Proceedings of the 5th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), 7~9 February 2020, KUET, Khulna, Bangladesh (ISBN-978-984-34-8764-3)

ENVIRONMENTAL MONITORING AT AND AROUND THE MATUAIL LANDFILL SITE OF DHAKA CITY USING REMOTE SENSING

Md. Sayeduzzaman Sarker*[1], Nokibul Alam Chowdhury[2], Md. Moshiur Rahman[3], Rafsun Ahmad[4] and Afzal Ahmed[5]

[1]Student, Department of CE, AUST, Bangladesh, e-mail: shafin1619@gmail.com
[2]Student, Department of CE, AUST, Bangladesh, e-mail: e-mail: nokibaust@gmail.com
[3]Student, Department of CE, AUST, Bangladesh, e-mail: moshirr415@gmail.com
[4]Student, Department of CE, AUST, Bangladesh, email: rafsunahmad@gmail.com
[5]Professor, Department of CE, AUST, Bangladesh, email: afzal.ahmed2008@gmail.com

***Corresponding Author**

ABSTRACT

Municipal Solid Waste (MSW), a part of which is being disposed off at Matuail sanitary landfill located within Jatrabari Thana. This study has analysed the environmental impacts at and around this landfill using remote sensing techniques. Special attention was given on the effect of biodegradation process of waste which results gas emissions and leachate contamination of land. Information can be gained from remote sensing data by grasping the nature of electromagnetic radiation in terms of their wavelength and frequency. Data from satellite platforms can be utilized to landfill management and monitoring practices, solve future waste management agenda without being kept in touch of earth's surface using remote sensing. The objective of this research is to develop a means of environmental monitoring at the landfill site and its surroundings through the implementation of various time series remote sensing indices e.g., Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI) and Modified Soil Adjusted Vegetation Index (MSAVI). LST is the skin temperature of the earth which is calculated by SW algorithm. It is used to observe the spatio-temporal pattern of temperature distribution. NDVI, SAVI and MSAVI are the Bio-indicators and they are helpful to analyse the vegetation health condition at and around the landfill area. Vegetation coverage plays a significant role on the LST distribution. The Landsat data were downloaded from United States Geological Survey (USGS) websites for Landsat 4-5 TM and Landsat 8 OLI/TIRS by using the path and row of 137 and 44 respectively. Images at a 5-year interval starting from 1993 to 2018 were used to monitor the impact in this study. From the result of LST, it is observed that the average temperature of the Jatrabari thana has increased from 23.12℃ in 1993 to an optimum temperature of 35.20℃ in 2013, then it went down to 29.09℃ in 2018. Also, the average temperature of the Existing Sanitary Landfill (ESL) has increased from 22.56℃ in 1993 to 31.99℃ in 2018 and from 21.97℃ in 1993 to 31.52℃ in 2018 for Fulfilled Semi-aerobic Landfill (FSAL). The NDVI result for the study period shows that the percentages of 'Bare Soil' and 'Structural Object' has increased drastically from 10% to 41.20% and 13.30% to 31.52% respectively for this 25-year period in Jatrabari thana. On the other hand, the percentages of 'Shrub and Grassland' and 'Moderate Vegetation' have gone down from 54.20% to 25.15% and 12.55% to 0% respectively. SAVI and MSAVI also show the evidence of increasing the amount of bare soil and structural object and decreasing the amount of vegetation. From overall assessment, it can be said that due to the inappropriate waste management at the Matuail landfill, a harmful effect has been done to the surrounding environment. As an outcome, temperature has risen rapidly and amount of vegetation has declined to a significant extent.

Keywords: *Landfill Monitoring; Land Surface Temperature (LST); Normalized Difference Vegetation Index (NDVI); Soil Adjusted Vegetation Index (SAVI); Modified Soil Adjusted Vegetation Index (MSAVI).*

1. INTRODUCTION

Bangladesh is located in the South-East Asia region which has a population over 160 million. Dhaka is the capital of Bangladesh. More than 15 million people live in this city. A study by the Department of Environment (DoE) revealed that Dhaka's problem regarding solid wastes is worse compared to cities in other developing countries. Total wastes produced in Dhaka city is about 4600 tons/day (Abedin & Jahiruddin, 2015). Besides, the amount of waste generation rises during the wet season. It seems like impossible to dispose that amount of waste as the city does not have enough resources. Dhaka City Corporation (DCC) uses two landfill sites specifically; Matuail (40ha) which is a sanitary landfill and Amin Bazar (20ha) is under operation process for sanitary condition. Among total wastes 1150 tons/day to 1450 tons/day wastes are disposed off at Matuail landfill. The rest of the wastes are disposed off at Amin Bazar landfill (Bhuyan, 2010). Matuail landfill site is located around 8 kilometers from the center of the south of Dhaka city which is mainly used for disposal of municipal solid waste by the Dhaka South City Corporation (DSCC). It is located in the DSCC region in between latitude of 23°42.97' to 23°43.35' N and longitude of 90°26.83' to 90°27.2' E (Hossain, Jahan, Parveen, Ahmed & Uddin, 2018). Matuail landfill is located in Jatrabari thana which has an area of 13.19 square kilometers and the total population is about 260772 and the population density is about 19770/km² where average monthly temperature is around 30°C; average monthly rainfall is around 100mm; average monthly wind speed is around 15kmph and average monthly humidity is around 50% from 2009 to 2018 (Bangladesh Meterological Department [BMD], 2018). A location map of Jatrabari thana is given in the figure 1 below.

