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LAND USE CHANGES AND ITS IMPACT ON ENVIRONMENT: A CASE STUDY ON URBAN AREA IN KHULNA ,BANGLADESH

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ABSTRACT

Land is a part of the physical environment with various natural uses. Temperature, rainfall, humidity, salinity plays a serious role to make the environment habitable for both human beings and other species. These factors changes with the change of land use pattern of an area. The transformation of land use in an unplanned way resulted in environmental degradation, rise in temperature, entropy, change of precipitation, humidity, eco-system. To fulfill the several needs of the people, the rapid changes in land use occur in an area which is one of the driven forces of its environmental change. The research purpose is to identify and analyze the changes of land use pattern and then to evaluate the impacts of some criteria for land use change (LUC) in urban area.

The study was conducted using the data for two different time section 2002 and 2018. The study area was selected as Mujgunni Ward No 9 and Nirala, Ward No 24 Khulna City Corporation, Khulna by observing the recent rapid environmental change in the study area through secondary data analysis and by reading some available research paper to see the environmental change with the change of land use pattern. Landsat 5(TM) and Landsat 8 (OLI) images has been used in ERDAS Imagine 2014 for the year 2002 and 2018 respectively to identify the land use scenario. To analyze the land use change, land use was classified into five categories such as Build up area, Agricultural Land, Vacant Land, Vegetation and Waterbody. GIS based analysis in ArcGIS helped to relate these land use change between both areas. The Mann-Kendall test, trend analysis and co-efficient of variation were calculated to show average annual and seasonal average temperature and total rainfall changes that occurred due to LUC in the last 16 years at the study area.

A GIS based satellite image of 2002 and 2018 analysis showing that 229.53 acres and 48.2 acres of the buildup area has increased at Mujgunni and Nirala respectively which indicates a high rate of LUC at Mujgunni. The present land use type percentage shows that Mujgunni is still the more environmentally sound than Nirala. But the land use conversion rate is causing environmental change at Mujgunni and Nirala. The result shows that the average temperature was increased by 1.01^0C with the increasing rate of 0.04162^0C/year. The trend analysis shows that the average temperature in spring, summer and autumn was increased with the rate of 0.1534^0C/year in spring, 0.02701^0C/year in summer, 0.0076^0C/year in autumn and decreased in winter with the rate of 0.00816^0C/year. This increasing rate of temperature melts the ice in the polar and rises sea water level. The value of Z and co-efficient of determination showed the significance level for different values. Again total annual rainfall increasing rate is 17.64 mm/year. Seasonal total rainfall has also been increased during the study period with the rate of 4.17 mm/year in spring, 5.69 mm/year in summer, 5.15 mm/year in autumn and 2.10 mm/year in winter. As the study revealed that land use change in an unplanned way has impacts on the environmental change. So, the study will help people to have a clear vision on the impacts of land use change in an unplanned manner.

Keywords: *Land use pattern, Environmental change, Mann-Kendal test.*

1. INTRODUCTION

After 1950, urban population has increased about 7 times which resulted in the massive transformation of vacant land, waterbodies, forest land, vegetation and agricultural land into built up area in the urban area. This massive transformation has influence in resource use, pollution and environmental degradation (Sarraf et al., 2004). The main purpose of this research is to identify and analyze the changes of land use pattern in two different wards, Ward No 24 Nirala and Ward No 9 Mujgunni in KCC boundary. And then to evaluate the impacts of some criteria for land use change. Environment is the physical, chemical and biological entity surrounded by us. All things in the world are the part of the environment. An environment that is made up of good, sound and beneficial ingredients for human health is called healthy environment. A healthy environment ensures sufficient waterbody, vegetation, greeneries, build-up and vacant land use needed to serve its people. Increase or decrement of any elements of the environment indicates environmental change. But rapid increment or decrement of any elements in an unplanned manner causes environmental degradation (Fattah et al., 2019). That changes the environment negatively by changing its temperature, precipitation, humidity, salinity, ecosystem, biodiversity.

Land is a part of the physical environment with various natural uses. Human being reshaped this physical environment and divided into a variety of land use categories for their different purposes. How and which purposes people are using this land category is Land Use Pattern (Tiwari & Sharma, 2013). Land use means the uses of land cover by human for their various purposes such as housing, industrial, commercial, agricultural, grazing, mining, and many other purposes to meet their requirements to improve their living standards and comfortable living conditions.

Land Use Change (LUC) is the change of land use categories naturally or by human being. With the passage of time, land use has been changing around the world, both in planned and unplanned way. Change of Land use pattern in a planned way defines development of any area (Bahadure & Kothakar, 2012). Land use change in an area in an unplanned manner impacts the environment by changing the temperature, average precipitation, salinity, humidity of the area. Temperature, eco-system, biodiversity, ground water level etc. are changing negatively for this reason. It would be a threat to future generations for the present generations unconsciousness.

