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The use of remote sensing techniques to measure the surface temperature of the Halda River

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Abstract
A surface temperature is one of the important physical factors of water body having an impact on metabolic rate and biological activity of aquatic organism. This physical property can also affect the other physical and chemical parameters (pH, salinity, density, toxicity, photosynthesis rate, dissolved oxygen etc.) of water body. The study is about using remote sensing techniques to assess the surface temperature in Halda River, the third major river in Chittagong region and an ecologically sensitive spawning bed for Indian major carp community. Here, March months of Seven years with an interval of 5 years - 1990; 1995; 2000; 2006; 2010; 2015 and 2020 - are selected to calculate surface temperature by these techniques. The thermal band 6 of satellite imagery collected by 'Landsat 5' and 'Landsat 7 ETM +' satellite are interpreted with the help of USGS website and ArcGIS 10.4 software. Following several equations and using data from those imageries, the respective average temperature of those seven years (March) are 21.6 ºC, 15.7 ºC, 19.5 ºC, 24.5 ºC, 27.3 ºC, 23.4 ºC and 26.9 ºC. And total average surface temperature of March months of all 7 years is 22.7 ºC by which we are informed about the temperature condition of this river easily and correctly. So, these modern applications might be an effective way to have a regular monitor on this vital physical factor which will help to ensure a proper management for not changing the aquatic life's habitat and would be a useful medium for other hydrological study about this river.

Keywords: Halda River, water temperature, thermal band 6 of satellite imagery of Landsat 5 and 7, ArcGIS 10.4 software

Introduction
Global warming - an environmental related alarming and major issue over the world (Weart, 2003; Houghton, 2005) [16, 6] - results from greenhouse gases (GHGs) mainly CO_2 emission day by day for combustion of fuel and deforestation and results in higher atmosphere temperature. Finally, the surface water temperature rises for the higher atmosphere temperature. Because of the today's surface water temperature upward movement, there have been both a direct impact and an indirect impact on fish community. As a direct impact, the abnormalities on fish physiology appear– growth rate, development, ovulation, spawning behavior and eggs maturation are being hampered (Brander, 2007) [4]. And as an indirect effect, the water body ecosystem is being changed– migration of predators, harboring of pathogen, spoiling of water quality etc. are the consequence of this degraded ecosystem.
Halda is the third major river of Chittagong (Kabir *et al*., 2014) [9], playing a pivotal roles on this region. The 98 km long and average 6.4m deep river starts from the Badantali hill ranges of Chittagong hill tracts in Ramgarh Upzilla, Khagrachari district, and it flows through Fatikchari, Hathazari and Raozan upazilas in where finally the river joins the karnaphuli river at Kalurghat region, about 40 km away from Bay of Bengal (Akter and Ali, 2012) [1] and gets the water flow form 17 hilly fountains (The daily strar, 2014) [13]. It is the only and one natural breeding ground (Kibra *et al*., 2009) [10] for fertilized eggs collection of pure Indian major carp: Rohu (*Labeo rohita*), Catla (*Labeo catla*), Mrigala (*Cirrhinus mrigala*), *Kalibaus* (*Labeo calbasu*) in Bangladesh and probably in south Asia (Simon *et al.*, 2016) [12]. The spawning behavior naturally makes this tidal river a unique heritage for this country (Tsai *et al*., 1981) [15]. Around 1100 egg collectors and 2000 fishermen rely on this river directly for their lives (Islam, 2009) [8]. During April to June (Azadi *et al*., 2004) [3], the fishing community collect the fertilized eggs (Patra *et al*., 1985) [11] and cultivate the fries from the eggs that will be supplied for whole country's carp culture (Ali *et al*., 2010) [2].

As the optimum temperature of water body has a positive influence on the fish growth and survival rate (Brett, 1979), and the fewer degree change of temperature affects the physical and chemical environment of water body (Relyea, 2002), so it is crucial to measure the water temperature regularly for hydrological research for which the remote sensing techniques could be an effective way.

In these techniques, the digital images of band 6 from the station of Landsat 5 and Landsat 7 satellite can be used (USGS). Here, Landsat 5 satellite has two types of sensor in where one type is the thematic mapper sensor (TM) used for recording the reflected electromagnetic radiation. The spectral band 6 (10.40-12.50 µm) with a spatial resolution of 120 meter of this sensor is the thermal infrared band (USGS). Landsat 7 has Enhanced Thematic Mapper Plus sensor. Band 6 (10.40-12.50 µm) with a spatial resolution of 60m is used as a thermal band. The thematic mapper sensor is designed to gain the temperature data in different ranges of frequencies along the electromagnetic spectrum (USGS) where the reflected radiations from earth surface were converted into digital image by the station.

Trisakti *et al*., 2004 [14] said that information regarding sea surface temperature (SST) by the analysis of Landsat satellite digital imageries can be used to estimate the water body phenomenon. So by using data from the those digital images and with the application of remote sensing techniques, the study shows the calculation of surface temperature (March of selected 7 years) of Halda River.

Hopefully, this study will make the related research sector inspired to have a frequent check on the water temperature condition by using these modern techniques and concerned about taking the scientific steps to protect this natural spawning ground.

