CARBON SEQUESTRATION POTENTIAL OF WETLANDS ACROSS PUNJAB AND POSSIBLE CLIMATE MITIGATION STRATEGY

DISSERTATION REPORT

Submitted in partial fulfillment of the
Requirement for the award of the
Degree of

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in
ENVIRONMENTAL ENGINEERING
(CIVIL ENGINEERING)

by

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Transforming Education Transforming India

(School of Civil Engineering)

Lovely Professional University

Punjab

2017

DECLARATION

I, Naveed Najam (11208308), hereby declare that this thesis report entitled **"carbon sequestration potential of wetlands across punjab and possible climate mitigation strategy"**
submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: **Naveed Najam**

Place:

CERTIFICATE

Certified that this project report entitled "carbon sequestration potential of wetlands across punjab and possible climate mitigation strategy" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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Signature of Student

NAVEED NAJAM

ABSTRACT

Wetlands comprise of areas of fens, humates or water and may be natural or man-made, temporary or permanent and depth of which at low tide does not exceed six meters. They are the ecosystems of various characteristics i.e., terrestrial, aquatic or semi-aquatic. Wetland formations are one of major and important sinks for carbon storage. Till now carbon is stored in the wetland formations naturally by various processes. Sequestration of carbon in wetlands may act as a strategy to extenuate climate change.

Punjab has vast biodiversity and is bestowed with various wetlands. There are about 30 wetlands across the state but many of them have lost the wetland characteristics and the state is left with less than 1% of its area under wetlands. Out of those wetlands there are some major wetlands which are preserved sites and internationally accepted as per Ramsar convention.

This work is an attempt to determine the carbon storage potential of some of the wetlands across the state of Punjab and to check the present status of the wetlands: determining the physico chemical and biological parameters of the water of the wetlands.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The term "carbon sequestration" is utilized to depict both natural and deliberate forms by which CO_2 is either expelled from the air or redirected from discharge sources and stored in the sea, earthly situations (vegetation, soils and residue) and geologic formations. The catching and long haul storage of carbon dioxide, by expelling it from the atmosphere and storing in repository is called carbon sequestration. It can be performed by geoengineering, furthermore happens normally by natural chemical weathering of rocks. This procedure is useful in moderating a worldwide temperature alteration and accumulation of greenhouse gasses is additionally backed off. There are natural carbon sinks where carbon sequestration happens for a drawn out stretch of time. The carbon is stored actually in seas, water bodies and wetlands because of photosynthesis by plants. The landfills are artificial hotspots for carbon reservoiring. The carbon is sequestered by the development of fossil fuels, clatharate and limestone in nature which is extracted through geoengineering.

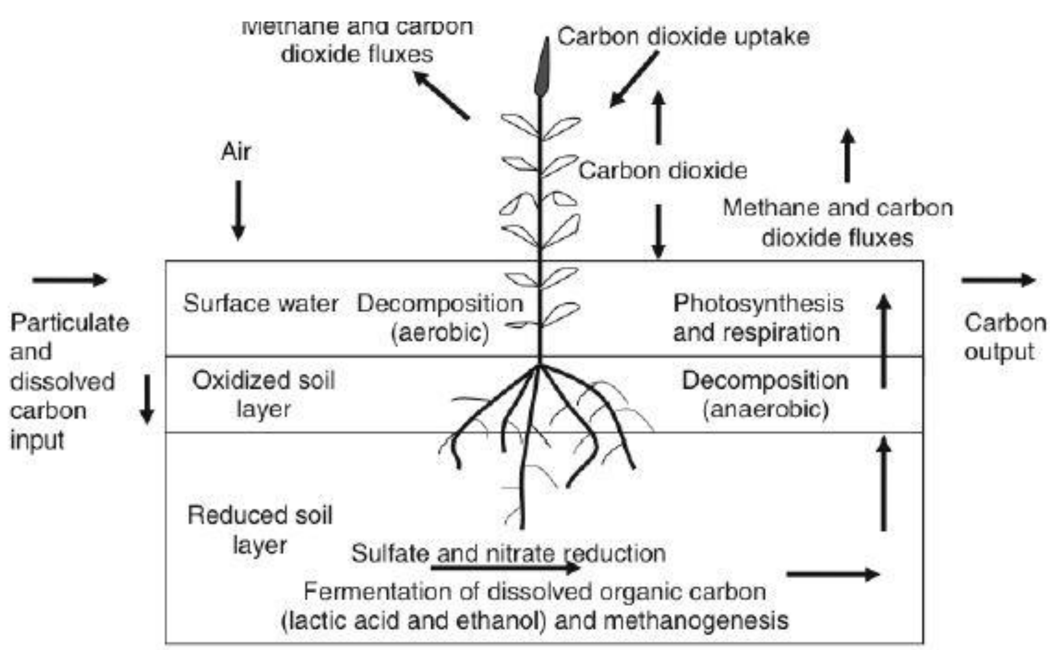

Figure 1.1 Various processes of the carbon cycle in Wetlands. Source: Kayranli et al., (2010).

Presently the atmosphere and sea have an ample amount of carbon while soils have lost carbon at an alarming rate because of improvement, transformation of local biome to cropland and agrarian exercise that diminish SOM. Assessments of the exact size and net annual change in carbon sinks fluctuate, but the relative sizes of each platform planets gathered from carbon - the oceans, plants and soil - certainly understand. Diminishing carbon stocks in the biosphere, including farming soils, have truly been a net wellspring of CO_2 outflows to the climate. The terrestrial sequestration approach goes for utilizing soil and vegetation to collaborate as long term storage pools for atmosphere-determined carbon in this manner both plants and soils can give an alluring component to carbon stockpiling. The amount of carbon stored in the soil is very critical in that it contains around three times the measure of carbon in vegetation and double the sum in the atmosphere. In such manner, soils are considered as the largest carbon supply of the carbon cycle.

Agriculture is one of the high prior sectors where the effects of climate change surpass resistance limits with suggestions for the vocations of a huge number of smallholder farmers reliant on this area. The capacity to catch and secure storage of carbon in soils is a function of depth, surface, structure, precipitation/water system, temperature, cultivating framework, soil administration and culturing/tillage, cropping intensity and nitrogen contributions to soil. Keeping up and expanding soil natural matter (SOM) adds to soil richness, water maintenance, and harvest production and carbon connected with soil minerals. Carbon can remain stored in soils for centuries or be immediately discharged once again into the environment.

Reclamation of wetlands is therefore the key for sequestration. The role of wetlands in carbon cycling has been under-estimated. Wetland structures are mangroves, salt bogs and in addition freshwater wetlands. Normally wetlands additionally include fens, lowlands and marshes. The carbon cycling in wetlands incorporate information sources, yields and capacity abilities. Controlling atmospheric CO_2 will require deliberate mitigation with an approach that joins reducing emissions and expanding stockpiling.

1.1 Status Of Wetlands in the World

As per Ramsar conventions 2007, 1200 MHa of total area of earth (9%) is covered by wetlands which stores about 35% of GTC (***CBD/Ramsar/STRP***). Wetlands are continuing to decline across the globe and it is estimated that 64-71% of the total area of wetlands has declined in the 20^{th} century. This loss of wetlands also leads to the economical losses of a nation. 50% of the area is lost in parts of Europe, New Zealand, North America and Africa. The loss of wetlands around the world varies between 30 - 90 %, depending on the region under consideration (***Junk et al., 2013***).

