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Research Article

Inventory of Watershed Area of the Halda River Basin for Ecosystem Health Management

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Abstract

Background and Objective: Watershed is an area of land that comprises a set of watercourses and rivers that all drain into a single larger water body (River). Watersheds are important since the surface water and storm water runoff within a watershed eventually drain to other bodies of water. During increasing and executing water quality protection and restoration actions, it is needed to consider these downstream impacts. The present study was conducted to explore the available major water sources of the Halda river.

Materials and Methods: Data were collected through extensive field survey and structured questionnaire survey from November, 2011-September, 2012. Data were analyzed by one-way analysis of variance (ANOVA) using SPSS. **Results:** A total of 34 watersheds of the Halda river were recorded. Out of them major seven watershed areas namely: Manikchari Khal, Dhurang Khal, Sattar Khal, Fatikchari Khal, Harualchari Khal, Baromasi Khal, Mondakini Khal were selected for the study. The mean width of the above mentioned Khals were 33.75, 37, 51.5, 19.5, 15, 12.5 and 19 m, respectively. The mean depth of these khals were 5.75, 8.5, 10.5, 5.5, 7, 4 and 6 m, respectively and the approximate length of these khals were about 25, 56, 45, 28, 19, 17 and 18 km, respectively. Noteworthy difference was found among the watersheds in terms of mean depth, mean width and mean length ($p < 0.05$). **Conclusion:** Discharged water of the watershed directly covers a large area through different khals of the river, indispensable resource for aquatic organisms and human being. Therefore, it is essential to conserve these watershed areas from haphazard pollution for sustainable ecosystem health management and meaningful development of the country.

Key words: Inventory, watersheds, khals, ecosystem, health management

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Halda river, the major rivers in the South-east region of Bangladesh and the only pure Indian major carp breeding ground of Bangladesh, probably in South Asia¹. This river is considered one of the most important rivers for the fishing industry because it is abundant with fertilized carp (a type of freshwater fish including popular species like rohu, katla and mrigal) and other types of fish eggs². The environment was suitable for the brood (egg-laying) fish that migrate to this part of the Halda for the purpose of spawning in the months of April and May from the Karnaphuli, Matamuhuri and Shangu rivers¹.

Watershed, an area of land that captures rain and snow, and then stores, filters, seeps or drains this water into a common water body, such as a river or lake. The term watershed was used interchangeably with drainage basin or catchments with complex interacting natural components. Human activities (ox-bow cutting, massive excavation of sands from river bed illegally by a section of deceitful traders, pollution of the river by industrial waste, unplanned construction of a good number of sluice gates by the locals for irrigation purpose, indiscriminate catching and killing of the brood fishes and climate change in the river) have a direct influence on the quality and quantity of surface water, ground water and other natural resources in the watersheds³. Terrestrial activities influence river currents and downstream water quality. Both surface and ground water systems have a limited tolerance for stress and long-term problems can develop that were costly and difficult to remediate².

Water capture, storage and release are three processes within a watershed that can protect water quality⁴. Slowing the movement of air, shading the soil and reducing temperatures can help to conserve moisture that lessen evaporation at the soil surface considered as management practices⁴.

Surface water layers were decreasing due to excess use in irrigation systems in the country. Streams are one of the most important water sources of the Halda watersheds. These watershed were mostly important to local people for drinking, washing, bathing, irrigation, domestic, cattle house, fisheries, river transportation and so on¹. The surface flow in streams was adequate to the requirements during the season. Lake is the sources of water in the Halda watershed¹. This study will provide baseline information on the watershed status of the Halda river for further studies. The knowledge acquired will be useful in the management of these important ecosystem and natural resources of the floodplain for the survival and

continued economic benefits to the community. Kibria¹ reported that, inventory of watersheds were important to save the Halda river from extinction. The present study was conducted to identify the origin and source of water of different watershed areas of the Halda river with effective management strategies for sustainable ecosystem health management.

MATERIALS AND METHODS

Sampling site: The present research was carried out from November, 2011-September, 2012 in the Halda river (22°28'56.09"N and 91°54'07.62"E). The main sources of water of the Halda river are Manikchari Khal (22°50'56.30"N and 91°50'28.10"E), Dhurang Khal (22°41'38.81"N and 91°47'26.83"E), Sattar Khal (22°31'10.77"N and 91°50'56.91"E), Fatikchari Khal (22°43'42.81"N and 91°44'39.16"E), Harualchari Khal (22°42'04.47"N and 91°44'39.16"E), Baromasi Khal (22°40'32.8"N and 91°45'35.37"E), Mondakini Khal (22°38'17.26"N and 91°47'17.15"E) (Fig. 1).