Mann–Kendall (MK) test is widely used in many climatic time series like temperature, humidity, rainfall etc. and many hydrological time series for the assessment of significance of trends (Hamed, 2009). The MK test illustrates a non-linear trend test, which measures monotonously up and down patterns or trends over a certain period of time (Lamchin et al., 2019). It is also a rank correlation test between the ranks of observations and their time sequence (Hamed, 2009). A trend is a recurring pattern and the method of data collection in an effort to identify this pattern is trend analysis. According to (Mondal & Hashemi, 2018) Trend analysis is conducted to spot a prevalent trend to identify how a trend developed or would develop over time. In research, trend analysis has been conducted to identify the trend of temperature, rainfall, salinity, humidity etc. data over a certain period of time. In this research Mann- Kendall test method is used with an accuracy rate of 85% to calculate temperature data and rainfall data.
Increase of temperature enhances the Earth's entropy, leading to rise of water level by melting ice in the pole. According to (Cazenave et al., 2014), sea level started rising at a mean rate of approximately 3.1 mm/year since early 1990s. Every year, hundred acres of land are going underwater and many famous cities will go under water within 2050. Many environmental pollutions occurred due to the rise in temperature, which making the environment unsuitable for human living (Liang & Li, 2018). Many factors work behind this negative environmental change like different types of pollution, hazard, use of plastic, industrialization, urbanization, destruction of forest, population growth etc. In most of the research, urbanization is considered as most responsible factors for the negative environmental change.

According to (Hooke et al., 2012) nearly 50% of Earth's Land surface has been modified by human being and nearly 24% of Earth's surface area experienced decline in productivity and ecosystem function during the year 1981 and 2003. (Folland et al., 1991) said that in the last 50 years the increasing rate of Earth's temperature is 0.13^0C which is twice that the last 100 years. These are alarming people about the dire environment in the future. Bangladesh is also facing this environmental problem due to its rapid land use transformation and population growth rate. According to (Mohiuddin, et al., 2014), the average annual temperature increased by 6.8^0C in the last 100 years in Dhaka. According to (Mondal et al., 2017), the annual average temperature was increasing by 0.007^0C/year and total annual rainfall was also increased by 3.392 mm/year in Khulna during the year 1960-2012. These all researchs showed the variety of environmental change for many years. But recently, statistics show that the environment is changing mostly in Bangladesh due to its increasing population, unplanned development, natural disaster and man-made reasons. In this research, recent land use change and environmental change were calculated which representing the current scenario and current problems. The value of the coefficient of determination, R^2 was found lower in seasonal average temperature change trend analysis because the study time of this research has been considered only for 16 years where, (Mondal et al, 2017) analyzed the data for 52 years. The research compared the difference between the two recently developing areas about their present environmental situation and calculated the average temperature and annual rainfall changes with the change of different Land Use Pattern (Buildup, agricultural land, vacant land, vegetation and waterbody) at the study area while most of the previous research focused on only one or two types of land use pattern of an area. The research also finds out the possible eco-friendly and environmentally sound area and a potential area for future urban growth among the two study area which will be helpful for future sustainable development.

2. METHODS AND MATERIALS

2.1 Study Area

Khulna is the 3rd largest city and Bangladesh's 2nd port entry has been developed largely in an unplanned manner (Source: BBS 2011). The Khulna City Corporation area is 14.30 sq. miles with a population of 232633 is divided into 31 wards. According to BBS 2015, from 2001 to 2011 the annual population growth rate was 0.68 in Khulna. With the increment of population, the land use pattern and the environment of Khulna is changing in every year. The study area Mujgunni KCC ward No 9 in Figure 1(a) and Nirala KCC Ward No 24 in Figure 1(b) was selected due to their continuous development and land use transformation in the recent years. Table 1 represents some necessary information about the study area.