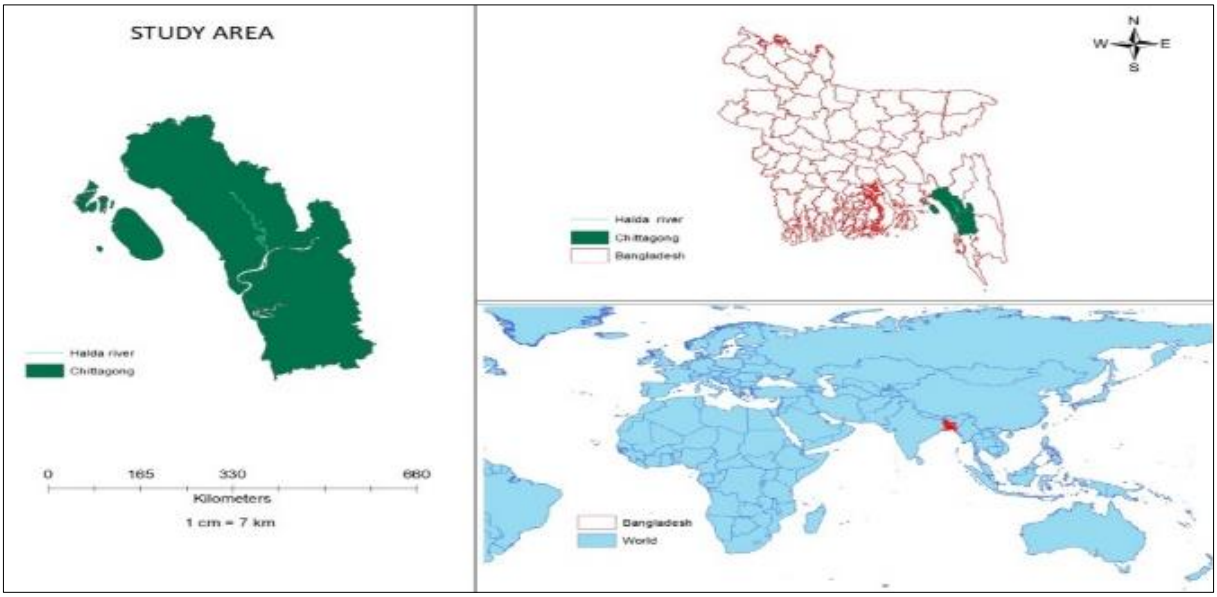


Fig 1: Location of the Halda River in Map

Method

Study area

Halda is the South - Eastern river of Bangladesh that lies within longitude 91º 48′- 91 º 54′E and latitude to 22 º 24′- 22 º 54′N. To assess the surface water temperature, 3 spots were selected as a source of water sample based on the sample accessibility to this river.

Table 1: Sampling stations

Sampling Station	Longitude	Latitude
1.North Mohara	91° 53′ 20′′ E	22° 25′ 47′′ N
2.North Madarsha	91° 51′ 45′′ E	22° 28′ 12′′ N
3.Garduara	91° 52′ 25′′ E	22° 29′ 53′′ N

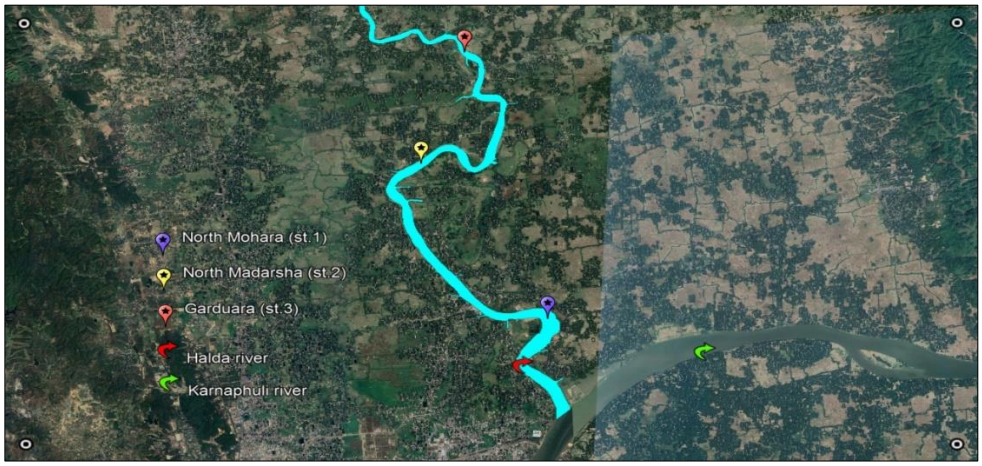


Fig 2: Sampling stations of the study area

Data collection

With the help of USGS, the satellite image of the sampling spots was downloaded. Thermal Band 6 of Landsat 5 and Landsat 7 ETM + digital imagery was selected as a layer in ArcGIS 10.4 apps. From the imaging data, the temperature of the sampling spot was calculated using "Raster Calculator" and following several equations. After the calculation, there had been total 21 temperature data from the three sampling spots by following the March month of seven years – 1990, 1995, 2000, 2006, 2010, 2015 and 2020.

Table 2: Data of March, 1990 and 1995

Data No	Sampling station	Type
1	North Mohara	Landsat 5
2	North Madarsha	Landsat 5
3	Garduara	Landsat 5

Table 3: Data of March, 2000, 2006, 2010, 2015 and 2020.

Data No	Sampling station	Type
4	North Mohara	Landsat 7
5	North Madarsha	Landsat 7
6	Garduara	Landsat 7

Calculation

Equation 1

$L\lambda = (LMAX\lambda - LMIN\lambda)/(QCALMAX - QCALMIN)\times(QCAL - QCALMIN) + LMIN\lambda$

Here,

$L\lambda$: Spectral radiance watts/(meter squared*ster*µm).