Field survey: Prior to study a detail structured field survey was conducted in order to collect primary data. Structured questionnaire used find out the recommendation to conserve the Halda river. During field survey a GPS (global positioning system) and google earth software were utilized to find out geographical coordinates in different watershed area.

Data collection: Through direct observation, primary data were collected from different stations by using tape and scaled bamboo. Data were also collected from stakeholders. Basic data regarding the watershed area were collected following by the procedure of Bala and Mukherjee⁵. An information collection sheet developed by Bala and Mukherjee⁵ was used to collect data from the field. The depth, width, length of different watershed of the Halda river was measured.

Data analysis: To show the differences among the watersheds one-way analysis of variance (ANOVA) was used by using (SPSS v.22) with significance difference of $p < 0.05$. Dendrogram was created to show the percentage of similarity among the watersheds using (PRIMER v.6). Tabular and graphical presentation of data by using MS Office software.

RESULTS

The Halda river is a tributary of the Karnafully river near the Chittagong city. Halda starts from the hilly area North

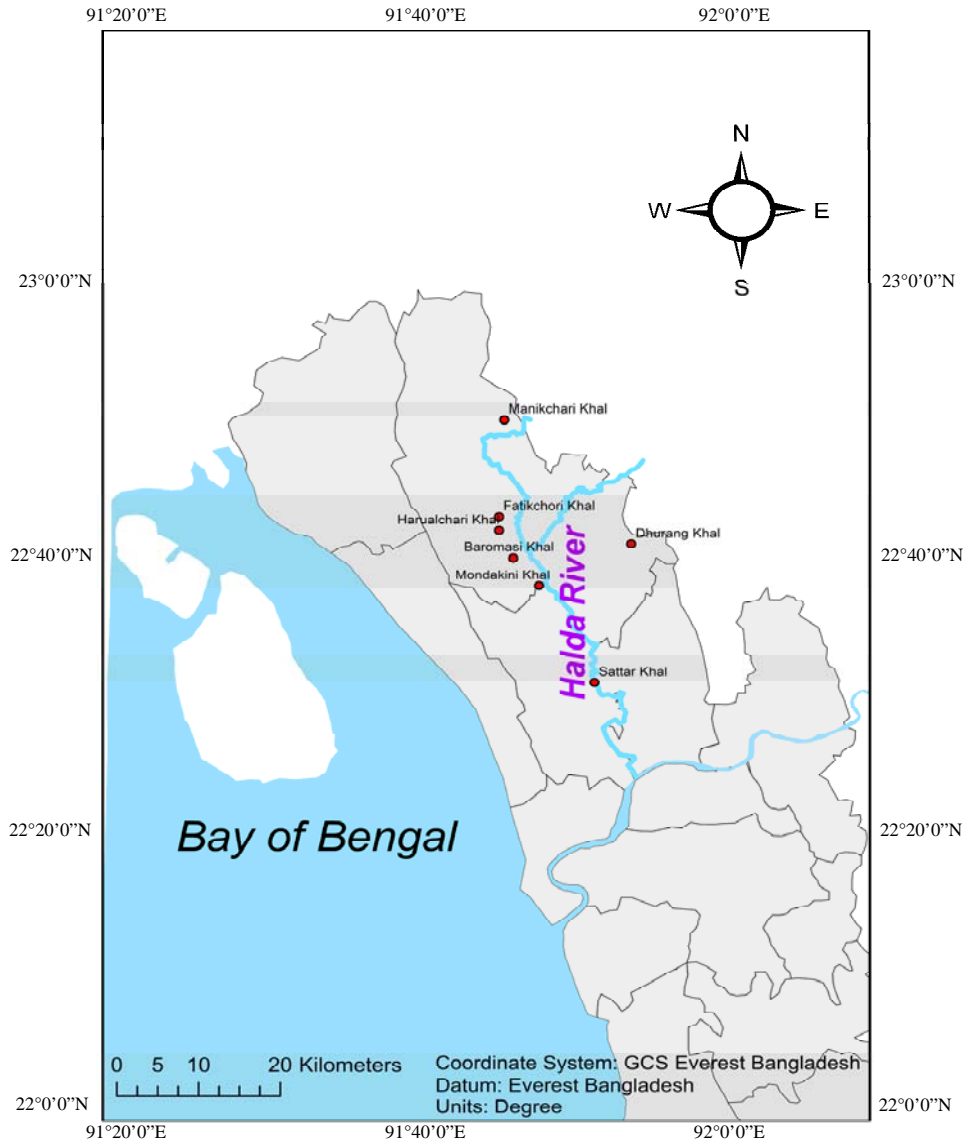


Fig. 1: Map showing the sampling sites of the Halda river (Map created by ArcGIS v.10.3)