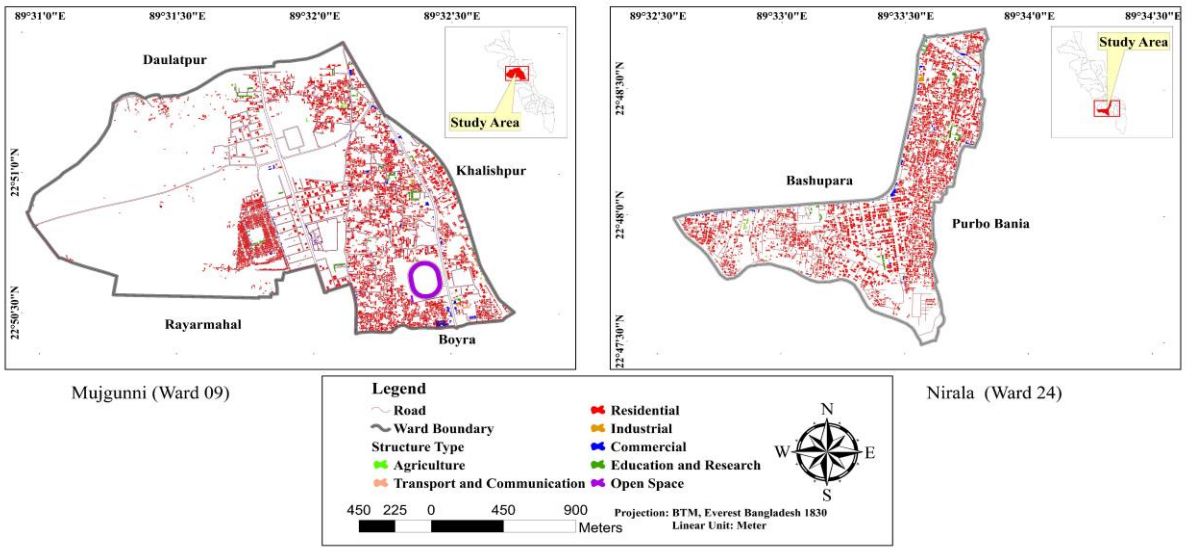

Figure 1: Study area map (a) Mujgunni KCC Ward No 9, (b) Nirala KCC Ward No 24 Khulna (source: Author 2019)

Table 1: Study area profile

Criteria	Mujgunni	Nirala
Ward No	9	24
Total Area	844.317 acres	392.7 acres
Population	31882	37889
Population density	38 person/acre	96 person/acre
Maximum Land Coverage	Buildup	Vegetation

(Source: BBS 2011)

2.2 Methodology

The study area was selected by reading some available research paper. The continual transformation of land use type in this area is also a reason for selecting the area. The study area was selected to see the environmental change like temperature and precipitation with the change of land use type or pattern. Other related papers most important and meaningful factors were selected and prioritized to analyze the data. To identify the land use pattern in the study area, Landsat 5(TM) and Landsat 8 (OLI) images having 30m resolution has been used in ERDAS Imagine 2014 for the year 2002 and 2018 respectively. For more accuracy of the data, atmospheric and radiometric correction has been conducted. To analyze the land use change, five types of land pattern has been selected such as Agricultural Land, Vacant Land, Vegetation, Waterbody and Build up area. GIS based analysis in ArcGIS helped to compare these land use change between both areas.

The monthly average temperature data and rainfall data on the Khulna station collected from the Bangladesh Meteorological Department over the study period 2002-2018. Seasonal mean values for the four seasons e.g. spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February) are determined from the monthly data and yearly mean values have also been calculated for the study period from meteorological department. In order to analyze the changing temperature and precipitation pattern, data were compiled for the station on a monthly, seasonal and annual basis. A very well-known method for trend analysis, Mann- Kendal Test method has been used for temperature and precipitation trend has been identified. And co-efficient of variation were calculated for measuring the level of significance of the average temperature and rainfall data.

3. RESULT AND FINDINGS

3.1 Land Use Type and Land Use Changes:

To identify the Land Use Type scenario at both in KCC Ward No. 9 and Ward No. 24, land use type was classified into 5 categories, namely agricultural land, vacant land, vegetation, waterbody and build up area. Supervised image classification in ERDAS IMAGINE 2014 helped to identify and measure the LUT in the year 2002 and 2018.

3.1.1 Land Use Change at Mujgunni KCC Ward No. 9

From GIS based satellite image analysis in 2002, it is found that the topmost land use type was vegetation 308.74 acres (37%) and then waterbody 208.19 acres (25%) showed in Table 2 and Figure 2(a). Build up area was only 64.99 acres (8%). The analysis shows that Build-up area was increased during the year 2002 to 2018 at both in Ward No-9 and Ward No-24. In 2018 total build up area increased to 294.52 acres at Ward 9 showed in Figure 2(b). Figure 3 describes that about 229.53 acres of built-up area increased at Mujgunni Ward No-9 that means 27% of the land converted into a

buildup area in the last 16 years due to the growth of population and to increase the amenities for this increased population.

From the field survey, it is found that many shops, administrative, institutional, residential, commercial building and road has been constructed in the recent years at Mujgunni which reduces the agricultural land, vacant land, vegetation and waterbody area rapidly at Mujgunni showed in Figure 2(b). Figure 3 shows that about 45% of waterbody and 40% of agricultural land transformed into build-up area at Mujgunni. The transformation of waterbody area and agricultural land is mostly because of the land use type and for the economical purposes. The reason for this drastic reduction of waterbodies is that people have filled the waterbody with sand to build infrastructure on it in future. Still in Mujgunni, people are filling waterbodies which will be a threat to the water ecosystem in there and will increase the water logging problem and temperature more rapidly at the study area.

