds seasonally migrate from Middle East to this area. That means this area is internationally important bird habitat. Negash Atnafu et al 2011 also recorded 62 species of wetland birds from this area. In 2008, bird count was conducted by EWNHS on Shesher and Welela sites. For one day, a total of 54 wetland bird species totally 18, 309 individual bird species were enumerated. During this count, three bird species take the lion share; Ruff, *Philomachus pugnax* (47%), Northern *Shoveller, Anas clypeata* (11%) and Egyptian Goose, *Alopochen aegyptiacus* (10%). This count confirm the the Welela and Shesher wetlands of Fogera plain as stronghold of water birds around Lake Tana.

Regarding fish, the farmers recognized the importance of fish especially from July to March from Shesher and Welela wetlands. The farmers mentioned *Kereso, Amibaza, Sorz and Qey asa* types by their local name. These fish species are used as food from July up to March and seasonally vanished following drying of wetlands water. Wassie Anteneh et al 2012 find out the wetlands of Shesher and Welela are important nursery habitat for *Clarias gariepinus* and migratory *Labeobarbus* fish species. Among the total fish species of this area, 16 are *Labeobarbus* species of which 15 are endemic (Nagelkerke & Sibbing 2000). Beside to bird and fish species, some mammal species of the area are mentioned by the community. These are Hyena (*Crocuta crocuta*), Jackal (*Canis mesomelas*), Monkey (*Cerapithecus aethiops*), Aardwolf (*Proteles cristatus*) and Aardvark (*Orycteropus afer*) are some of.

But currently these biodiversity resources of the area are under threat. Conversion of natural and semi-natural habitats to cultivation and over-exploitation of vegetation mainly grasses are the major threats. This resulted habitat distraction and loss. Over grazing, wetlands drainage in dry season, changes in hydrology and sedimentation are another threats. The large number of bird species is waterfowl that inhabit, breed and forage in or near the wetlands. During the dry season, these bird species loss both the breeding sites and ground nesting areas. Unfortunately, birds in this area are considered as pests, predating crops. As a result birds are subject to disturbance and harassment, especially by children of farmers.

### 4. Conclusion

The wetlands of Fogera plain are among the largest flood plain wetlands of the country. But the local community is practicing unsustainable use on these wetlands. Sediment deposition on the wetlands from the nearby upstream watersheds by Rib River caused the wetlands to loss their pristine nature and trigger farmers to plough. Problem of ownership of lands in this area is another factor that contributes for the conversion of wetlands in to agricultural land. The area of wetlands was 25.73% of the area in 1973 while it reduced in to 19.59% of the area in 2011. The farmers themselves notice the shrinkage of wetlands.

The wetlands on which there is deposition of sediments, lower content of soil carbon was identified. From this it is fair to conclude; there is low carbon content of sediments transported from the surrounding watershed. While from the wetlands which are less disturbed better content of soil carbon is measured. These wetlands are also found rich in bird species and is a habitat and nursery for fish species. But these biodiversity resources of an area face a serious threat mainly following wetlands sedimentation. Generally it can be concluded that sediment deposition(landscape variable) and further farmers farming practice weaken wetlands ecological role in carbon sequestration and being biodiversity habitat.

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