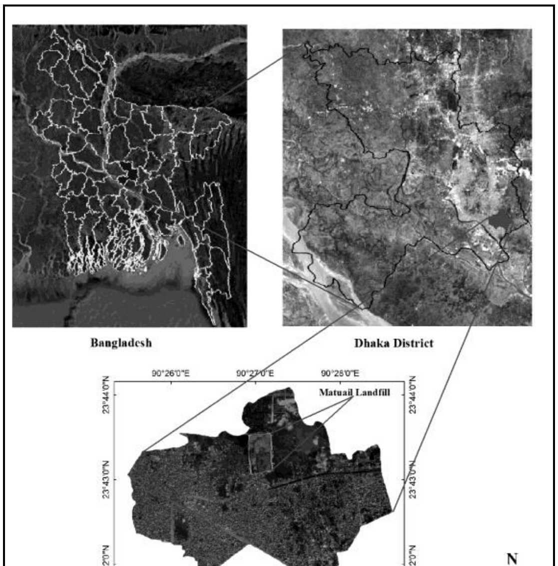

Fig 1: Location Map of Jatrabari Thana

Main waterbody in Jatrabari thana is Balu River which carries floodwater from the Shitalakshya and the Turag during the flood season. The Balu is important mainly for the local drainage and can be accessed by small boats. From Google earth it is assured that there is a huge amount of urban area in the south direction and a small portion of vegetation in the north-east corner and some water bodies are scattered in the whole region of Jatrabari thana area. Main crops are paddy, potato and various kinds of vegetables (Banglapedia, 2019). The overall objective of this research is to monitor the condition of Matuail landfill site and the surrounding area. The major objective of this research is:

1. To calculate and analyze various remote sensing indices e.g., LST, NDVI, SAVI and MSAVI.
2. To observe the temperature distribution pattern and vegetation health condition at the Matuail landfill site and the surrounding region.

3. To assess the present status of waste management at Matuail landfill site of DSCC.

2. METHODOLOGY

The methodology of the study comprises on extracting the LST, NDVI, SAVI and MSAVI of the Jatrabari thana area which covers the Matuail landfill. A systematic development of the methodology of this study is shown in the figure 2 below with the help of a flow diagram.

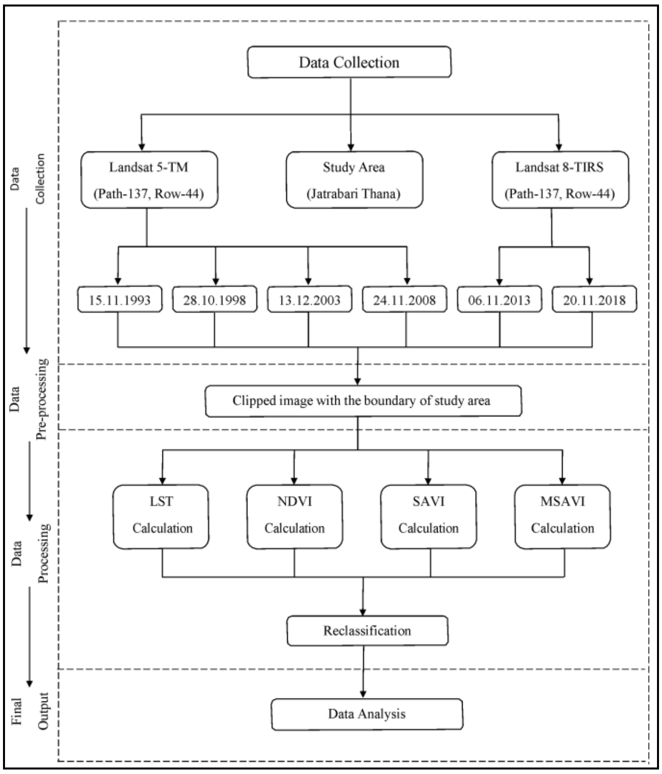

Fig 2: Methodology Flow Chart

2.1 Data Collection

The operational activities of Matuail landfill started in 1993. As the main focus of this study is to acquire the environmental effect of the Matuail landfill from its very beginning, images at a 5-year interval started from 1993 to 2018 are used in this study. The Landsat data were downloaded at free of cost from USGS websites, namely www.glovis.usgs.gov and www.earthexplorer.usgs.gov. The path and row is 137 and 44 respectively. ArcGIS 10.2.2 was used for data analysis. The shape file of Jatrabari thana is collected from Bangladesh Agricultural Research Council (BARC).