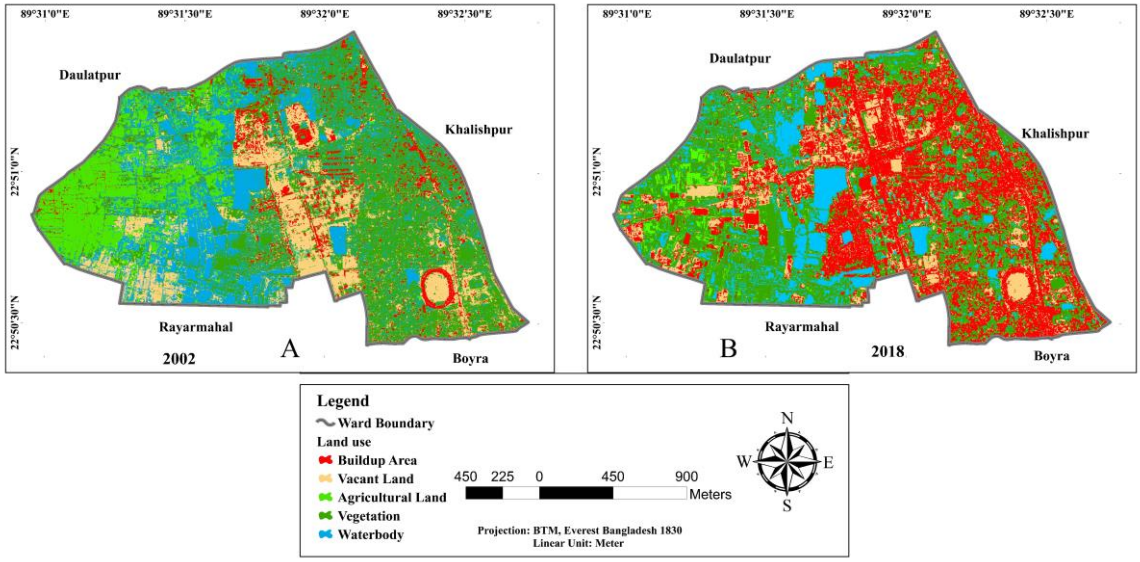

Figure 2: Land use map of Mujgunni KCC Ward No 9 (a) in 2002 and (b) in 2018. (Source: Author, 2019)

From the field survey 2019, it is found that most of the people of this area was dependent on agriculture for their income source. The reduction of the price of jute and agricultural products is the main reason of the reduction of agricultural land. And the growth of the need of land for residential purposes people gave priority to cash money rather than cultivating fish which is the main reason of the reduction of waterbody at Mujgunni. This drastic reduction of the waterbody, agricultural land and vacant land accelerates the environmental change at Mujgunni like increase of temperature, change of precipitation and humidity salinity and pH of the water.

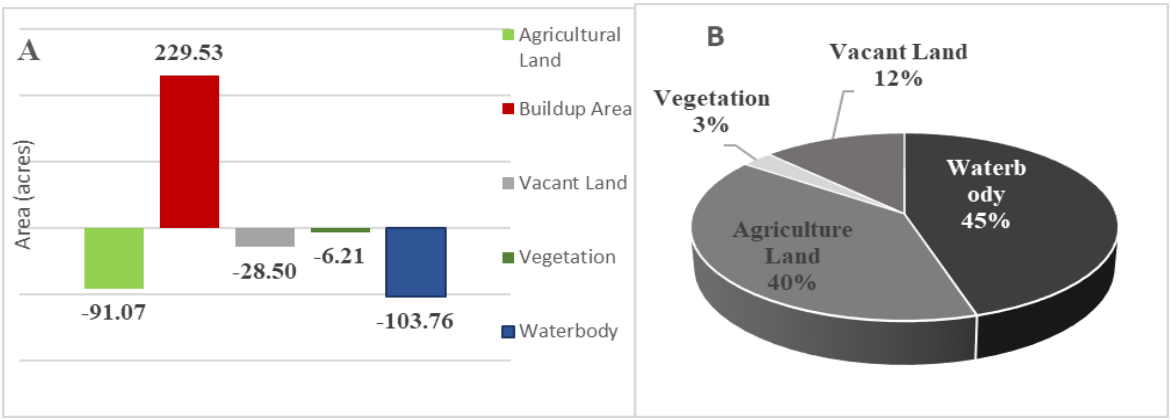

Figure 3: (a) Land Use Change scenerio (b) Transformation of different land use type into build up area at Mujgunni KCC Ward No 9 from 2002 to 2018 (Source: Author, 2019)

Table 2: Land Use Type scenario at the study area in 2002 and 2018 (Source: Author' calculation, 2019)

Land Use Type	Mujgunni Area (acres)		Nirala Area (acres)	
	2002	2018	2002	2018
Agricultural Land	125.77	34.70	35.6	31.2
Buildup Area	64.99	294.52	224.4	272.6
Vacant Land	136.63	108.13	45.1	14.5
Vegetation	308.74	302.53	70.5	68
Waterbody	208.19	104.43	17.1	6.4

3.1.2 Land Use Change at Nirala KCC Ward No. 24

GIS based satellite image classification in Figure 4(a) and Table 2 shows that in 2002, the topmost land use type at Nirala was build-up 224.4 acres (57%) and then vegetation 70.5 acres (18%) , vacant land 45.10 acres (11%), and agricultural land 35.5 acres (9%). But in 2018 with the growth of population and their demand of land for easy and better urban lifestyle, build up area was increased to 272.60 acres. At Nirala, about 30.6 acres of vacant land and 10.7 acres of waterbody transformed in the buildup area to provide housing and facilities to the people that showed in Figure 5.