Chittagong of Bangladesh and flows into the Karnafully river which carrying huge amount of runoff from the different catchments and tributaries. There were so many tributaries and streams that fall into the Halda and discharge the local runoff. The tidal water could reach up to few km interiors through the Karnafully river tidal action. Halda river has 34 watersheds. Among them seven major watersheds were selected through direct observation as major watershed which directly discharges water to the Halda river. Significant variation was found among the watersheds in terms of mean depth, mean width and mean length ($p < 0.05$).

Manikchari Khal lies from Ramghar hill region to Manikchari through Manikchari union and mixes with Halda. The approximate length of Manikchari Khal is 25 km (Table 1).

Width is about 30-37.5 m and depth is about 4-7.5 m during non-flooding and flooding condition, respectively. Run off from Ramghar hilly region is main source of water of Manikchari Khal (Table 2).

Dhurang Khal lies from Manikchari to Dhurang Union through Manikchari, Laxmichori, Fatikchari and mixes with Halda near Dhurang union. The approximate length of Dhurang Khal is 56 km. Wide is about 30-44 m and depth is about 7-10 m during non-flooding and flooding condition, respectively (Table 1). Run off water from Ramghar hilly region is main source of water of Dhurang Khal (Table 2). Cluster analysis showed the percentage of similarity among different watershed areas of the Halda river basin that was prepared on the basis of mean width, depth and length (Fig. 2).

Table 1: Depth, width and length of the major watershed of the Halda river

Name	Location	Mean width (m)	Mean depth (m)	Mean length (km)
Manikchari Khal	Amtola	33.75	5.75	25
Dhurang Khal	Fatikchori	37.0	8.5	56
Sattar Khal	Ghorira	51.5	10.5	45
Fatikchori Khal	Fatikchori	19.5	5.5	28
Harualchari Khal	Harualchari	15.0	7.0	19
Baromasi Khal	Baromasi	12.5	4.0	17
Mondakini Khal	Suabil	19.0	6.0	18

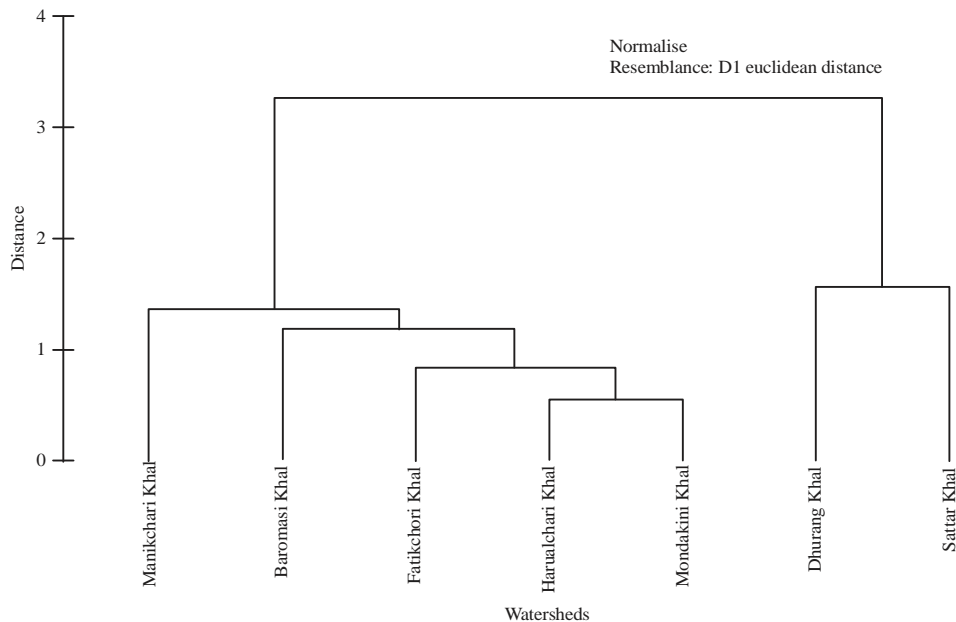


Fig. 2: Cluster analysis showing the percentage of similarity among different watershed areas of the Halda river basin that was prepared on the basis of mean width, depth and length