$LMIN\lambda$: Spectral radiance that is scaled to QCALMIN.

$LMAX\lambda$: Spectral radiance that is scaled to QCALMAX.

QCAL: Quantized calibrated pixel value in digital number.

QCALMIN: Minimum quantized calibrated pixel value.

QCALMAX: Maximum quantized calibrated pixel value.

Equation 2

$TLandsat = K2 /\ln((K1/ L\lambda)+1) - 273.$

Here,

TLandsat Effective temperature (ºC)

K1: Calibration constant 1 watts/ (meter squared*ster *µm).

K2: Calibration constant 2 watts/(meter squared*ster*µm).

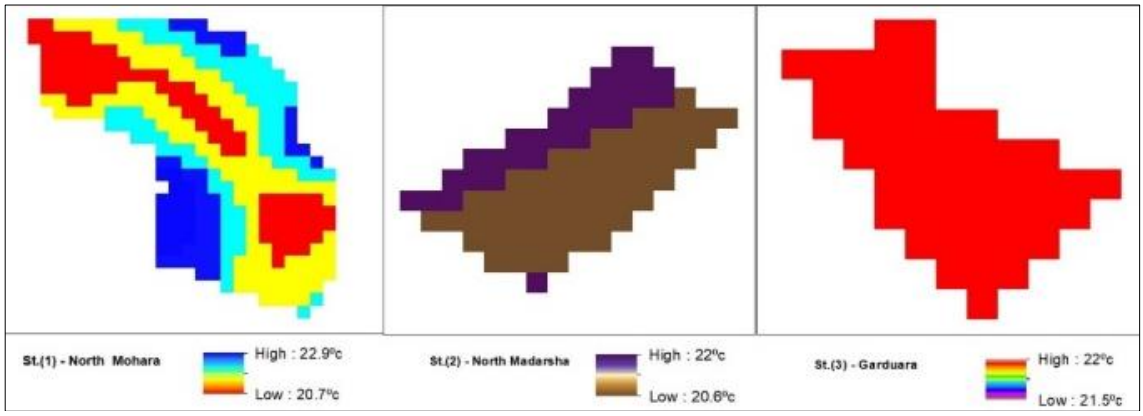
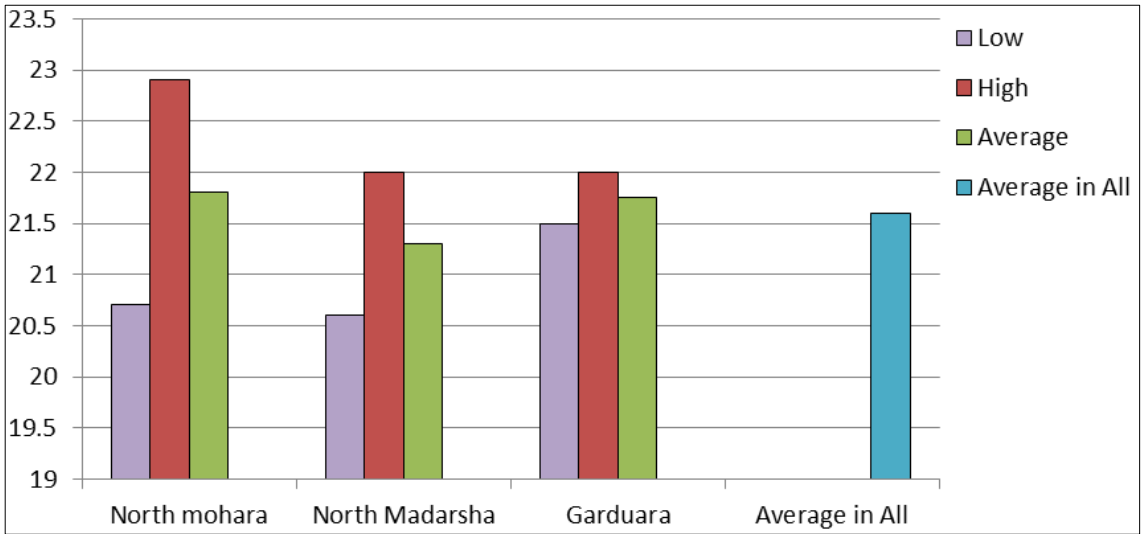


Fig 3: Image of the surface temperature distribution of Landsat 5 in March, 1990.



Graph 1: Temperature distribution (ºC) of March 1990 in Graph.

Table 4: Temperature distribution of March, 1990.