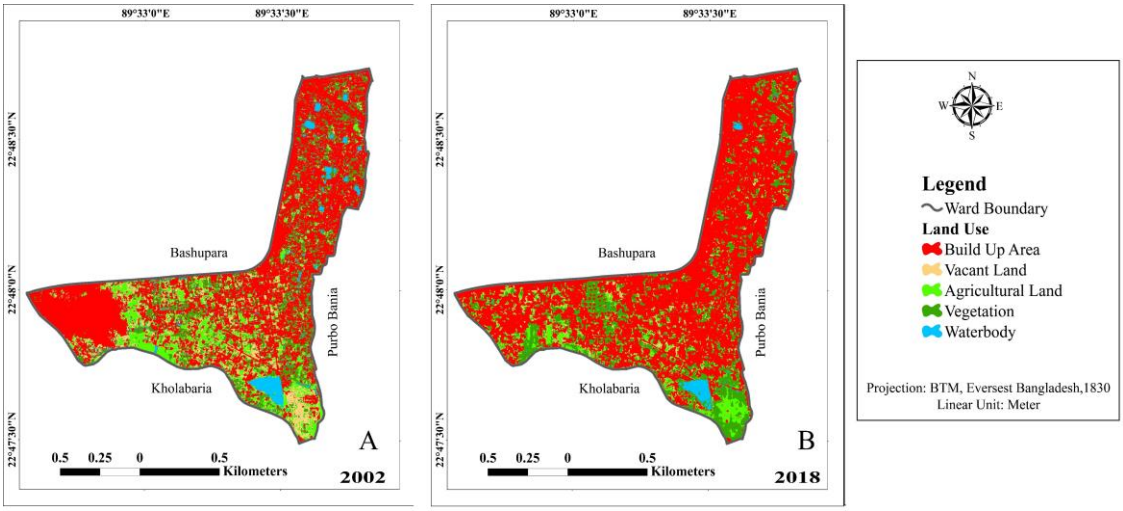

Figure 4: Land use map of Nirala KCC Ward No 24 (a)in 2002 and (b) in2018 (Source: Author, 2019)

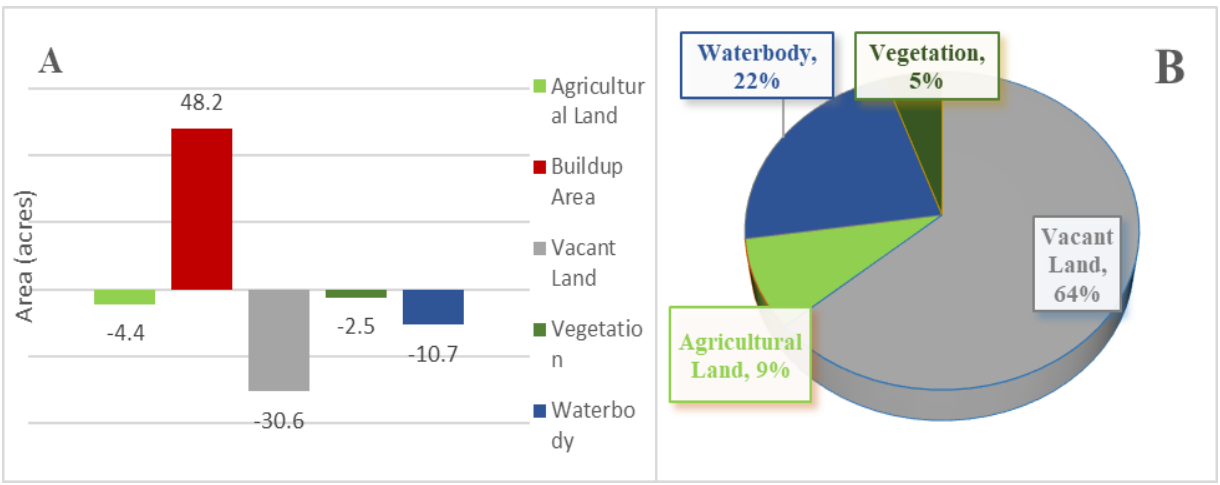

Figure 5: (a) Land Use Change scenerio (b) Transformation of different land use type to build up area at Nirala KCC Ward No 24 from 2002 to 2018 (Source: Author, 2019)

Figure 5(a) shows that nearly 48.20 acres of built up area increased at Ward- 24. This 48.20 acres of land have been used to build a new building to provide housing, amenities, service facilities and construction of roads. The demand for housing and employment is increasing day by day as the population increases. But compared to the demand, the amount of land is low. Considering the cost and adequacy people preferred vegetation, vacant land and waterbody for the development. This transformation of land use type played a negative impact on the environment.

Table 3 indicates the considerably more percentage of vegetation, build-up area, waterbody and vacant land area at Ward No 9 than Ward No 24. That means Ward No 9 is environmentally more sound than Ward No 24 and also have places for future sustainable development. The transformation of these land use type at Ward No 9 in a planned way will be a potential for ecofriendly sustainable development.

Table 3: Land Use percentage at the both study area in 2018

Land Use Type	Nirala, Ward 24	Mujgunni, Ward 9
Agricultural Land	8%	4%
Buildup Area	69%	35%
Vacant Land	4%	13%
Vegetation	17%	36%
Waterbody	2%	12%

(Source: Author' calculation, 2019)

3.2 Environmental Change

Two types of environmental changes, temperature and precipitation change has been calculated in this research from the year 2002 to 2018 by using Mann-Kendall Test.