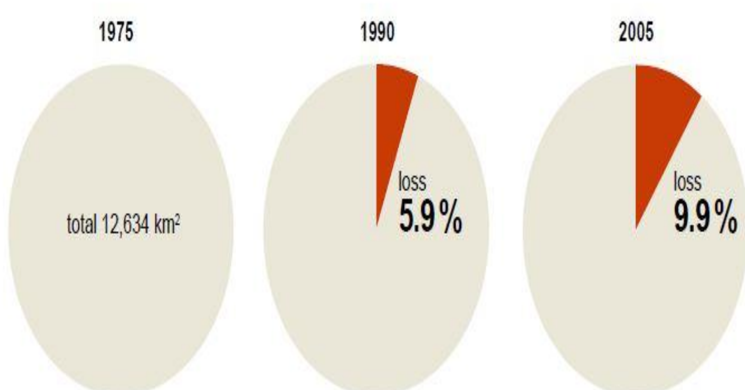

Figure 1.2. The loss of wetlands across Mediterranean between 1975, 1990 and 2005.

1.2 Status of Wetlands in India

India has both inland and coastal wetlands including natural and man-made. The total estimated area under wetlands is 15.26 Mha that comprises 4.63% of the total area of the country. About 7440247 Inland Wetlands are identified in India out of which 25 have been declared as Ramsar Sites. Out of total area under wetlands 69% are inland wetlands, 27 coastal and 4% are other wetlands (SAC, 2011). Gujarat contributes the largest ratio (22.8%) and Chandigarh has almost trifling part of the entire wetland area of the country. Management of wetlands in India relates to the limnological prospect and bionomic aspects (***Nitin Bassi et al., 2014***). But, the physical (such as hydro-logical and land-use changes in the catchment) and socio-economic (such as population growth andchanges in economic activities) processes leading to limnological changes have not been explored sub-stantially. Water-spread area of wetlands changes over seasons. After monsoon, the total are under water of the states; Sikkim, Nagaland, Mizoram, Meghalaya, and Jharkhand is more than 90% of the entire wetland areas of India.

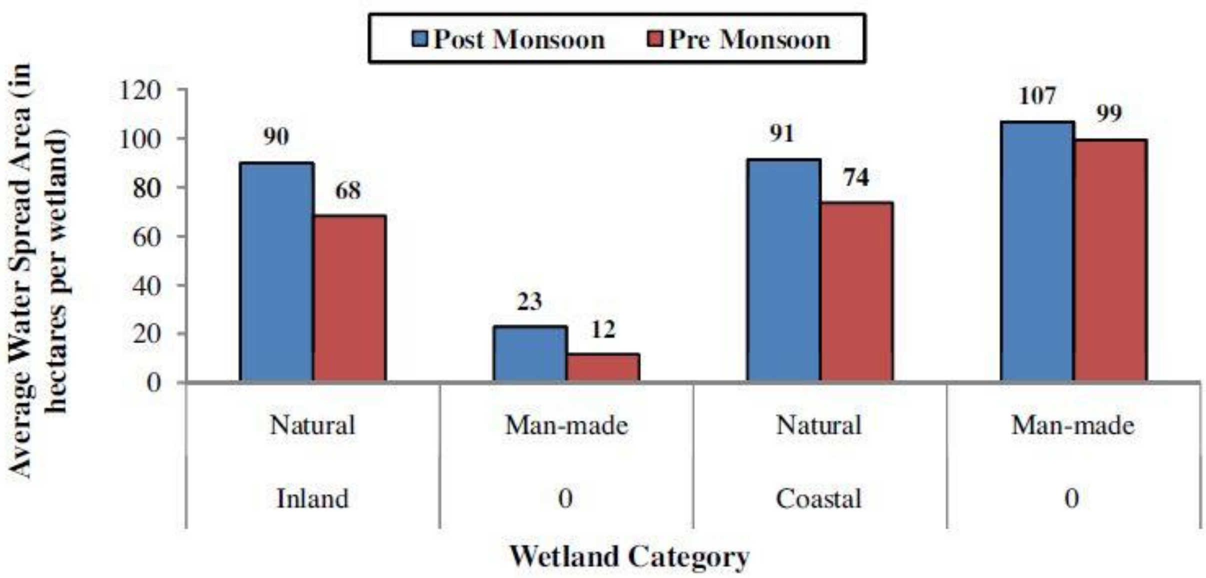

Figure 1.3. Area of water Spread under various wetlands in India. Source: (SAC, 2011)

Table 1.1 State wise area covered by wetlands

State	Number Of Wetlands	Area(Ha)
Andhra Pradesh	1	90100
Assam	2	4504
Bihar	2	11490
Chandigarh	1	148
Gujarat	8	1270875
Himachal Pradesh	5	15736
Haryana	2	288
Jammu and Kashmir	7	117325
Jharkhand	2	98965
Karnataka	7	4250
Kerala	5	213229
Madhya Pradesh	12	359814
Maharashtra	3	40298
Manipur	1	26600
Mizoram	2	285
Orissa	4	122580
Punjab	3	5648
Rajasthan	1	24000
Sikkim	6	164
Tamil Nadu	3	46283
Tripura	1	240
Uttar Pradesh	9	12083
Uttaranchal	1	800
West Bengal	5	553090

1.2.1 Status of Wetlands in Punjab

Punjab has 20 wetlands out of which 3 are recognized Ramsar sites viz., Harike, Kanjli and Ropar and cover a total area of 5648 Ha. i.e., less than 1% of the total area of the status. Thus, there is a need to preserve these natural resources as there are almost 20 wetlands which have lost their wetland characteristics.

1.2.1.1 Harike Wetland

The wetland is counted among one of the largest wetland of north India. This wetland is spread over ha and covers three district borders Ferozepur, Kapurthala and Tarn Tarn.
The longitudinal (72^0 12’ E) and latitudinal (31^0 13’ N) is the location of this wetland.
This wetland was formed in 1952 by the construction of barrage at intersection of Sutlej and Beas rivers. Total area of this wetland is 4100 Ha.

Figure 1.4 View of Harike wetland. (a) (b)

1.2.1.2 Kanjli Wetland

The wetland of Kanjli is located at 75^{0}22’E longitudinal and 31^{0} 25’E latitudinal and was formed as a result of construction of head works in the rivulet of Holy Bein in the year 1970. It lies 4 km away from Kapurthala city. This wetland is spread over an area of 183 ha and covers 12 villages.

Figure 1.5 View of Kanjli Wetland (a) (b)

CHAPTER 2
TERMINOLOGY

CDM	Clean Development Mechanism
Pg	Petagrams
SCC	Soil Carbon Content
SCS	Soil Carbon Sequestration
CC	Carbon Capture
WMP	Wetland Management Practices
SSW	Seasonally-Saturated Wetlands
WS	Wetland System
WW	Wetland Water
GCC	Global Carbon Cycle
GTC	Global Terrestrial Carbon
AGPB	Above Ground Plant Biomass
TCS	Total Carbon Storage
FAO	Food And Agriculture Organization
BGPB	Below-Ground Plant Biomass
Mg/Ha	Metagrams/Hectare
%	Percentage
BD	Bulk Density
SOCD	Soil Organic Carbon Density

CHAPTER 3

RATIONALE AND SCOPE OF THE STUDY

Inland wetlands i.e., riverine wetlands accumulate more C as compared to the other types of wetlands as the water carries various nutrients along it and productivity of wetland increases with the C deposited in the Wetland soils. Thus, the C content within the water body basin will be high which will act a sink of carbon. The storage of carbon in the various available sinks reduces the emissions of GHG's into the atmosphere, therefore, is a potential method of climate mitigation.