2.3 Data Processing

Before data processing, image is clipped with the help of desired shape file of the Jatrabari thana area. The process of estimating LST for two satellites is different. Required data were extracted from respective metadata file and digital number (DN) of thermal band is converted to radiance. Then, LST is estimated by the required equation. For NDVI, Near Infrared Reflectance (NIR) and Red band is needed which represents the band reflectance obtained in the near-infrared and red (visible) wavelengths respectively. Then, SAVI was improved by conjoining a soil reconcilement factor L into the NDVI equation. The L value differs with the quantity of green vegetation. Lastly, MSAVI is a modification of SAVI that further diminish soil brightness dominances, therefore, resulting in higher vegetation susceptibility. In SAVI, L is generally left alone at a constant 0.5, but for MSAVI, the soil reconcilement factor is simply computed by an equation. Images of LST and NDVI are reclassified into categories to understand the variation of values to compare with each other and to analyze the values properly. The temperature classes are (19-22), (22-25), (25-28), (28-31), (31-34), (34-37), (37-40) and (40-44) Degree Celsius, while the categories for NDVI are (-0.5-<0), (0), (>0-0.05), (0.05-0.1), (0.1-0.3), (0.3-0.6) and (0.6-0.8) for water body, no vegetation, bare soil, structural object, shrub and grassland, moderate vegetation and high vegetation respectively.

3. RESULT AND DISCUSSION

3.1 Thermal Comparison

Table 1: Comparison of Highest, Lowest and Average Temperature of Jatrabari Thana

Year	Highest Temp (°C)	Lowest Temp (°C)	Average Temp (°C)
November 15, 1993	26.67	19.28	23.12
October 28, 1998	30.42	22.81	25.89
December 13, 2003	30.82	21.50	25.10
December 10, 2008	29.18	21.06	24.69
November 6, 2013	43.96	30.42	35.20
November 20, 2018	34.84	25.32	29.09

From the overall comparison of temperature of Jatrabari thana shown in the table 1, it is observed that the highest temperature increases rapidly from 26.27℃ in 1993 to 43.96℃ in 2013 and then it goes down to 34.84℃ in 2018 and the lowest temperature rises drastically from 19.28℃ in 1993 to 30.42℃ in 2013 and then it fells down to 25.32℃ in 2018. The average temperature of the Jatrabari thana increases 12.08℃ by an interval of 20 years (1993 to 2013). Though the average temperature reduces 6.11℃ from 2013 to 2018, but in the contrast of 1993 to 2018, the average temperature increases significantly.

The reclassified images of LST of 1993, 1998, 2003, 2008, 2013 and 2018 are given in the figure 3 to 8 below.

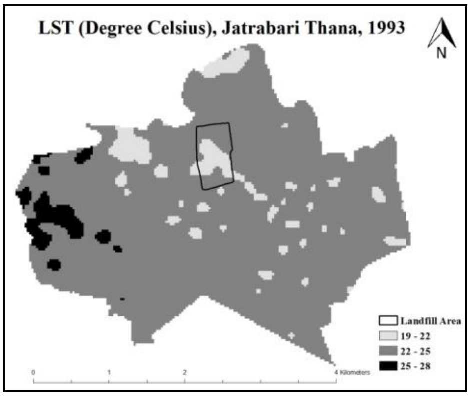

Fig 3: The reclassified LST Image (1993)

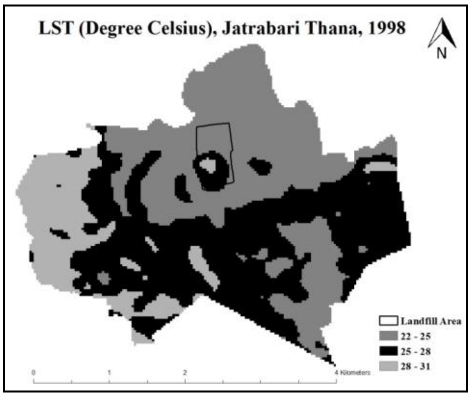

Fig 4: The reclassified LST Image (1998)

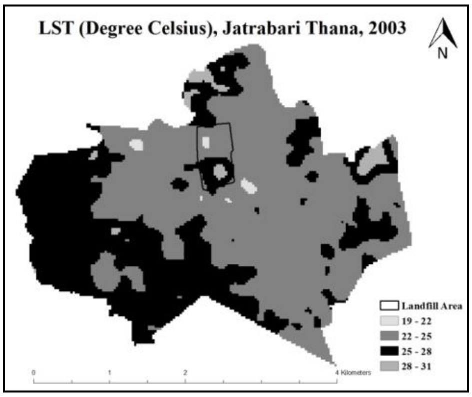

Fig 5: The reclassified LST Image (2003)

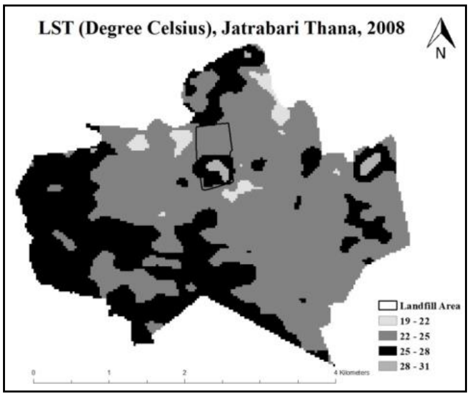

Fig 6: The reclassified LST Image (2008)