3.2.1 Annual Average Temperature

As there is only one weather station in Khulna City, the data will same for all of the places in Khulna City. The data represent that the annual average temperature is increased in both KCC Ward No. 9 and Ward No. 24. In 2002, the average temperature was 25.34^{0}C and in 2018 it stood at 26.35^{0}C. The Mann-Kendall test trend analysis results in Figure 6 represents that the annual average temperature was increased by 0.04162^{0}C/year with its average 26.00588^{0}C.

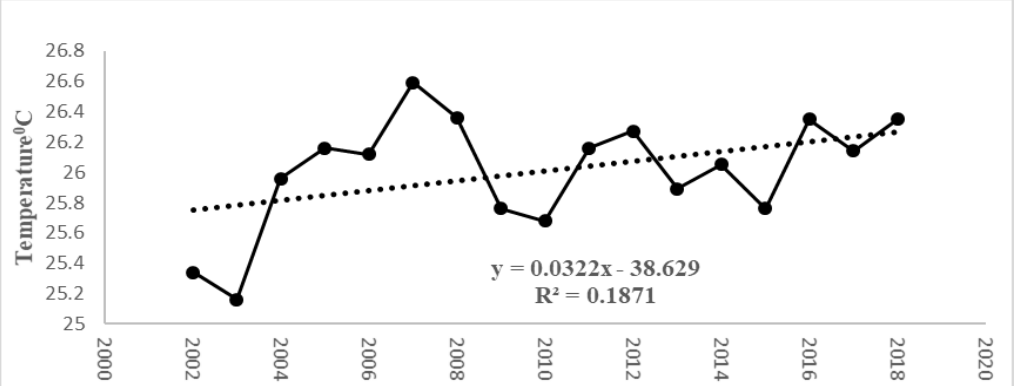

Figure 6: Average annual temperature trend at the study are from 2002 to 2018 (Source: Bangladesh Meteorological Department, 2019)

The increasing trend of average annual temperature coefficient of determination, R^2= 0.1871 which was significant. From the analysis, it is found that the maximum and the minimum observed temperature was 37.63^{0}C and 12.72^{0}C respectively in 2002. In 2018, the maximum observed temperature was 41.14^{0}C and the minimum observed temperature was 9.76^{0}C. It indicates that, the temperature during the summer is increasing and during winter it is decreasing en every year. Changes of land use type and population day by day are the reason behind this negative change.

3.2.2 Seasonal Avrage Temperature

Figure 7 A,B,C and D shows the overall seasonal variation of the average temperature of the both study areas for spring, summer, autumn and winter during the study time period 2002 to 2018 using Man-Kandell Test. The test shows an increasing trend in spring, summer and autumn season, but in the winter season decreasing trends. The value of the coefficient of determination (R^2) for the spring season in Figure 7(A) is 0.132 is moderately significant. Which indicates that the average temperature of spring season in Khulna have increased moderately. But in Figure 7(B), Figure 7(C) and Figure 7(D), the value of the coefficient of determination R^2 is 0.0115, 0.0475 and 0.0384 are not statistically significant. The lower value of R^2 indicates that the average temperature of these seasons has not changed much in the last 16 years in the study area. In rise of temperature in spring is 0.1534^{0}C/year, in Summer 0.02701^{0}C/year and in autumn 0.0076^{0}C/year, but the average decrease of the temperature in winter is 0.00816^{0}C/year.