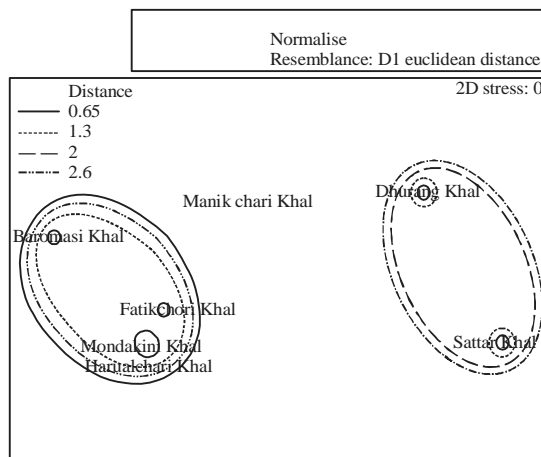


Fig. 3: Dendrogram showing the percentage of similarity among different watershed areas of the Halda river basin that was prepared on the basis of mean width, depth and length

Sattar Khal lies from Kawkhali hill region to Ghohira. Through Kawkhali and Raozan Upazilla and mixes with Halda river near Ghohira. The approximate length of Sattar Khal is 45 km (Table 1). Width is about 47-56 m and depth is about 9-12 m during non-flooding and flooding condition respectively. Run off from Kawkhali hill region is main source of water of Sattar Khal (Table 2). Dendrogram showing the percentage of similarity among different watershed areas of the Halda river basin that was prepared on the basis of mean width, depth and length (Fig. 3).

Fatikchari Khal lies from Fatikchari to Harualchari Union. Through Harualchari Union and mixes with Halda near Harualchari Union. The approximate length of Fatikchari Khal is 28 km. Width is about 18-21 m and depth is about 4-7 m during non-flooding and flooding condition, respectively (Table 1). Run off water from Fatikchari hill region is main source of water of Fatikchari Khal (Table 2).

Mondhakini Khal lies from Udalia hill region to Nazirhat through Suabil and Farhadabad Union and mix with Halda

Table 2: Source of major watersheds of the Halda river

Name	Water source	Upazilla	Starting place	End place	Pass through	Length km	Mix with
Manikchari Khal	Run off from Ramghar hilly region	Manikchari	Ramghar hill region	Manikchari	Manikchari	25	Halda river
Dhurang Khal	Run off from Ramghar hilly region	Manikchari and Fakickchari	Manikchari	Dhurang	Manikchari, Laxmichori, Fatikchari	56	Halda river
Sattar Khal	Run off from Kawkhali hilly region	Kawkhali	Kawkhali hill region	Ghoria	KawkhaliRaozan	45	Halda river
Fatikchari Khal	Run off from Fatikchari hilly region	Fatikchari	Fatikchari	Harualchari	Harualchari	28	Halda river
Haruachari Khal	Run off from Fatikchari hilly region	Fatikchari	Fatikchari	Harualchari	Harualchari	19	Halda river
Baromasi Khal	Run off from Baromasi hilly region	Fatikchari	Baromasi hill region	Baromasi	Baromasi	17	Halda river
Mondakini Khal	Run off from Udalia hilly region	Hathazari	Udalia hill region	Nazirhat	Suabil and Farhadabad	18	Halda river

near Nazirhat. The approximate length of Mondhakini Khal is 18 km (Table 1). Width is about 17-21 m and depth is about 4.5-7.5 m during non-flooding and flooding condition, respectively. Run off from Udalia hill region is main source of water of Mondhakini Khal (Table 2).

Baromasi Khal lies from Baromasi hill range to Baromasi, through Baromasi and mixes with Halda near Baydear hat. The approximate length of Baromasi Khal is 17 km. Width is about 11-14 m and depth is about 3-5 m during non-flooding and flooding condition respectively (Table 1). Run off water from Baromasi hill region is main source of water of Baromasi Khal (Table 2).

Harualchari Khal lies from Fatikchari to Harualchari Union. Through Harualchari Union mixes with Halda near Harualchari Union. The approximate length of Haruachari Khal is 19 km. Width is about 14-16 m and depth is about 5.5-8.5 m during non-flooding and flooding condition respectively (Table 1). Run off from Fatikchari hill region is main source of water of Fatikchari Khal (Table 2).