Wetlands being home to various species of flora and fauna, the biomass content in the wetlands will be subsequently high. Thus, being a rich sink of carbon and will help in maintaining various criterion for designing and constructing of wetland in various urban dwellings.

This study also compares the quality of water at the upstream and downstream of the wetlands. Thus, a comparative study of water quality of the wetlands is studied.

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CHAPTER 4

OBJECTIVES

1. To estimate the net carbon content in the wetlands. i.e., soil and plant carbon.
2. To find the content of biomass present.
3. To compare the various physico-chemical characteristics of the water bodies.
4. To determine the carbon sequestration potential of the wetlands.

CHAPTER 5

REVIEW OF LITERATURE

CO_2 is the primary gas that adds to net change in global climate. Prevention of CO2 emissions into atmosphere is the possible remedy to reduce the net effect (***IPCC 2007 a, b; Stern et al. 2006***). Reducing biosphere pools of carbon, i.e., soils have always been source of CO2 emissions to the atmosphere (***Marland et al. 2007***). Carbon is found as a building block of all the living organisms. It is prevalently found as SOC, plant biomass, CO_2 in atmosphere, also as dissolved form in seawater (***ESA, 2000***). Terrestrial sequestration is done through woods and soil protection rehearses that improve the capacity of carbon by reestablishing woodlands, wetlands, and meadows) or decrease CO_2 outflows like decreasing agricultural culturing and stifling rapidly spreading fires. The current carbon on land can be easily affected by aggravations like fire, climate-change and pattern of land use. Changing agricultural land to wetlands may expand carbon sequestration, upgrade natural life and water quality, and increment surge stockpiling and recreational potential– yet the loss of farmlands will diminish the production of crops (***USGS,2008***).

Soil Carbon capture increases with restoring land into the grassland, forests and wetland (***Lei Deng et al., 2016***). Plants, soils and products of plants have long term capability to store C which can effectively reduce the climate change in nature. The methods of crop land and forest management are important factors to stockpile C in terrestrial ecosystems. (***Sheikh AQ et al., 2014*).** The CDM of Kyoto protocol does not include CO_2 capture in soils. This should be initiated by FAO including the need of carbon capture (***Sartaj A Wani et al., 2015***). Soils having high amounts of Organic matter are probably going to experience generous height subsidence subsequent to seepage (***Megan MacClellan,2016***). Variations in carbon content of soil depict the net outcome of carbon inflow (plant litter), carbon loss (decay). To enhance a pickup in carbon stockpiling, a new administration way should increment the measure of carbon entering the soil as plant deposits or stifle the rate of soil carbon disintegration. The previous is a component of the net essential generation (plant yield) and the extent of the plant yield that is in the long run come back to the dirt as plant litter then again trim buildups. The rate of decay is controlled by soil conditions (e.g. dampness, temperature, and oxygen availability), arrangement of the natural material, situation of the material inside the soil profile, and the level of physical security (***Bruce et al.,1990***). The macro-nutrients like NPK are usually derived from OM in soils (***Donahue RL et al. 1990***). Bulk density can possibly be affected by normal farm administration practices, like animals grazing and the utilization of machinery. Management impacts on soil bulk density and soil compaction may have more noteworthy impacts on SCS (***Rachael Carolan et al., 2016)***. Controlled till system is widely practiced and is based on special tools, various herbicides and genetically enhanced seedlings for modified CSP (***Daniel Kane, 2015***). There is an increase SOC pool as the biomass is added to soils with the depletion in SOP as a result of pattern of land use (***Lal 2001, Wolde Mekuria et al., 2009***). The various issues identified with SCC are proper use of fertilizers and pesticides, enhanced use and management of soils and utilization of excrement for supplement increments are proficient method for SOC sequestration (***Smith 2008, Stan 2000***).

The biomass content of forests is an important reservoir of C, although with increase in temperature of the soil there will be decrease in the CSP as temperature and CSP have inverse relation (***K. Kathiresan et al., 2012***). With improvement in grassland productiveness there will be enhancement of SOC stocks (***L. Vesterdal, 2010***). Grasslands may reduce the increasing levels of CO2 in atmosphere by SCS but there is no certain proof for the area, its distribution and behavior of this "spot" (***FAO,2010***).

Wetlands are ecosystems which can serve as great sinks of carbon being very diverse. They provide various products and services and are believed to possess unparalleled bionomic characteristics(***Prasad et al., 2002***). Their great productivity and availability of water gives them the carbon sequestration potential in the soil, which helps to reduce the green house effect due to CO_2 emissions in the atmosphere and mitigate any change in climate. As per latest research, small water bodies like water reservoirs, ponds and wetlands have CSP at higher rates. (***Smith et al., 2002; Renwick et al., 2005***). A vital part of directing the water vapor, CO2, NH3, NO3, SO2 and other GHG's in the atmosphere is influenced by the wetlands. They have the tendency to be hotspots for C and N but the circumstances differ from place to place and depend on type of wetland (***Pritchard)***. The CSP of SSW is strongly vulnerable to variations in agricultural and WMP. There is a further need to work on the role of wetlands in GCC on various wetland types and their role as sink and source of GHG's (***STRP, 2007***). Also change in climatic conditions can have distinguishable impact on WS where wetting and drying phases can give reasonable changes in pedogenic OC equilibrium (***J.J. Maynard et al., 2011***). The utilization of common systems to amass carbon is a standout amongst cost effective apparatuses to diminish the net impact of greenhouse gas outflows and decrease environmental change (***Hanley and Spash, 2003***). Carbon obsession under wetland anaerobic soil conditions gives extraordinary conditions to long haul stockpiling of carbon into histosols. In any case, this carbon sequestration process is personally connected to methane discharge from wetlands. The potential commitment of this transmitted methane to the greenhouse impact can be mitigated by the evacuation of environmental CO_2 and stockpile into peat. (***Ruchi Sharma et al.***). Although, methane production occurs under the water due to anaerobic decomposition,1/3rd to 1/4th of the total carbon pool is contributed by wetlands(***Mitra et al. 2005; Bridgham et al. 2006; Mitsch and Gosselink 2007; Lal 2008***). Fe fertilization can improve "organic pumping" by the expansion of productivity of phytoplankton and marine biota (***Lal, 2008*).** The macrophytes in term of CSP are underestimated due to their size, circulation and growth however their effective CC and capacity role and rates are significantly maintainable (***Chesfida Maqbool et al. 2013***). The vegetation of wetland and its soil remarkably impart the natural stock and also the nutrients, pathogens and sediments are filtered. The upheaval of WW is decreased by plants due to their plain surface and characteristics of flow, also, it allows this stuff to settle down from water column, subsequently plants get nutrients (***Marwa Muraza et al., 2013***). Wetlands in temperate climatic conditions exhibit larger C pool than that of tropical wetlands and the maximum concentration of OC in soils is found at the centre depth (***Middleton ,2008***).