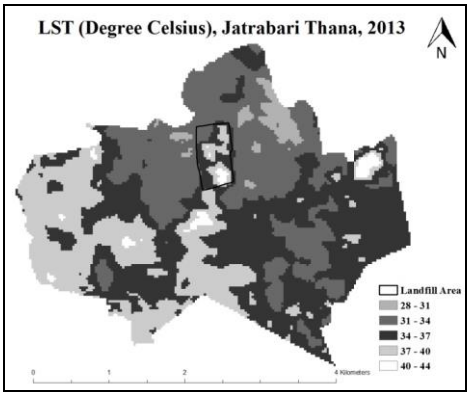

Fig 7: The reclassified LST Image (2013)

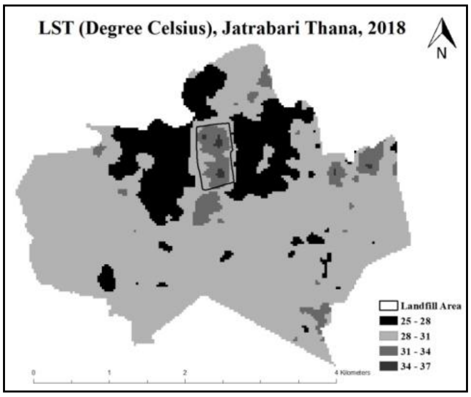

Fig 8: The reclassified LST Image (2018)

Table 2: The LST Pixel Percentage of Each Range over the Whole Area (Based on Pixel Count)

Temp Range (℃)	**Pixel Percentage of Each Range Over The Whole Area**					
	Nov ‘93	**Oct ‘98**	**Dec ‘03**	**Dec ‘08**	**Nov ‘13**	**Nov ‘18**
19-22	7.1	-	0.5	2.3	-	-
22-25	89.3	40.1	57.8	60.5	-	-
25-28	3.6	44.71	39.8	36.4	-	18.3
28-31	-	15.2	1.9	0.8	2.5	76
31-34	-	-	-	-	32	5.5
34-37	-	-	-	-	40.7	0.2
37-40	-	-	-	-	24.4	-
40-44	-	-	-	-	1.4	-

From the table 2, it can be said that 22-25 ℃ temperature range has a covering of 89.3% in 1993. In 2013, 34-37 ℃ has become the major covering temperature range. By the year of 2018, 28-31 ℃ is the major covering temperature range and also some temperature ranges as 19-22 ℃ and 22-25 ℃ disappear in 2018. To find out the temperature variation pattern year by year, two polygons are generated within Matuail landfill area which represents ESL and FSAL. A layout of ESL and FSAL within Matuail landfill is given in the figure 9.

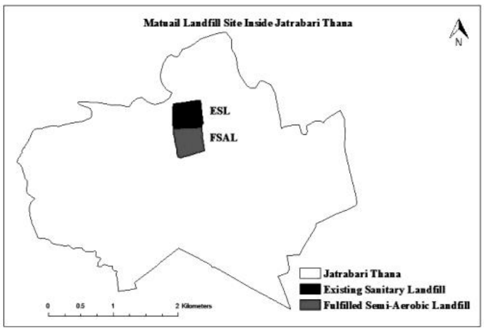

Fig 9: Layout of ESL and FSAL within Matuail Landfill

Table 3: Maximum, Minimum and Average Temperature of ESL and FSAL from 1993 to 2018

Year	Polygon	1993	1998	2003	2008	2013	2018
Maximum	ESL	23.68	26.25	26.27	25.40	40.07	34.69
Temp (℃)	FSAL	23.25	29.59	28.77	29.18	41.36	34.84
Minimum	ESL	21.50	23.25	21.94	22.38	31.20	28.86
Temp (℃)	FSAL	19.28	24.54	24.11	24.55	33.75	28.32
Average	ESL	22.56	23.81	23.53	23.33	35.81	31.99
Temp (℃)	FSAL	21.97	26.83	26.61	26.97	37.11	31.52

The capacity of FSAL was fulfilled by 2006, so the construction of ESL was required and ended in 2005-2006. From the table 3, it can be concluded that temperatures of ESL are comparatively less than temperatures of FSAL for almost every particular year. In 1993, as these places were barren land, temperatures were stable. By the year of 1998, waste composition process of FSAL influences to increase temperature for it and ESL also. Temperatures increase drastically between 2008 and 2013, striking at around 40-44℃ and this can be explained by the stabilization process of wastes. As it takes many years to stabilize the decomposed waste, it emits a huge quantity of heat during this long period. This stabilization process takes nearly 15-20 years sometimes depending on some major criteria. The study clearly revealed that as the landfill activities starts, the temperature at and around Matuail landfill increases rapidly to 40-44 ℃ from 19-22 ℃ range.