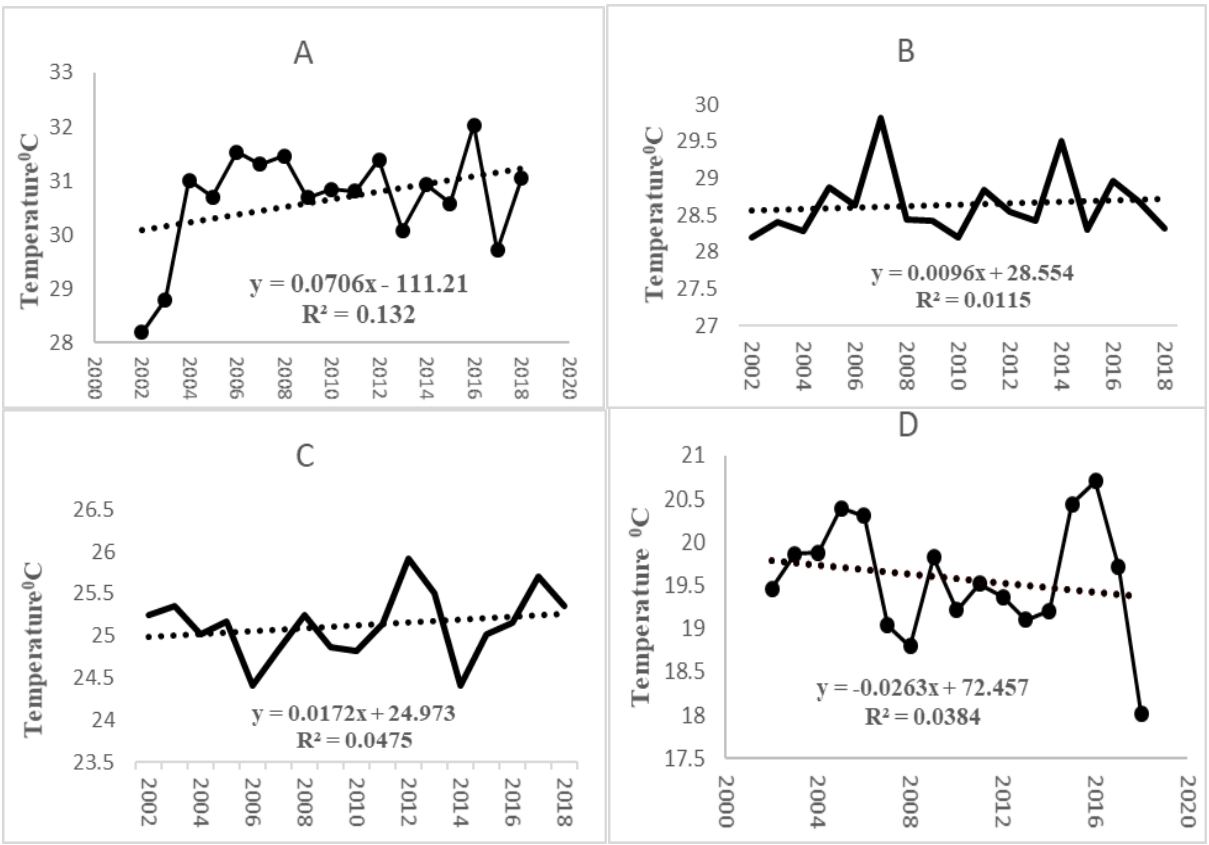

Figure 7: Average seasonal temperature trend for (A) Spring (B) Summer (C) Autumn (D) Winter season during the study period 2002 to 2018 (Source: Bangladesh Meteorological Department, 2019)

3.2.3 Annual Total Rainfall

The total annual rainfall in the study area is showing an increasing trend over the study period 2002 to 2018. Statistics show that the average total annual rainfall of the last 16 years is 1960.101 mm/ year. In 2002, the total annual rainfall was 1507.23 mm, but in 2018 it was found 2528.64 mm. This shows a positive increment of total annual rainfall in the study area during the study period. The highest annual rainfall 4324.81 mm measured in the year 2017 and the lowest annual rainfall 1306.03 was

measured in the year 2005 in the study area. The trend analysis shows that the increasing rate of annual rainfall in the study area is 17.64 mm/year which is a positive sign for the environment.The increasing trend of precipitation coefficient determination, R^2= 0.4518 which was significant (Figure 8). Though annual rainfall has increased in the last 16 years, but the amount of waterbody has decreased due to which water logging and related problems are increasing day by day.

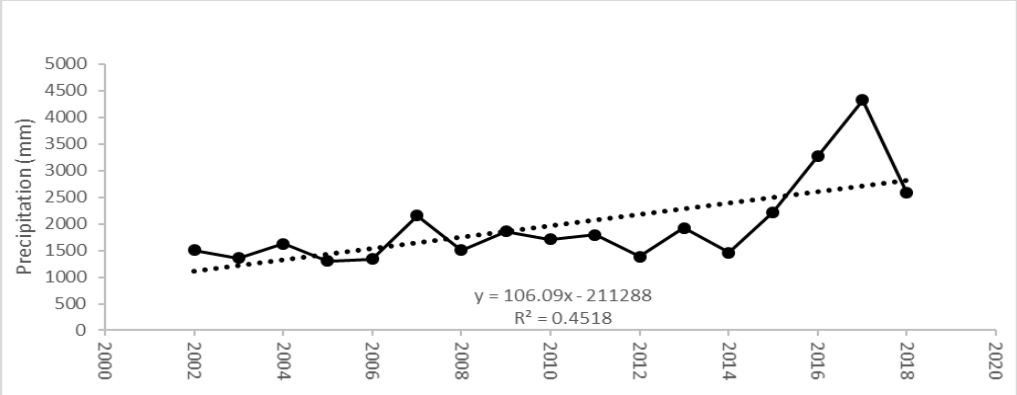

Figure 8: Total annual rainfall trend at the study are from 2002 to 2018 (Source: Bangladesh Meteorological Department, 2019)

3.2.4 Seasonal Total Rainfall

The overall seasonal variation of the total rainfall scenario during the study time period 2002 to 2018 in spring, summer, winter and autumn in the study area represents the gradual increasing trends in all season. The Mann-Kendall Test trend analysis shows that the increasing the total for the spring, summer, autumn and winter are 4.17 mm/year, 5.69 mm/year, 5.15 mm/year and 2.10 mm/year respectively showed in Fugure 9 A, B, C and D.