CHAPTER 6

RESEARCH METHODOLOGY

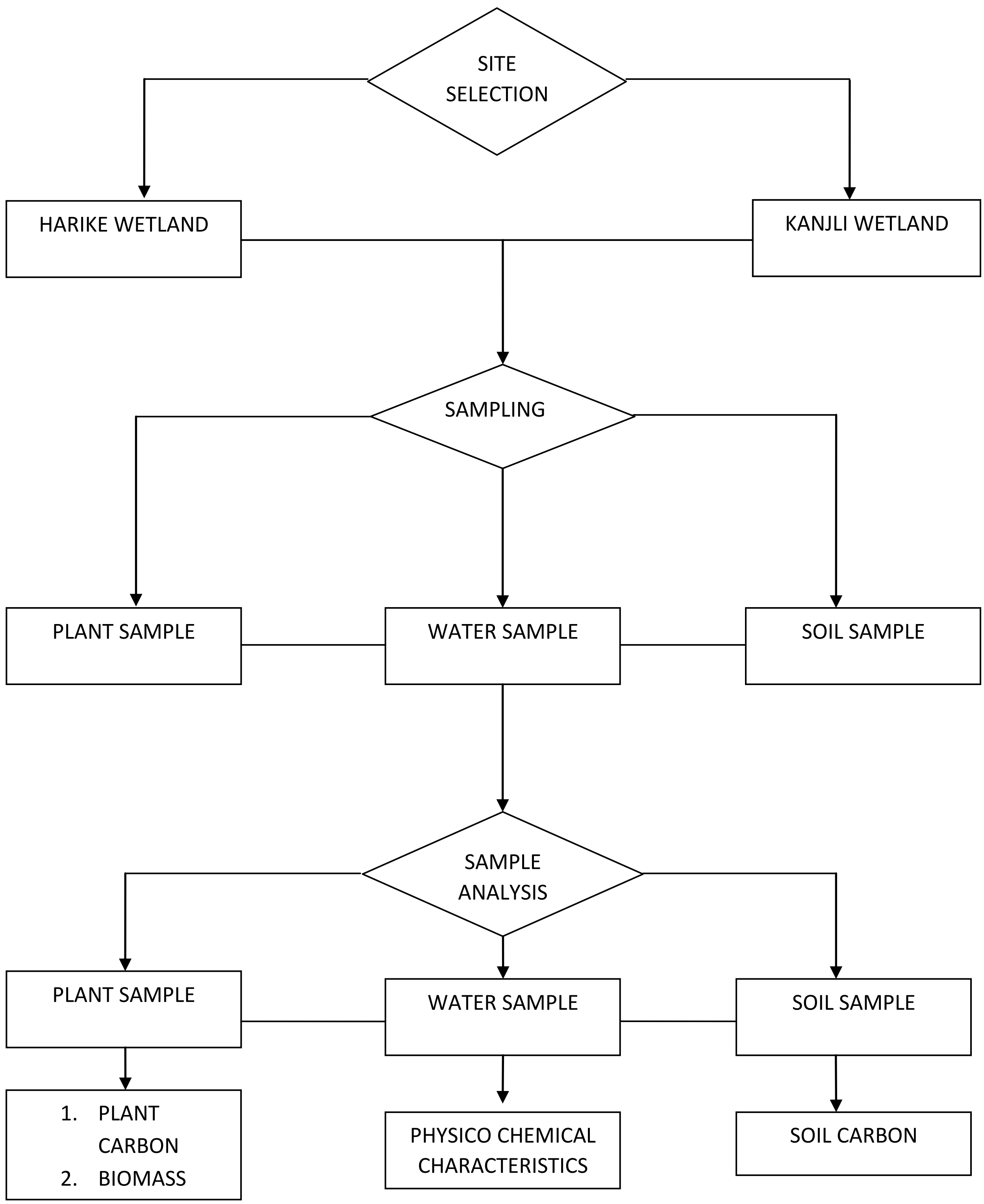

Figure 6.1 Flowchart of methodology.

6.1 Selection of Site:

The sites selected for the assessment are Kanjli Wetland and Harike Wetland. Three locations from each site were selected for the collection of samples. A control sample was also collected at some distance from the selected location.

The locations for samples at Harike wetland were:

Site A: 31^{O}08’12.53”N
74^{O}57’10.06’E

Site B: 31^{O}07’41.03”N
74^{O}58’27.17”E

Site C: 31^{O}09’25.67”N
74^{O}56’34.69”E

Control sample: 31^{O}09’39.62”N
75^{O}06’10.11”E

The locations for samples at Kanjli wetland were:

Site A: 31^{O}24’45.34”N
75^{O}22’50.59”E

Site B: 31^{O}25’00.03”N
75^{O}23’09.18”E

Site C: 31^{O}24’34.41”N
75^{O}22’43.48”E

Control sample: 31^{O}24’53.77”N
75^{O}22’41.07”E

Figure 6.2 Kanjli Wetlands

Figure 6.3 Harike Wetlands

6.2 Determination of SOC:

The Organic Carbon content in the soil was calculated for every month from January to April. Soil samples were collected at a depth of 15cm by digging a pit of 10*10 cm^2.

The SOC of the wetland was determined by Walkley Black Method (1934).

Reagents to be used:

1. 0.4 N potassium dichromate solution ($K_2Cr_2O_7$).
2. Triple-distilled water.
3. Standard 0.2 N ferrous ammonium sulfate ($Fe(NH_4)_2(SO_4)_2.6H_2O$) solution

$$\text{Organic carbon (\%)} = ((F_b - F_s) \times 0.0006)/ M)*100$$

Where,

F_b is the vol. of ferrous solution used in the blank titration,

F_s is the vol. of ferrous solution used in the sample titration,

M is the mass of the sample. (***Faina Gelman et al, 2011.***)

$$\text{SOCD (Mg ha}^{-1}) = \text{SOC (\%)} \times \text{BD (Mg m}^{-3}) \times \text{depth(m)} \times 10^4 (\text{m}^2\text{ha}^{-1}) / 100$$

6.3 Plant Biomass Measurement:

Plant biomass is to be found by trimming the AGPB at ground level. Five 1*1 m^2 quadrants of above ground plants are to be sampled, then dried in oven at a temperature of 70^0 for 3 days and dry weight is taken. (***Deepa Dhital et al., 2014***)

The AGPB has been calculated by multiplying volume of biomass and wood density (Pandya *et al*., 2013)
The BGPB has been calculated by multiplying above ground biomass taking 0.26 as the root shoot ratio (***Chavan and Rasal, 2011; Hangarge et al., 2012***).

BGPB (g) = 0.26 X BGPB (g).

The estimated biomass (g/m^2) = Dry weight (g)/Plot Area(m^2)

6.4 Determination of Plant Carbon:

The carbon content in plants is 50% of the total biomass ***(Pearson et al., 2005)*** i.e. Carbon Storage = Biomass/2. (***Suryawanshi et al., 2014***)

6.5 Testing of water samples:

The test for various physico chemical properties need to be done as per the guidelines provided by IS codes or methods adopted as per CSIR (1974). -

The various characteristics of water that are to be found are:

1. pH
2. Turbidity
3. DO
4. Hardness
5. Alkalinity
6. Sulphates
7. Chlorides
8. Nitrates (***Tehmina Yousuf et al., 2015***)

CHAPTER 7
RESULT AND DISCUSSION

7.1 Determination of SOC:

The Organic Carbon content in the soil was found varying in the ranges as low as 57.77 Mg/Ha in the month of January in for a sample to as high as 185.75 Mg/Ha in the month of April for both of the wetlands.

Table 7.1 Monthly variation of SOC in Harike and Kanjli wetland (in Mg/Ha).