3.2 Bio-Indicators

3.2.1 NDVI

The reclassified images of NDVI of 1993, 1998, 2003, 2008, 2013 and 2018 are given in the figure 10 to 15 below.

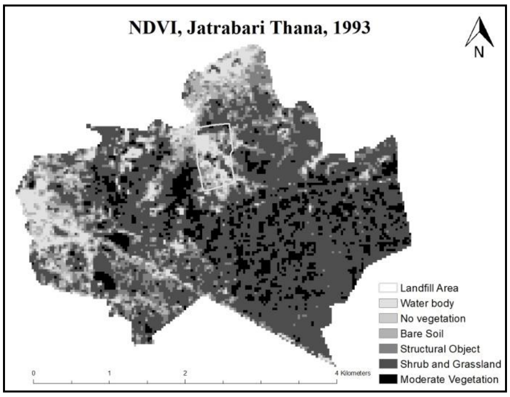

Fig 10: The reclassified NDVI Image (1993)

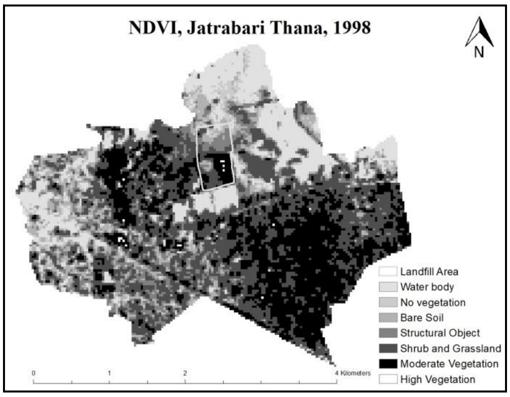

Fig 11: The reclassified NDVI Image (1998)

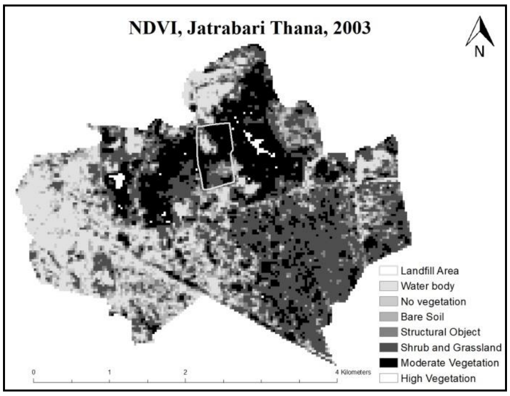

Fig 12: The reclassified NDVI Image (2003)

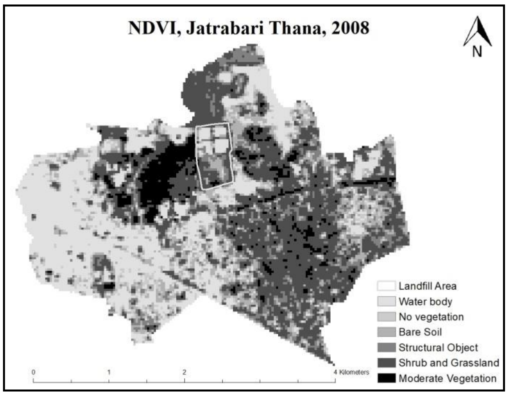

Fig 13: The reclassified NDVI Image (2008)

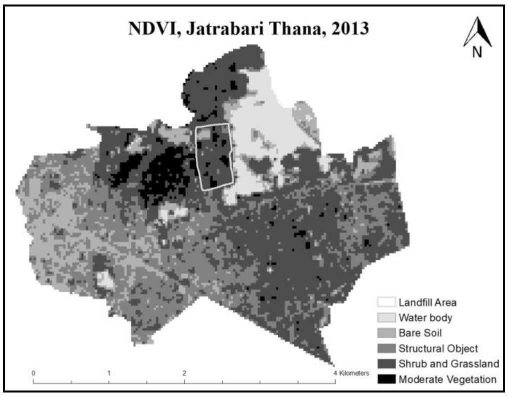

Fig 14: The reclassified NDVI Image (2013)

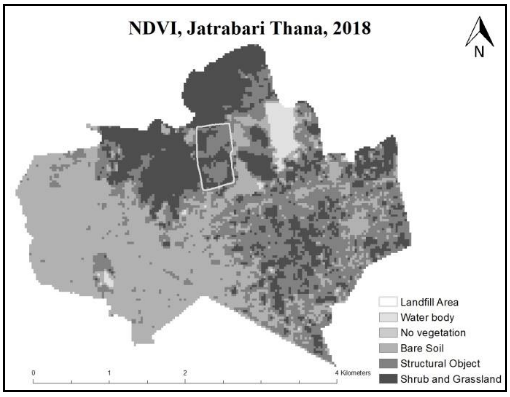

Fig 15: The reclassified NDVI Image (2018)

Table 4: The NDVI Pixel Percentage of Each Range over the Whole Area (Based on Pixel Count)