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	20.7	20.6	21.5
High	22.9	22	22
Average	21.8	21.3	21.75
Average in all	21.6 ºC		

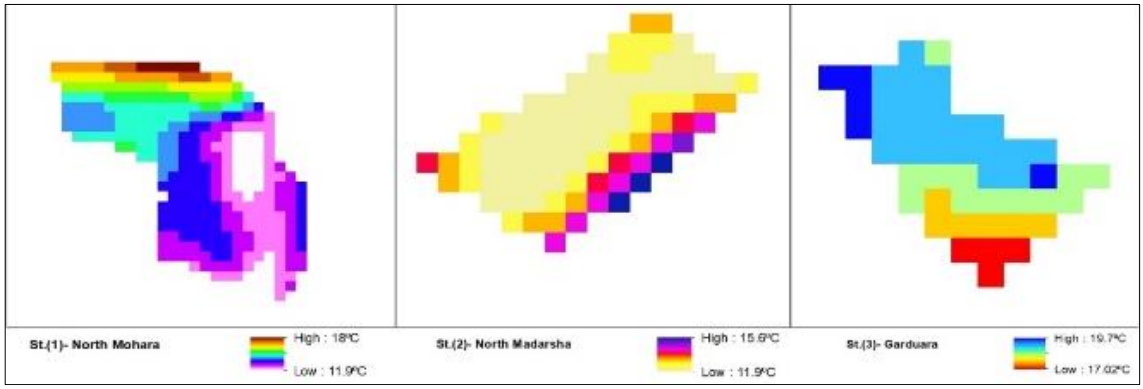
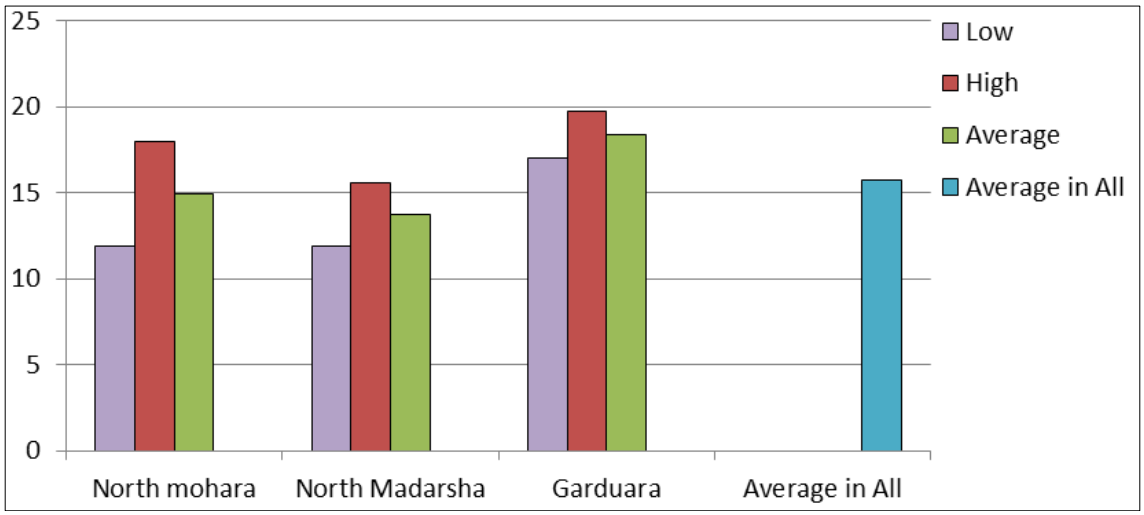


Fig 4: Image of the surface temperature distribution of Landsat 5 in March, 1995.



Graph 2: Temperature distribution (ºC) of March 1995 in Graph.

Table 5: Temperature distribution of March, 1995.

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	11.9	11.9	17.02
High	18	15.6	19.7
Average	14.95	13.75	18.36
Average in all	15.7 ºC		

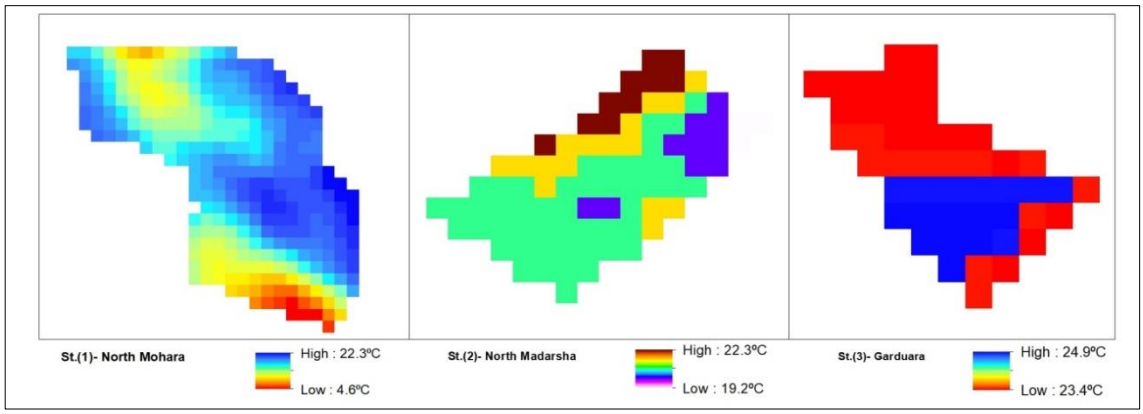
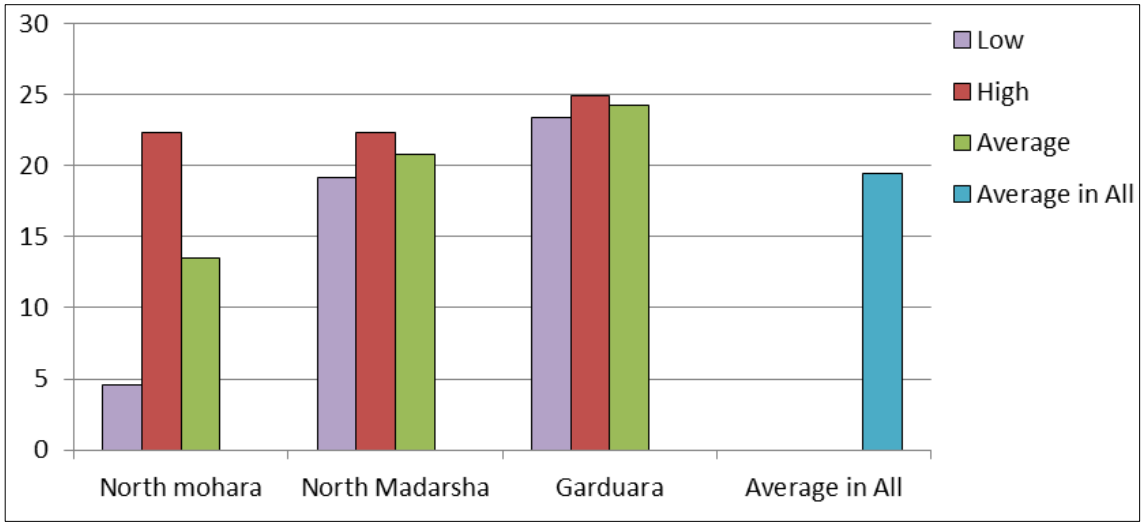