Month	**Harike**		**Kanjli**	
	Sample	Control	Sample	Control
January	57.8	48.50	57.77	40.5
February	93.4	72.50	71.25	45.25
March	99.32	84.25	97.5	52.00
April	107.75	90.00	185.75	65.5

There is a gradual increase in the SOC content over the months. This may happen due to the organic and decaying matter present or accumulated over the months. The total change in carbon stored in Harike wetland is 49.95 Mg/Ha. from the month of January to April. The total change in carbon stored in Kanjli wetland is 127.98 Mg/Ha.

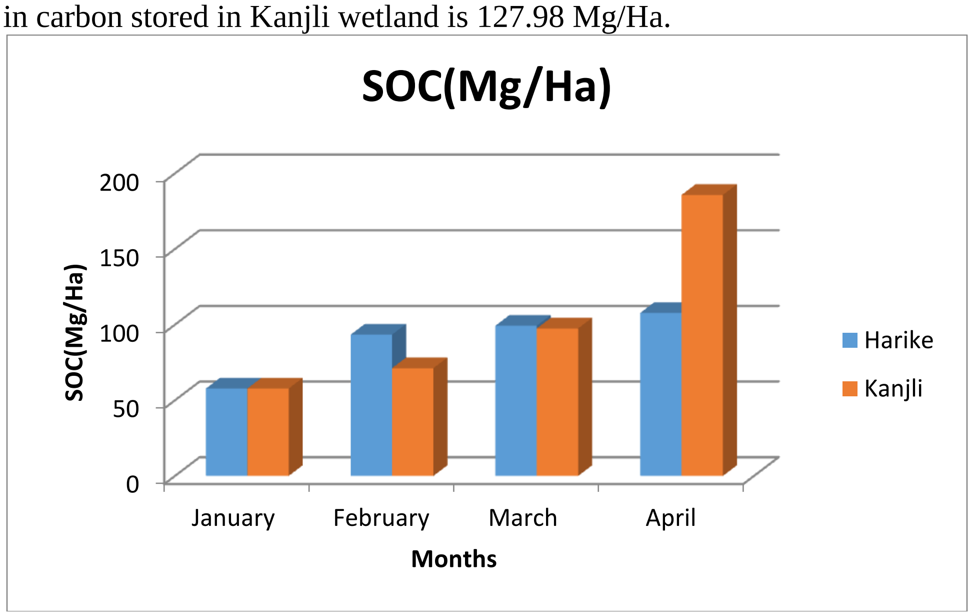

Figure 7.1 Comparative Monthly variation of SOC in Kanjli and Harike wetland.

It can be seen in Table 7.1 that there is significant difference between the SOC in the control and the samples taken from the sites in both of the wetlands. Also, there is a gradual increase (Figure 7.1) in the SOC monthly. As our study is time limited, we cannot give conclusions on the long term effects and trends.

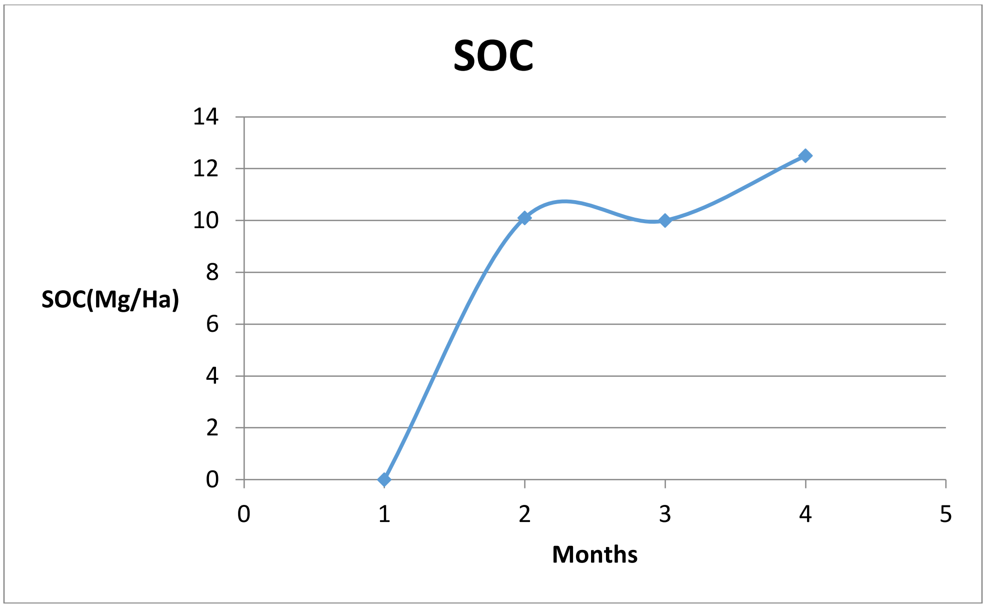

Figure 7.2 Monthly variation of SOC in Harike wetland.

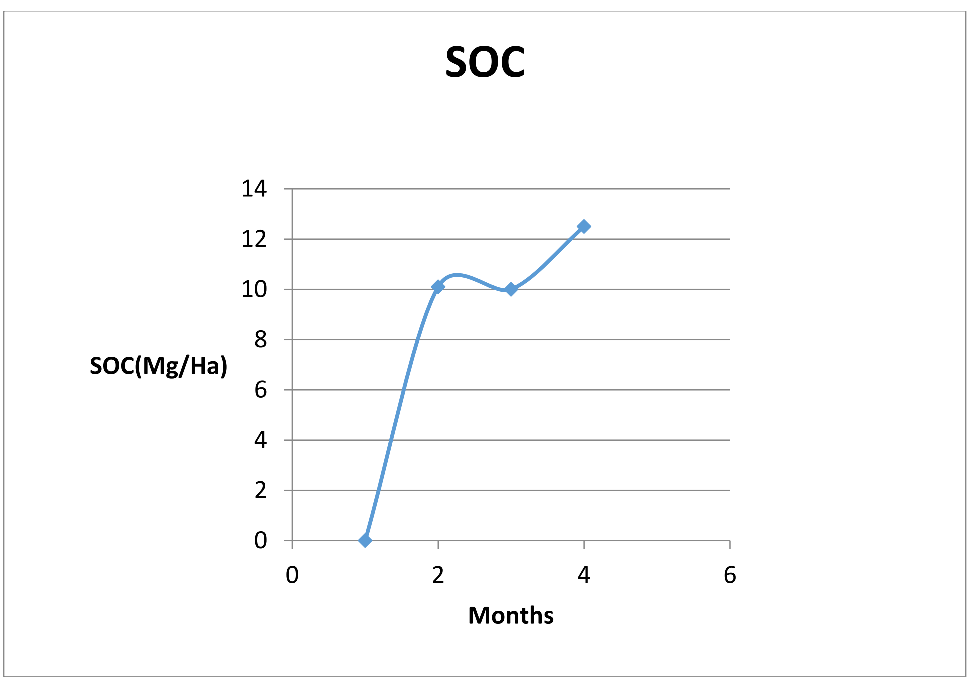

Figure 7.3 Monthly variation of SOC in Kanjli wetland.

7.2 Determination of Plant Biomass:

Plant Biomass is estimated and calculated and the allometric equations are generated using MS Excel 07. The equations are generated to establish a relationship between calculated and estimated values of biomass. Shoot height and dry mass co-relationships are also generated to calibrate the values.