NDVI Category	**Pixel Percentage of Each Range Over The Whole Area**					
	Nov '93	**Oct '98**	**Dec '03**	**Dec '08**	**Nov '13**	**Nov '18**
Water Body	6.6	14.9	16.9	27.3	7.5	2.1
No vegetation	3.35	4.1	5.5	5.9	-	0.007
Bare Soil	10	10.1	11.5	13.1	14	41.2
Structural Object	13.3	12.1	10.5	13.9	30.6	31.52
Shrub and Grassland	54.2	33.8	34.7	33.45	43.3	25.15
Moderate Vegetation	12.55	24.9	20.3	6.35	4.6	-
High Vegetation	-	0.1	0.6	-	-	-

Higher NDVI value represents healthy vegetation, whereas lower NDVI value represents defective and unhealthy vegetation. From the table 4, it is clearly exposed that within the 25 year period, amounts of bare soil and structural object increase vastly, on the other hand, amounts of vegetation health and water body is diminishing. Improper waste management system is affecting the natural environment of the surroundings. The waterbody percentage is almost 27.3% in 2008, which seems unreal. Also the figure 13 shows water body in some areas which are covered with structural object and roadway in real (assured from Google Earth). Jatrabari thana is a low lying area and also the drainage system of some parts of this area are mostly ineffective. 2007, 2008 and 2009, in these three consecutive years a huge amount of rainfall occurred (BMD, 2018), thus creates huge waterlogging problem in the area. Reclassified images of 2007 and 2009 are given in the figure 16 and 17.

Comparing these images with the reclassified NDVI image of 2008 (figure 13), it can be said that due to waterlogging problem the water body percentages have reached 27.3%.

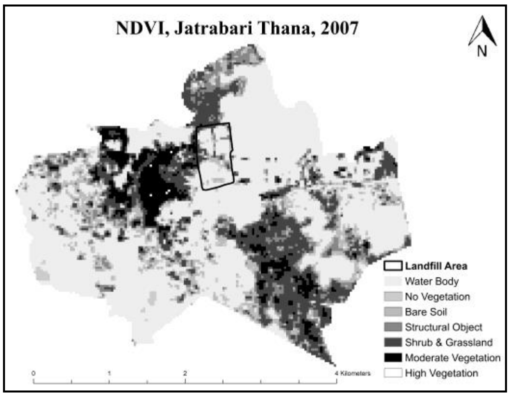

Fig 16: The reclassified NDVI Image (2007)

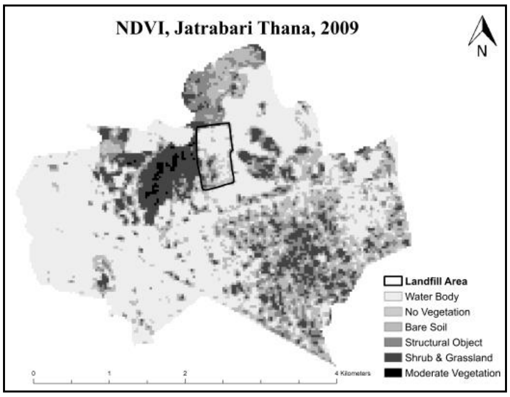

Fig 17: The reclassified NDVI Image (2009)

3.2.2 SAVI

The images of SAVI of 1993, 1998, 2003, 2008, 2013 and 2018 are given in the figure 18 to 23 below.

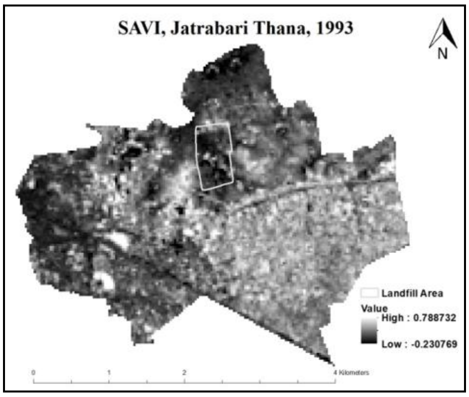

Fig 18: The reclassified SAVI Image (1993)

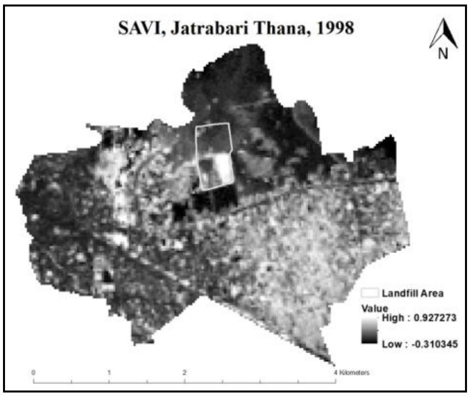

Fig 19: The reclassified SAVI Image (1998)

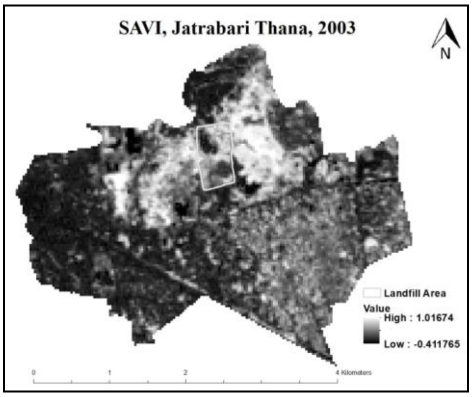

Fig 20: The reclassified MSAVI Image (2003)