Fig 5: Image of the surface temperature distribution of Landsat 7 in March, 2000.



Graph 3: Temperature distribution (ºC) of March, 2000 in Graph.

Table 6: Temperature distribution of March, 2000

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	4.6	19.2	23.4
High	22.3	22.3	24.9
Average	13.5	20.8	24.2
Average in all	19.5 ºC		

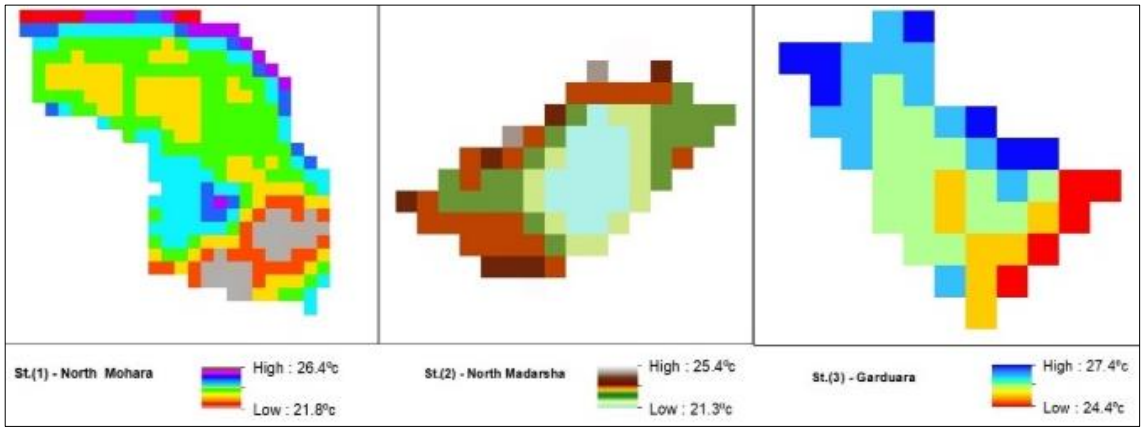
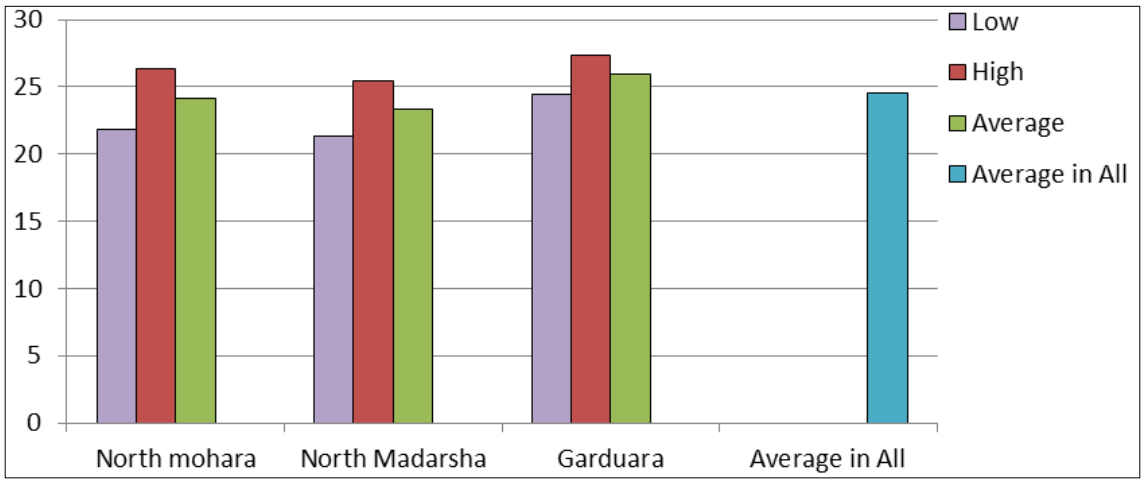


Fig 6: Image of surface temperature distribution of Landsat 7 in March, 2006.



Graph 4: Temperature distribution (ºC) of March 2006 in Graph.