DISCUSSION

Watersheds were a dynamic part of the any hydrological cycle. Surface and ground water resources were tied directly to all watersheds. There were also diverse and dynamic ecosystems that rely on the continuity of a watershed to survive⁶. Anything that can be picked up with rainfall runoff or any other drainage can end up in the watershed. The area of watershed was also known as the drainage area and it was the most important watershed characteristic for hydrologic analysis⁷. It reflects the volume of water that can be generated from a rainfall. A watershed was a reservoir of natural water. Watershed always retain, store and discharge water to adjacent river system⁸. So watershed was a basic need of a river ecosystem⁹. All lands on the surface of the earth were in a watershed. Bangladesh Country's land area consists of portions of numerals watersheds that ultimately drain to the Bay of Bengal.

There were so many tributaries and streams that fall into Halda and discharge the local runoff. The tidal water can reach up to few km interiors through the Karnafully river tidal action. In the present study, 7 major watersheds were identified as major source of water of the Halda river from 34 watersheds. This was similar as Kibria¹ that a total number of 34 canals and five main canals/Tributaries of the Halda river. Islam¹⁰ found six tributaries, nine canals and four streams of the Halda river. The total calculated river and stream area were 192 hectares. Aktar¹¹ found a total 30 sub watershed which was discharging their run off in the Halda river.

All the watersheds are directly fall in the Halda river. Streams, lakes and water bodies of different hilly areas of the Halda river were linked with these tributaries and canals. As a result a lot of nutrients fall into the Halda river. As a results these tributaries and canals creates a favorable condition for the breeding of carp fishes. Those watersheds maintain water flow and environment needed for the breeding of carp fishes of the Halda river. Four streams were found in the study area. Run off of these areas coming from the streams helps to maintain the healthy ecosystem of the Halda river.

There remain no doubt that if the watershed of the Halda river and the source of water was not restored, the natural ecosystem of the Halda river will be lost. As a result, not only the spawn fishery in the Halda river will be lost, but also the carp stocks in many drainages of the Bay of Bengal which are maintained by the recruitment of carp juveniles spawned from the Halda river will be destroyed.

So, it was crying need to discover and conserve watersheds for a sustainable ecosystem health management.

CONCLUSION AND FUTURE RECOMMENDATIONS

A tidal river, the Halda is gifted with splendid fisheries resources, known as gene Bank of carp fishes in the country. A monitoring program needed to save this indigenous derivative river for the national interest. For this major watershed of the Halda river should be conserved. Excess utilization of land and resources through modern cultivation system and engineered water networking structures in this watershed may make the Halda river under risk. Sluice gate and cutting of oxbow-bend (lake) is most important risky factor of river runoff and water resources. Excessive sediment deposition occurs due to the cutting oxbow-bends, is the main cause of river bed rising and river bed rise is resulting in the increase flood. To ensure the natural condition of the Halda river, need to identify major watershed of the Halda river. To save those watersheds need to explore suitable watershed management strategies for sustainable environmental management of the Halda river.

Sustainable use and protection of the aquatic biodiversity and resources of the Halda river for future generations at the following area of the Halda river following recommendation will contribute a lot.

- Since the Halda river receives water and nutrients from the tributaries, canal, rainfall, there is a need to synchronizing the hydrological changes to the nutrient, primary production and phytoplankton changes over the yearly basis at the Halda river

- There is a need for intensifying the recording of physical parameter such as water levels and wind speed and direction as they do have a significant impact of the nutrient levels and productivity of the Halda river
- In order to have a clear understanding of nutrient dynamics at the Halda river, nutrient budget and sediment analysis study should be done. The same study should be done at the main rivers too, so that contribution of river to the ecosystem can be assessed. A continuous record should be done so as to get the trend and pattern of changes in physico-chemical characteristic and phytoplankton primary production
- Different man-made and natural disasters like destruction of spawning ground by ox-bow cutting, massive quarry of sands from river bed illegally by a section of unscrupulous traders, pollution of the river by industrial waste, unplanned construction of a good number of sluice gates by the locals for irrigation purpose, indiscriminate catching and killing of the brood fishes and climate change in the river have posed a serious threat to the biodiversity of the Halda. Due to these risk factors, the river that was once a heaven for brood fishes for releasing their eggs has now turned into a quite dangerous one, resulting in drastic fall in the availability of eggs and fish-fries of natural species as lesser number of brood fishes have come here for releasing eggs in the recent years. So it is urgent to invent the watershed area of the Halda river basin and take necessity steps to save river from extinction

SIGNIFICANCE STATEMENTS

This research prepared a preliminary baseline data on the Halda river watersheds. This research data will provide helpful resources for the researchers, academicians and policy makers to conserve the watershed area of the Halda river that other researchers were not capable to explore. Thus a new era will open in the research of the Halda river (natural breeding ground of Bangladesh).

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