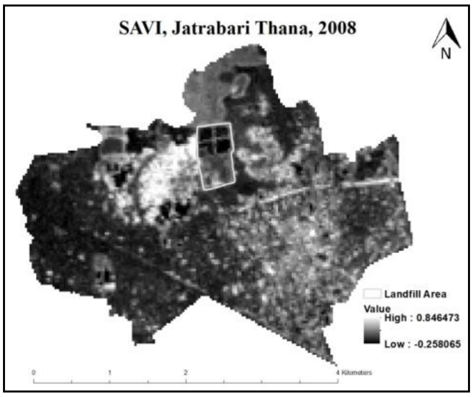

Fig 21: The reclassified MSAVI Image (2008)

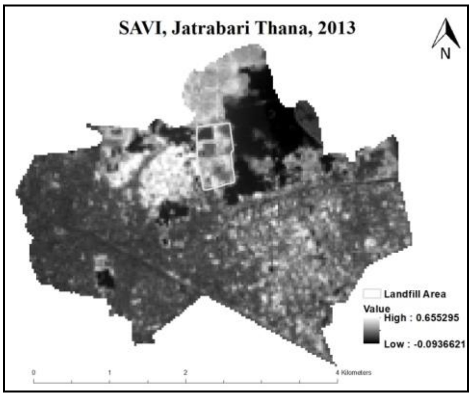

Fig 22: The reclassified MSAVI Image (2013)

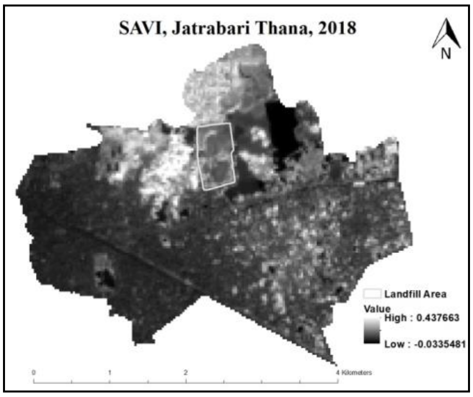

Fig 23: The reclassified MSAVI Image (2018)

SAVI is improved by the alteration of NDVI to be used in infertile areas whereas vegetative cover is little. The highest value increases from 0.78 in 1993 to 1 in 2003. Then it starts to decrease from the optimum value to 0.43 in 2018. Consequently, the lowest value decreases from -0.23 in 1993 to -0.41 in 2003. From the peak point it increases drastically to -0.03 in 2018. As the positive higher value represents healthy vegetation growth and positive lower value represents poor vegetation growth, so it can be said that, the vegetation growth diminishes in a significant way. Here, negative value represents water body. Though only from the minimum and maximum highest and lowest value, it cannot be said clearly how much the vegetation growth increases or decreases for these particular year.

3.2.3 MSAVI

The images of MSAVI of 1993, 1998, 2003, 2008, 2013 and 2018 are given in the figure 24 to 29 below.

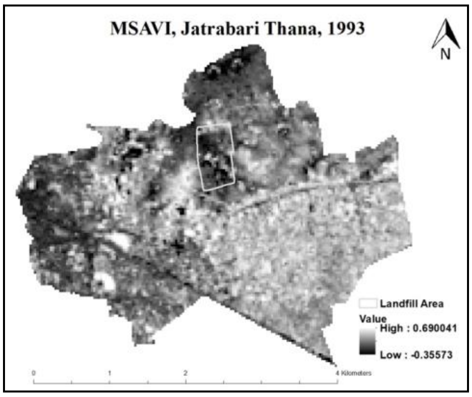

Fig 24: The reclassified MSAVI Image (1993)

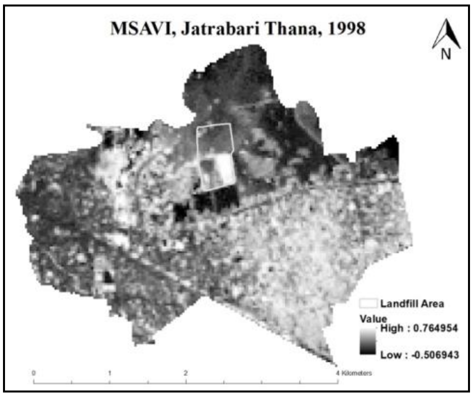

Fig 25: The reclassified MSAVI Image (1998)

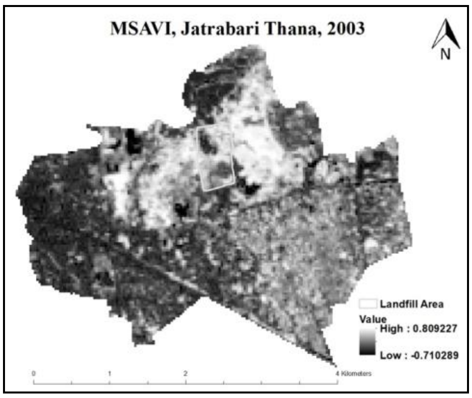

Fig 26: The reclassified MSAVI Image (2003)