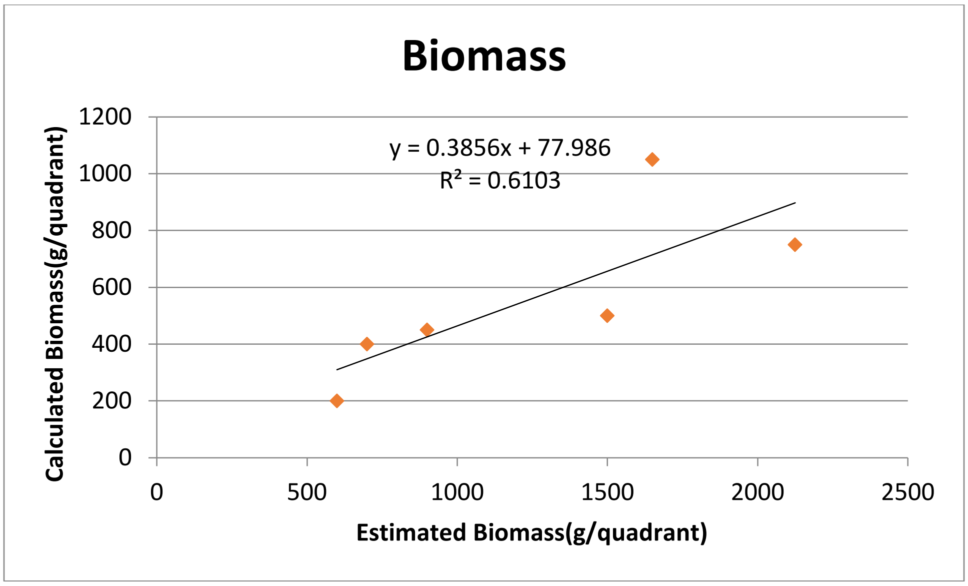

Figure 7.4 Estimated vs. Calculated Biomass (g/quadrant) for Kanjli wetland.

The equations generated here follow the same as it was in Whitaker (2013).

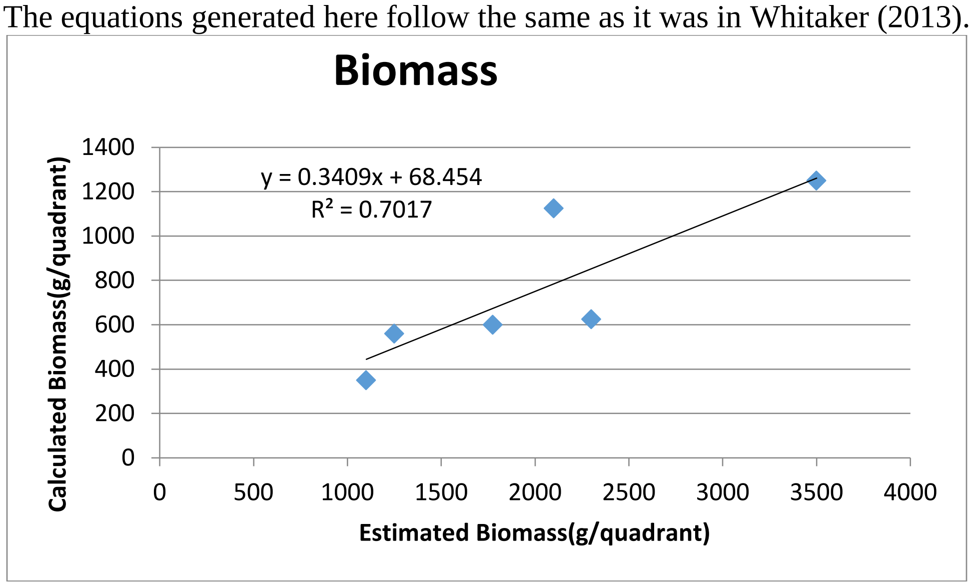

Figure 7.5 Estimated vs. Calculated Biomass (g/quadrant) for Harike wetland.

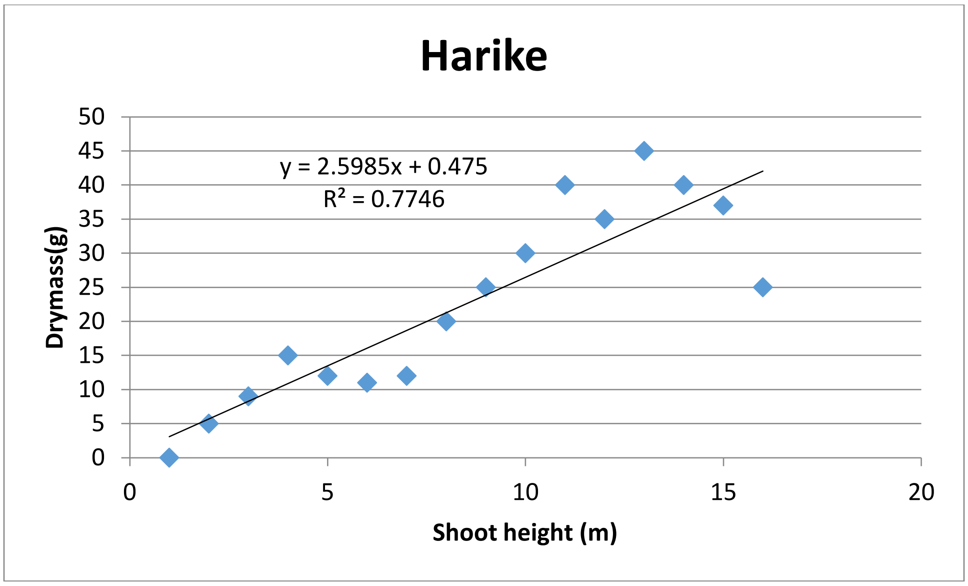

Figure 7.6 Shoot height (m) vs. drymass (g) relationship (Harike wetland)

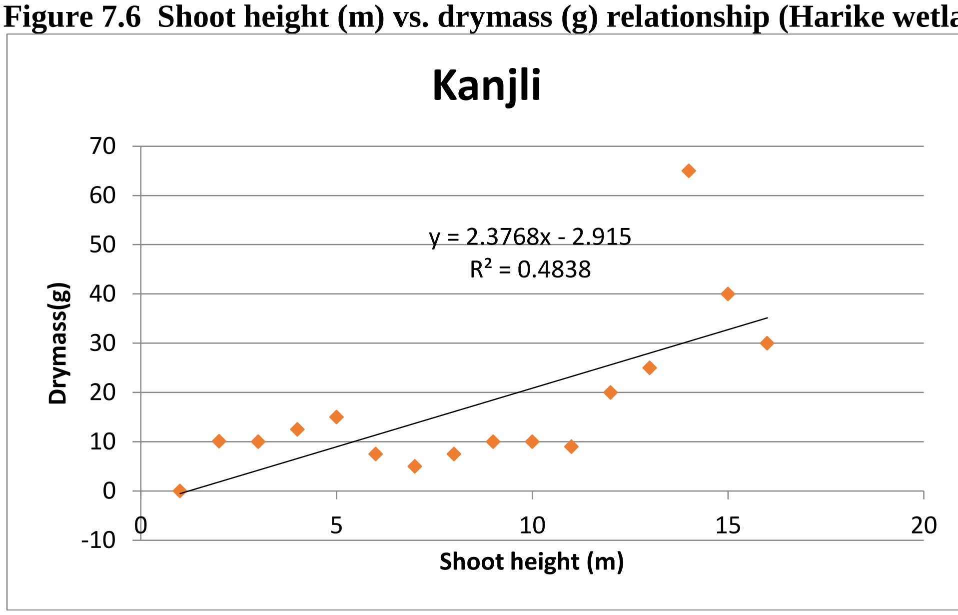

Figure 7.7 shoot height (m) vs. drymass (g) relationship (Kanjli wetland)

The calculated biomass was found varying each month, lowest being in the month of January in Kanjli wetland and highest being in month of February for Harike wetland. The plant biomass was comparatively higher in case of Harike than in Kanjli wetland.