Table 7: Temperature distribution of March, 2006

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	21.8	21.3	24.4
High	26.4	25.4	27.4
Average	24.1	23.35	25.9
Average in all	24.5 ºC		

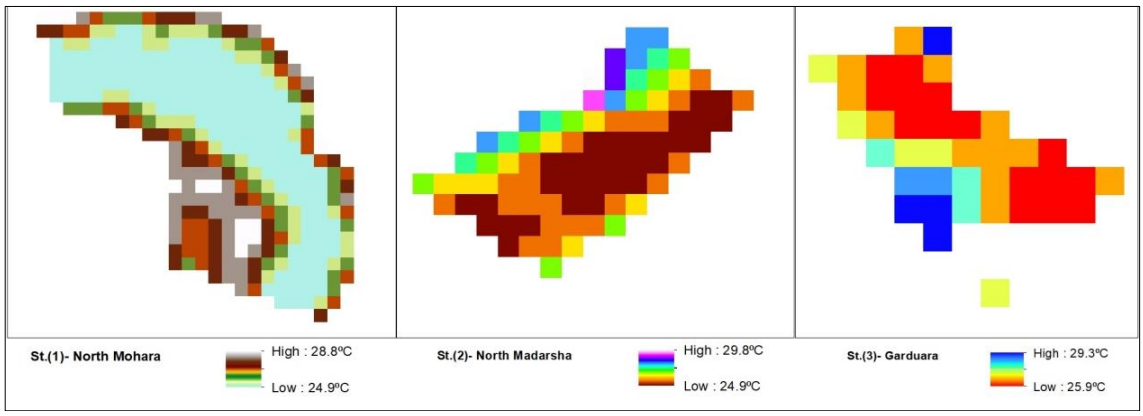
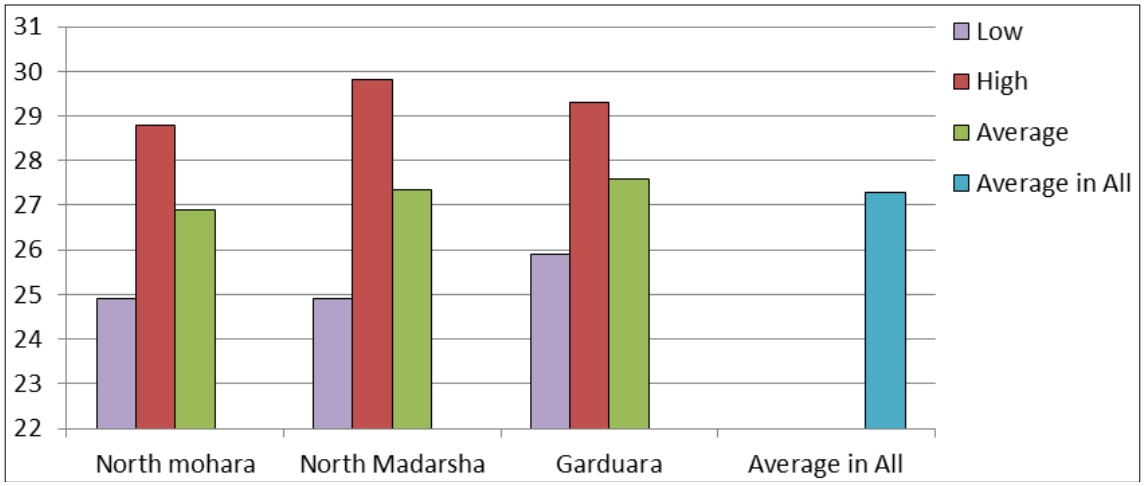


Fig 7: Image of surface temperature distribution of Landsat 7 in March, 2010.



Graph 5: Temperature distribution (ºC) of March 2010 in Graph.

Table 8: Temperature distribution of March, 2010

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	24.9	24.9	25.9
High	28.8	29.8	29.3
Average	26.9	27.5	27.6
Average in all	27.3 ºC		