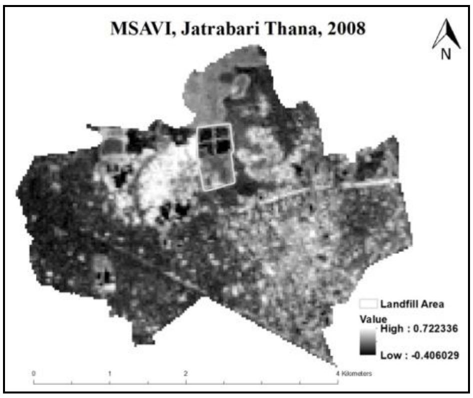

Fig 27: The reclassified MSAVI Image (2008)

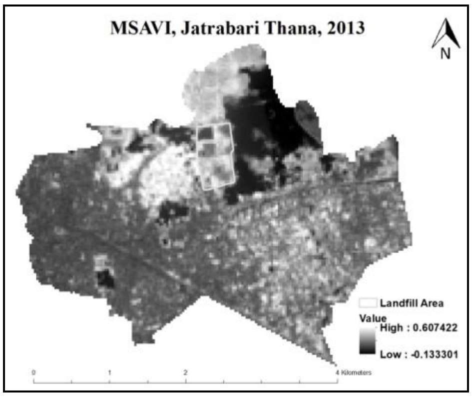

Fig 28: The reclassified MSAVI Image (2013)

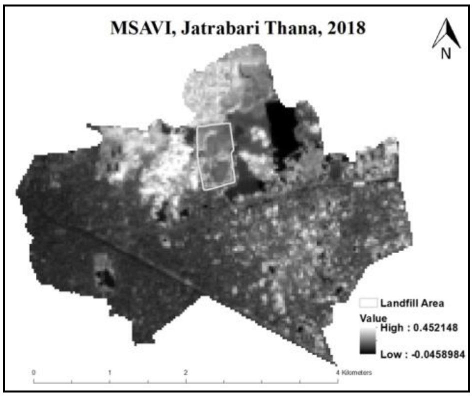

Fig 29: The reclassified MSAVI Image (2018)

MSAVI is the further modification of SAVI. The highest value rises from 0.69 in 1993 to 0.81 in 2003. Then it reducess from the optimum point to 0.45 in 2018. Similarly, the lowest value falls from -0.35 in 1993 to -0.71 in 2003. From the optimum point it ascends drastically to -0.04 in 2018. As like SAVI, the positive higher value represents healthy vegetation growth and positive lower value represents poor vegetation growth, so it can be said that, the vegetation growth has diminished in a significant way. Here also, negative value represents water body and from the minimum and maximum highest and lowest value, it is quite obscure that how much vegetation growth increases or decreases for these particular year.

4. CONCLUSIONS

This research analyses the spatio-temporal pattern of LST and interprets the vegetation health measuring indices such as NDVI, SAVI and MSAVI as indicators of environmental degradation in Matuail landfill and its surrounding region between 1993 and 2018. Though global warming which occurs mainly due to human activities such as the emission of greenhouse gases and so on has an impact on increase in global surface temperatures and there are some industries which also influenced the rise of the temperature in Jatrabari thana, mainly the landfill operations have a great impact on the LST increase of the study area. Because, Poor vegetation growth obtained from NDVI appears at and around the Matuail landfill which indicates the increase of surface temperature as NDVI and LST are vastly correlated. So, this goes without saying that LST increases in the study area significantly mainly due to the landfill gases by rising the average air temperature from the decomposition process of wastes alongside with some other factors as urbanization, deforestation and so on. In addition, the overall activities happened in the landfill severely impacts the output values of NDVI, SAVI and MSAVI. Threateningly, more and more wastes are generating every day and little in the way of recycling and separation of waste will lead to a disastrous condition in the future.

REFERENCES

Abedin, M. A., & Jahiruddin, M. (2015). Waste generation and management in Bangladesh: An overview. *Asian Journal of Medical and Biological Research*, 1(1), 114-120.

Bangladesh Meteorological Department (2018). *Climatic information of Jatrabari thana.* Retrieved from http://datalibrary.bmd.gov.bd/maproom/Climatology/index.html

Banglapedia (2019). *Geographical information of Jatrabari thana.* Retrieved from http://en.banglapedia.org/index.php?title=Jatrabari_Thana

Bhuyan, M. S. S. (2010). *A Study on Quantity and Quality of Leachate of Matuail Sanitary Landfill* (Master's thesis). Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

Hossain, M. F., Jahan, E., Parveen, Z., Ahmed, S. M., & Uddin, M. J. (2018). Solid Waste Disposal and its Impact on Surrounding Environment of Matuail landfill Site, Dhaka, Bangladesh. *American Journal of Environmental Sciences*, 14(5), 234-245.