Table 7.2 Comparative Monthly variation of biomass in Kanjli and Harike wetland.

Month	Calculated Biomass in Kanjli (Mg/Ha)	Calculated Biomass in Harike (Mg/Ha)
January	1.024	2.672
February	1.621	2.975
March	2.101	1.474
April	1.848	2.171

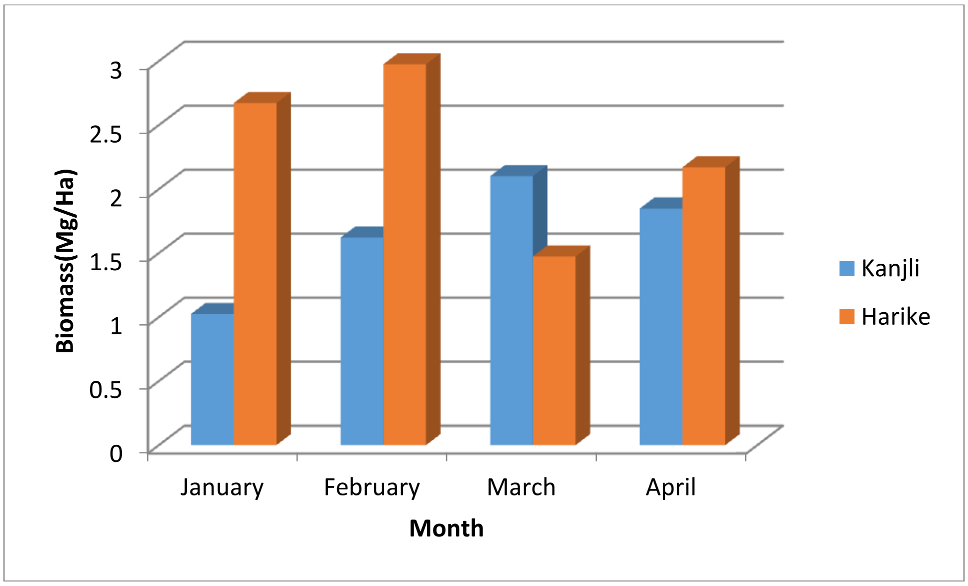

Figure 7.8 Comparative Monthly variation of biomass in Kanjli and Harike wetland.

7.3Determination of Plant Carbon:

50% of the total plant biomass contributes towards the plant carbon. Plant carbon also contributes towards the total carbon stored in the wetland area.

Table 7.3 Comparison of Plant carbon of Kanjli and Harike wetland

Month	Plant Carbon (Kanjli) in Mg/Ha	Plant Carbon (Harike) in Mg/Ha
January	0.512	1.336
February	0.811	1.488
March	1.051	0.874
April	0.924	1.086

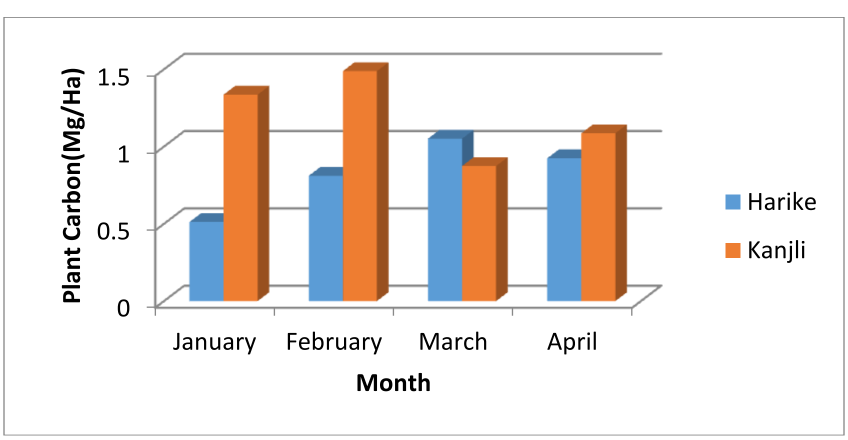

Figure:7.9 Comparison of Plant carbon of Kanjli and Harike wetland

7.5 Testing of water samples:

The water samples collected from both of the sites were analyzed in the laboratory set up at Department of Civil Engineering, Lovely Professional University. The analyzed samples showed variable results depicted in Table 1 and 2.

Table 7.4 Monthly variations of various physico-chemical characteristics of water of Kanjli wetland.

	January	February	March	April	
pH	7	7.3	7.8	8.2	
Turbidity	64	63	69	71	NTU
DO	4.9	5.2	7.1	6.1	mg/l
Hardness	114	116	137	116	mg/l
Conductivity	180	250	170	214	Mohs/cm
Alkalinity	238	124	127	138	mg/l
Sulphates	8.5	11.7	14	15	mg/l
Nitrates	207	305	402	180	µ/l

It can be seen that pH is highest towards April being 8.2 while as lowest in January i.e., 7.0. Similar trend is followed in Harike. pH is gradually increasing from the month of January to April.

Similar trend is followed for DO in the water of both of wetlands. These trends are followed with almost all the parameters. This may happen due to the increasing anthropogenic activities towards the month of April.

Table 7.5 Monthly variations of various physico-chemical characteristics of water of Kanjli wetland.

	January	February	March	April	
pH	7.4	7.2	8.3	7.8	
Turbidity	84	87	62	78	NTU
DO	7.3	5.4	4.8	6.8	mg/l
Hardness	142	161	158	210	mg/l
Conductivity	370	420	320	250	Mohs/cm
Alkalinity	270	230	180	210	mg/l
Sulphates	14.2	10.5	11.2	7.5	mg/l
Nitrates	305.5	307	607	205	µ/l

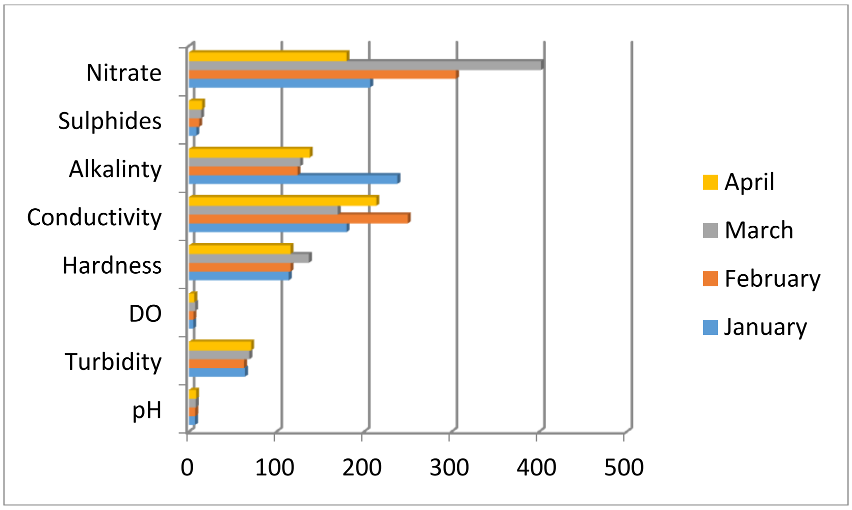

Figure 7.10 Monthly variations of various physico-chemical characteristics of water of Kanjli wetland.