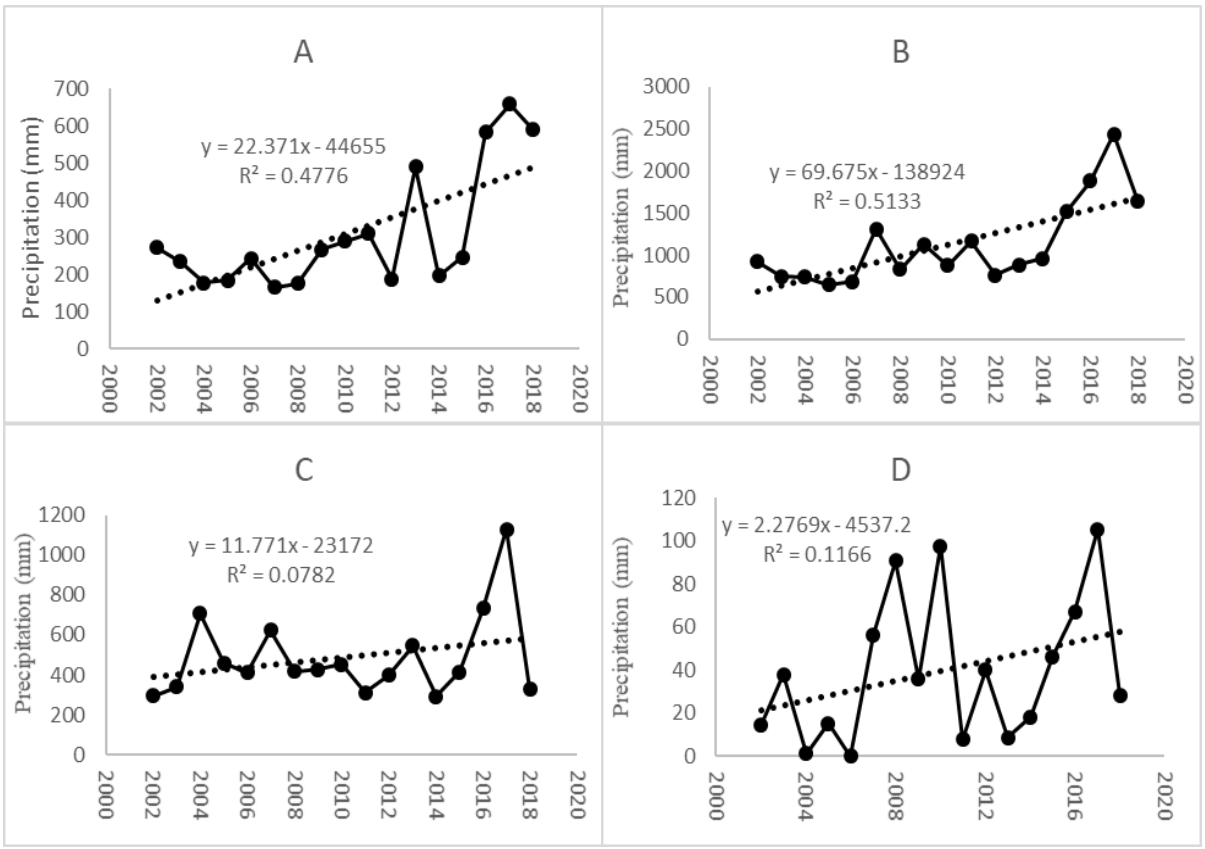

Figure 9: Total seasonal rainfall trend for (A) Spring (B) Summer (C) Autumn (D) Winter season during the study period 2002 to 2018 (Bangladesh Meteorological Department, 2019)

The value of coefficient of determination, R^2 for spring 0.4776, summer 0.5133, winter 0.1166 in Figure 9 (A), (B), (D) indicates that the result was statistically significant for all these season and the average rainfall has increased mostly during the summer season. But the value of R^2 for autumn 0.0782 in Figure 9 (C) indicates the poor increasing rate of average rainfall in autumn during the study period at the study area.

4. CONCLUSIONS

Transformation of land use type of an area in an unplanned and extensive manner critically affects the environment which results in the change of temperature, rainfall, humidity, salinity, etc. But the research focused on only the change of the average temperature and annual rainfall in a developed and a developing area due to their land use changes. The research showed Nirala as an already developed area and Mujgunni as a potential area for future sustainable development due to its moderate percentage of vegetation, waterbody and vacant space. The rapid transformation of land use resulted in the increasing trend of annual average temperature (by 0.04162^0C/year), seasonal average temperature, annual total rainfall (17.64 mm/year) and seasonal total rainfall during the study period. If the conversion rate of waterbody remains same, within a few days there will be a shortage of waterbody in Mujgunni that is what the people of Nirala are currently facing. The increase of temperature boosts the Earth's entropy, leading to rise of water level by melting ice in the pole. As a result, the lowland and coastal areas are becoming more and more destructive and many related problems are coming out. The result is a slight exception because of the high rate of land conversion in the recent years. The study exposed that land use change in an unplanned way has impacts on the environmental change. This type of research will concern people and will further help to plan an area by thinking about the aspects of environmental change for unplanned land transformation.

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