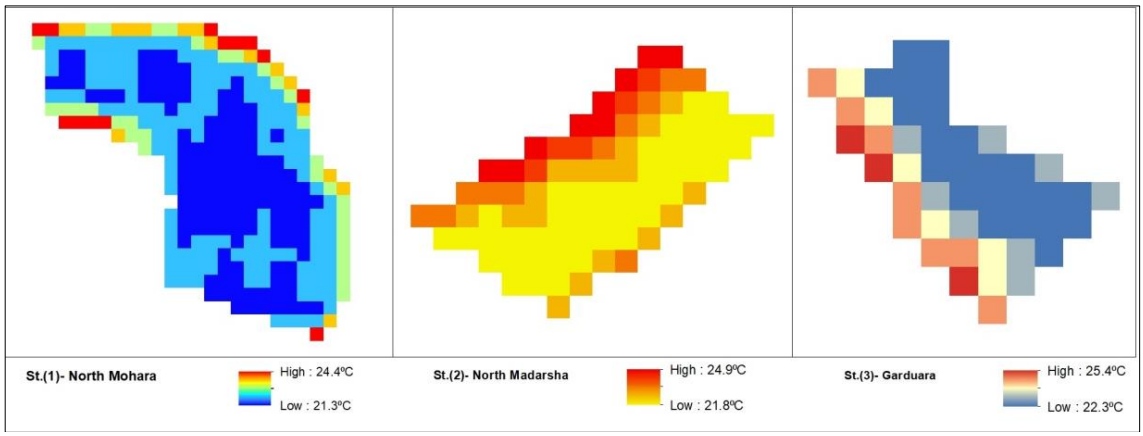
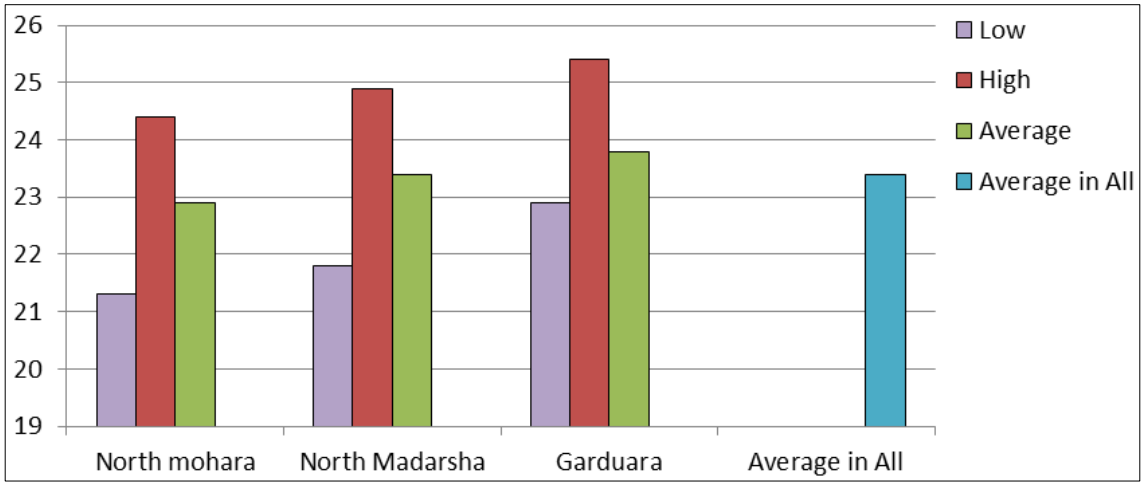


Fig 8: Image of surface temperature distribution of Landsat 7 in March, 2015.



Graph 6: Temperature distribution (ºC) of March 2015 in Graph.

Table 9: Temperature distribution of March, 2015

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	21.3	21.8	22.3
High	24.4	24.9	25.4
Average	22.9	23.4	23.8
Average in all	23.4 ºC		

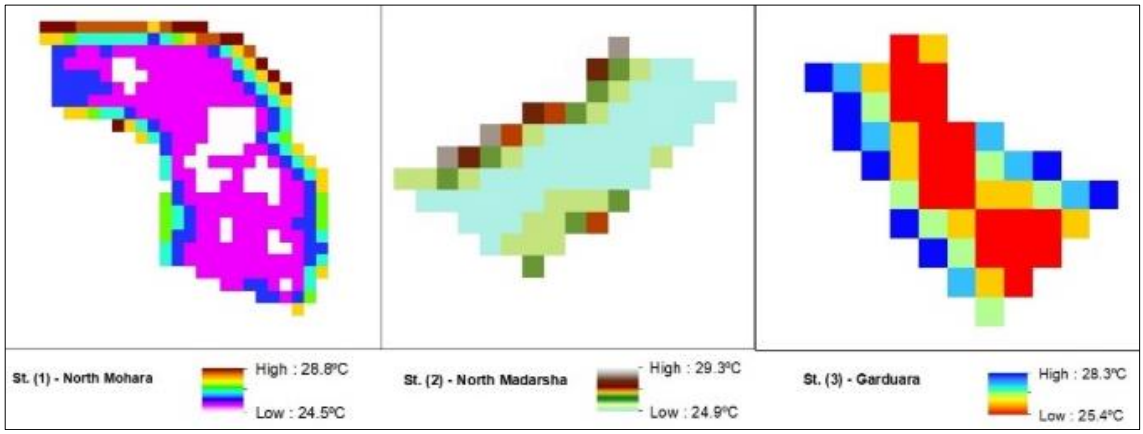
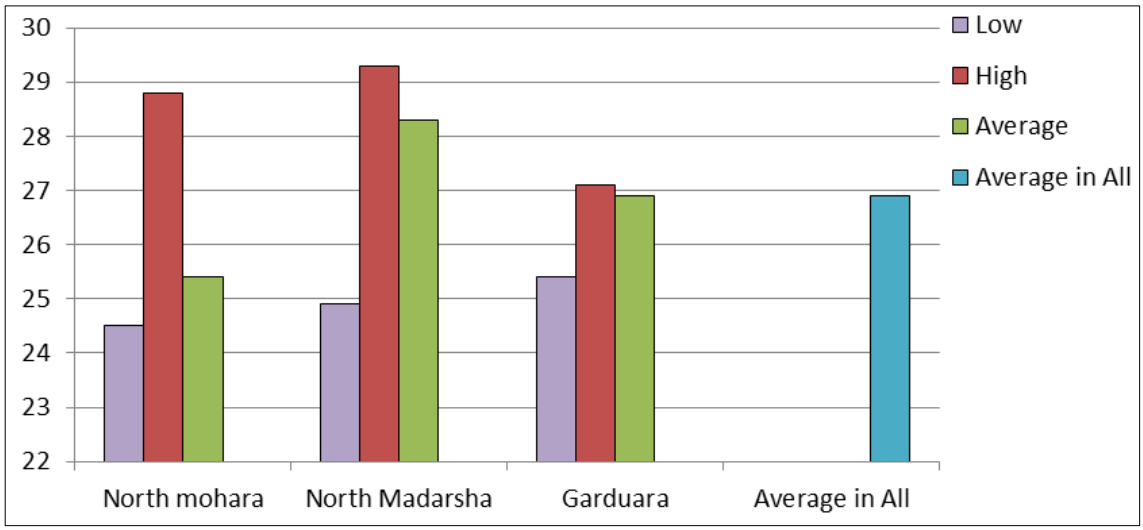