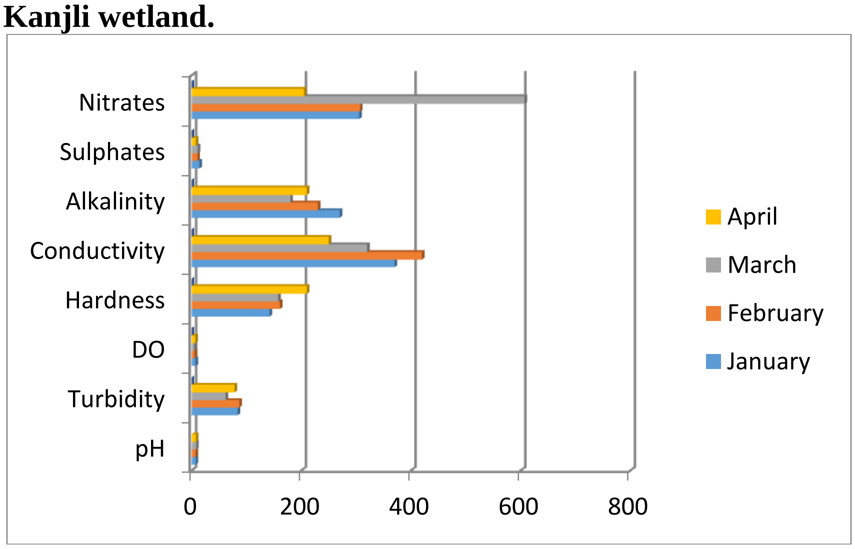

Figure 7.11 Monthly variations of various physico-chemical characteristics of water of Harike wetland

CHAPTER 8
CONCLUSION AND FUTURE SCOPE

Conclusion:

The total carbon content in wetland is contributed mainly by the SOC and the plant biomass. The SOCD is significantly high in both of the wetlands when compared with the control samples taken outside the catchment of the wetlands. The total carbon sequestered in the wetlands is a effective strategy to mitigate the climate as storage of carbon reduces the emission of GHG's like CO_2 and CO to the atmosphere. Though, our work is time limited we can't conclude the long term effects but there is significant potential of long term storage of carbon in the wetlands as concluded in most of the literature.

The physico chemical characteristics are degraded when compared to previous data. There is a significant change in the characteristics of the water of both of the wetlands.

Future Scope:

- Long term effects and the CSP can be studied for various wetlands.
- The CSP of various individual species can be studied.
- A framework for the constructed wetlands can be provided to help in climate mitigation in cities and towns.
- Various different components in the wetlands that can act as pools for carbon can be considered and in depth analysis can be done.

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APPENDIX

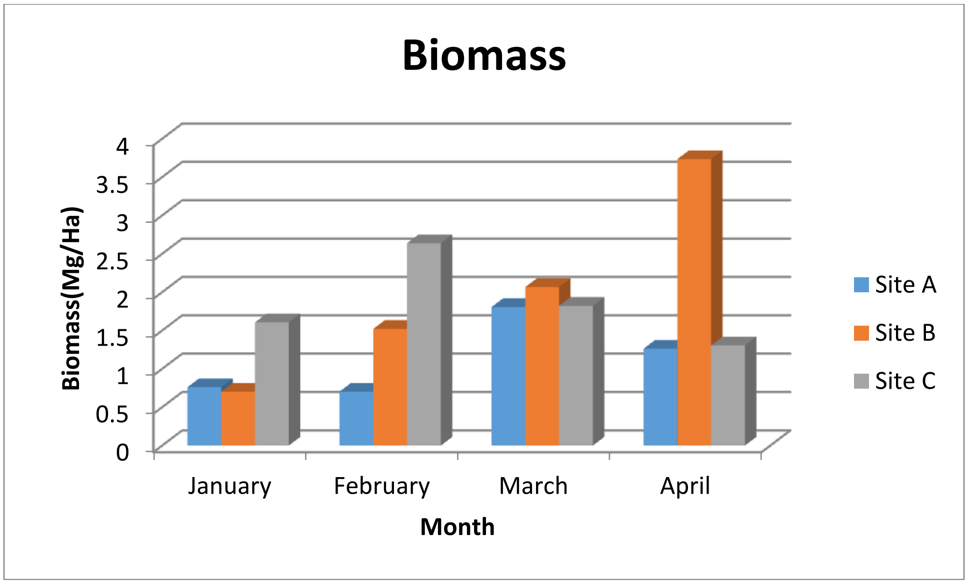

Figure 1. Monthly variation of biomass in Kanjli wetland in various sites.

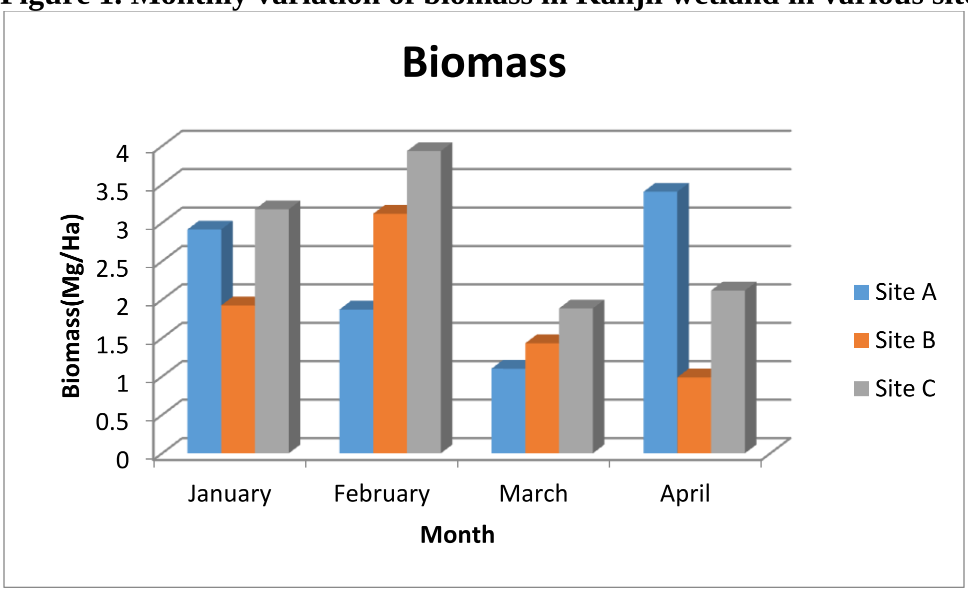

Figure 2. Monthly variation of biomass in Harike wetland in various sites.

Table 1. Monthly variation of Biomass in Kanjli wetland.

Month	Estimated Biomass (Mg/Ha)	Calculated Biomass (Mg/Ha)
January	3.455	1.024
February	4.269	1.621
March	3.856	2.101
April	4.877	1.848

Table 2. Monthly variation of Biomass in Harike wetland.

Month	Estimated Biomass (Mg/Ha)	Calculated Biomass (Mg/Ha)
January	5.299	2.672
February	6.430	2.975
March	7.999	1.474
April	6.372	2.171