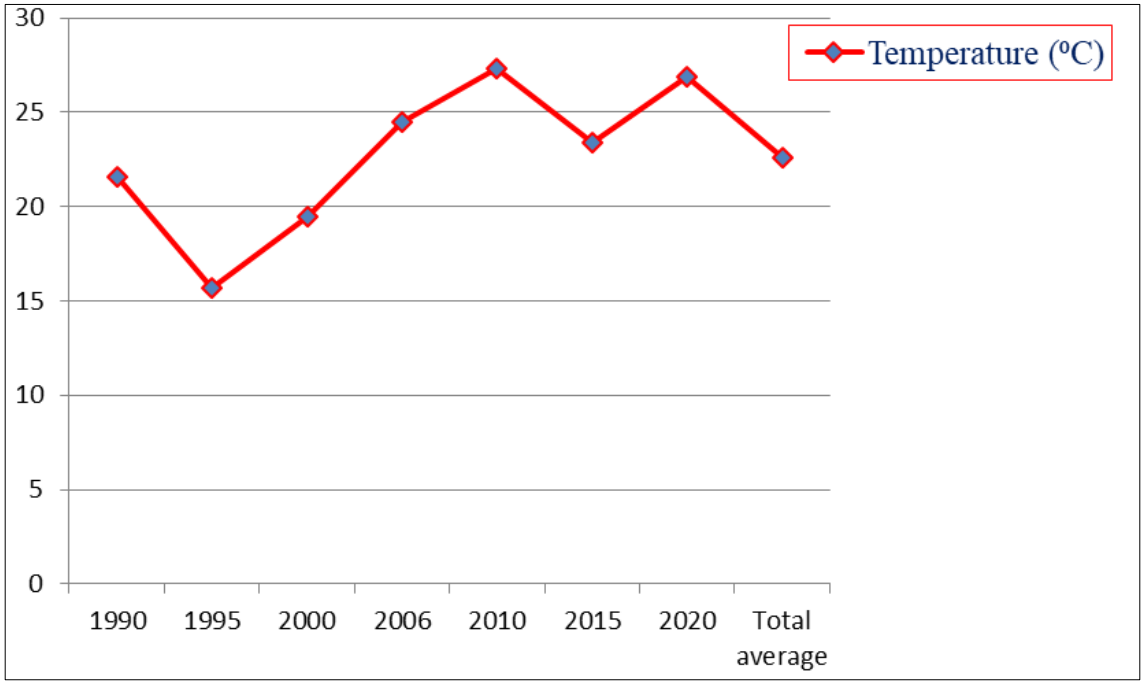
Fig 9: Image of surface temperature distribution of Landsat 7 in March, 2020.



Graph 7: Temperature (ºC) distribution of March 2020 in Graph.

Table 10: Temperature distribution of the March, 2020

Temperature (ºC)	North Mohara	North Madarsha	Garduara
Low	24.5	24.9	25.4
High	28.8	29.3	28.3
Average	26.7	27.1	26.9
Average in all	26.9 ºC		



Graph 8: The pattern of respective average temperature of all selected 7 years (March) and total average temperature of all those years (March).

Table 11: Respective average temperature of all selected 7 years (March) and total average temperature of all those years (March)

Temperature (ºC)	1990	1995	2000	2006	2010	2015	2020
Average (each year)	21.6	15.7	19.5	24.5	27.3	23.4	26.9
Total Average (all)	22.7ºC						

Results and Discussion

After calculation of temperature data by analysis of the thermal band 6 of Landsat images, there have been different distributions of the surface temperature in the selected seven years. The above figures 3, 4, 5, 6, 7, 8, and 9 depict the distribution pattern of the surface water temperature with color bands. In March, 1990, 1995, 2000, 2006, 2010, 2015 and 2020, the respective average surface water temperature of those 7 years are 21.6 ºC (Figure 3, Graph 1, Table 4), 15.7 ºC (figure 4, Graph 2, Table 5), 19.5 ºC (Figure 5, Graph 3, Table 6), 24.5 ºC (Figure 6, Graph 4, Table 7), 27.3 ºC (Figure 7. Graph 5, Table 8), 23.4 ºC (Figure 8, Graph 6, Table 9) and 26.9 ºC (Figure 9, Graph 7, Table 10) and the total average (Graph 8, Table 11) temperature of those selected seven years (March) is 22.7 ºC. By doing this study, it can be inferred that the temperature of this river is now going to be higher day by day and is close to cross the optimum temperature of this spawning ground (according to Islam *et al*., 2012, the standard temperature for the carp spawning behavior in this river is 20-30 ºC) what might be a threat for the normal ecological environment of this carp community.

Conclusion

The Study suggests that the surface temperature of Halda River could be calculated by using the remote sensing applications in which we would be correctly and easily indicated about the current status of the river temperature. In this case, these techniques could be a fruitful method to have a constant experiment on temperature distribution of this water body that might draw the attention of the connected authority specially Department of Environment (DOE) an Government of country to properly apply the sustainable managements and the scientific planning for retaining the optimum physical, chemical and biological environment in this valuable water resource and might play a significant role for the other Hydrological study of this river.

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