Estimation of Land Surface Temperature Using Landsat by Split Window Algorithm: A Case Study in Bahir Dar Zuria, Ethiopia

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Abstract
Urbanization is global issue that have both positive and negative impact on environment. With the modern development the rural of world changed to urban it may change the livelihood of the nation.in the other hand the rural poor migrating to urban areas this is the negative impact of urbanization in urban area. In the other hand it influencing temperature raise in the city area when compared with surrounding rural. The peri-urban area of Bahir dar is converted to city center, agricultural in around the city gradually converted to residential area. The agricultural land and vegetation in peri-urban of the city converted to different land use, industrial zone, residential. This proses negative impact on the city condition with rise of land surface temperature. Large area of peri-urban of Bahir dar city is surrounded by different industrial zone.This study found that the land surface temperature is increasing gradually between the selected study periods (1995 to 2016). The mean temperature estimated between the selected years are varied depending on the factor considered. The result of this study shows that the mean temperature of the area was 25.7°C in 1995 which became 25.9°C in 2001 and down to 26.4°C in 2010, the temperature in 2016 estimated 28.7°C. The Temperature change between 11 years study periods revealed that 3 °C increased. The correlation between air temperature observed during the study period from meteorological station and estimated land surface temperature is found positively correlated with a R^2 value of 0.84 in 2010 the other year are not done because of the absence of metrological data at the study period. The study found that green space in city center, wetland and water body is very important to moderate land surface temperature. The mayor of municipality have to keep the existing wetland and green space in city center.
Keywords: LST, NDVI, Climate variability, Climate

1. Introduction
The world urbanization is growing extremely with the increasing population growth. According to report (UN, 2008) by the year of 2030, the world's urban population is likely to rise to 5 billion. From this population number about 3.9 billion, with the maximum concentrations being in Asia and in Africa. This implies that there are high correlation between global urbanization and population growth. Different researcher from Climatological studies from different disciplines across the world have proved that urbanization and population growth is the cause of land surface temperature of urban areas. According to (Weng, et al., 2004) LST can provide significant information about the surface physical properties and climate, which plays a role in many environmental processes. Satellite based thermal infrared (TIR) data is directly linked to the LST through the radiative transfer equation (NASA 2015).

The remote sensing is becoming a tool to calculate with in the evaluation and monitoring of environmental and ecological processes. There are different remote sensing product used for estimation of LST. However, for this study land sat in different year used to estimate LST of Bahir dar Zuria. There are many studies in this area in different country by different method.

However, few studies have been carried out to estimate this important climatic parameters for studying urban climatology (LST) in northern Ethiopia. (Worku G. 2016), this research article investigate the relation between LST and NDVI by using Landsat in Addis Ababa city, which is capital of Ethiopia. (*Abineh Tilahun 2015*) this research article mainly examine the application of GIS for estimation of brightness temperature using Landsat. In northern region of Ethiopia there are limited number of study s related with LST estimation.
Therefore, this study intended to bridge this gap which aims to estimate the land surface temperature and shows trend analysis Landsat image acquired on (1995, 2001, 2010 and 2016).

2. Objective of the Study
The main objective of the study was estimating the land surface temperature by using Landsat 5, 7 and 8 thermal bands imagery by using Split-window algorithm methods.
The specific objective to:
- To estimate the land surface temperature of the selected urban area from Landsat.
- To determine the amount of mean temperature increased from the selected time frame (1995 to 2016).
- To analysis relationship between land surface temperatures, normalized difference vegetation

index and land use types in Bahir dar Zuria.

2.1 Study area

Bahir Dar is one of the leading tourist destinations in Ethiopia with a variety of attractions in the nearby Lake Tana. It is located on the southern shore of Lake Tana, the source of the Blue Nile. It lies between latitude 10.95^o and 12.78^{0}N, and longitude 36.89^o and 38.25^o E. There is a climatic variability in time and space in the basin. There is a diurnal difference in temperature.
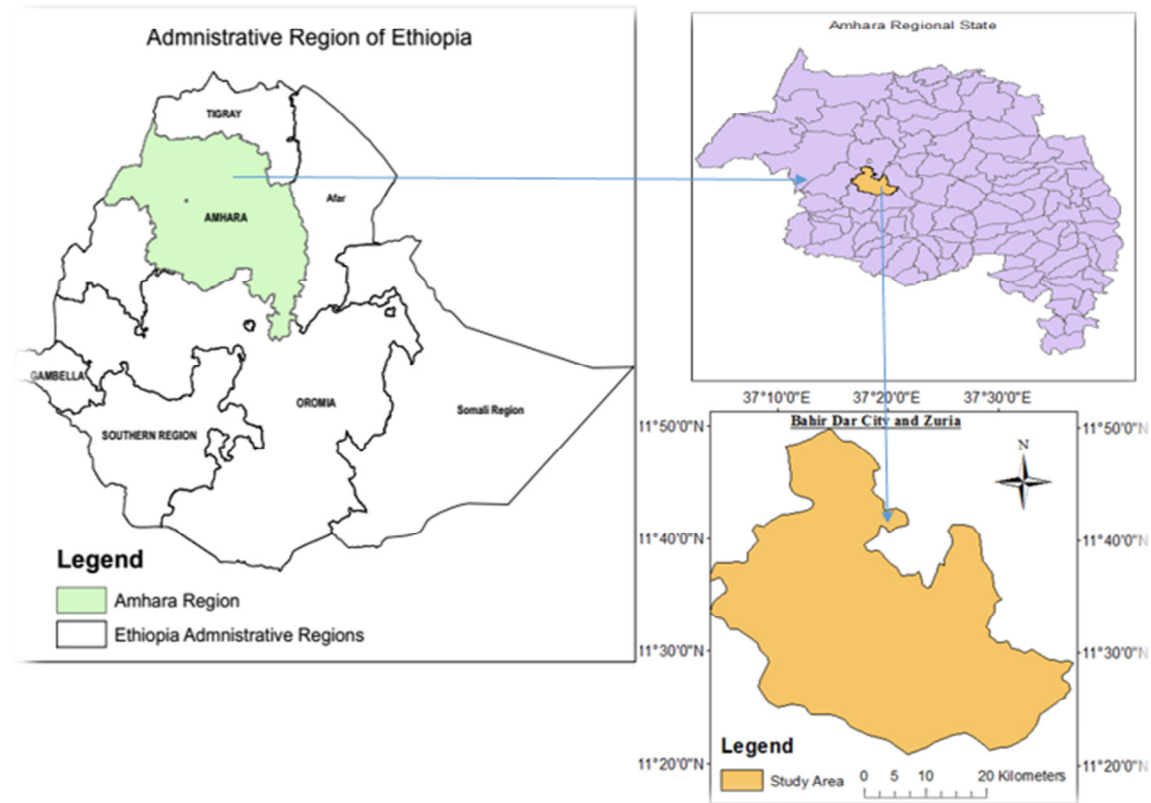

2.2 Data Source and Methodology

The data source used from USGS for assessing LST patterns and their relationship with surface characteristics. Different time period was used to evaluate the increment of land surface temperature in Bahir dar city and Zuria.

Acquisition Date	Sensor	Path	Row	Band	Spatial Resolution
1995-01-28	Landsat 5	170	052	6	30
2002-02-05	Landsat 7 ETM+	170	052	6	30
2010-01-21	Landsat 5	170	052	6	30
2016-01-21	Landsat8 OLI-TIRS	170	052	10 and 11	30

2.3 Methodology

This study used extraction of land surface temperature from different satellite image acquired from USGS. The main proses that utilized in this study is as follows: to come up with the result of the objective the following steps are employed.
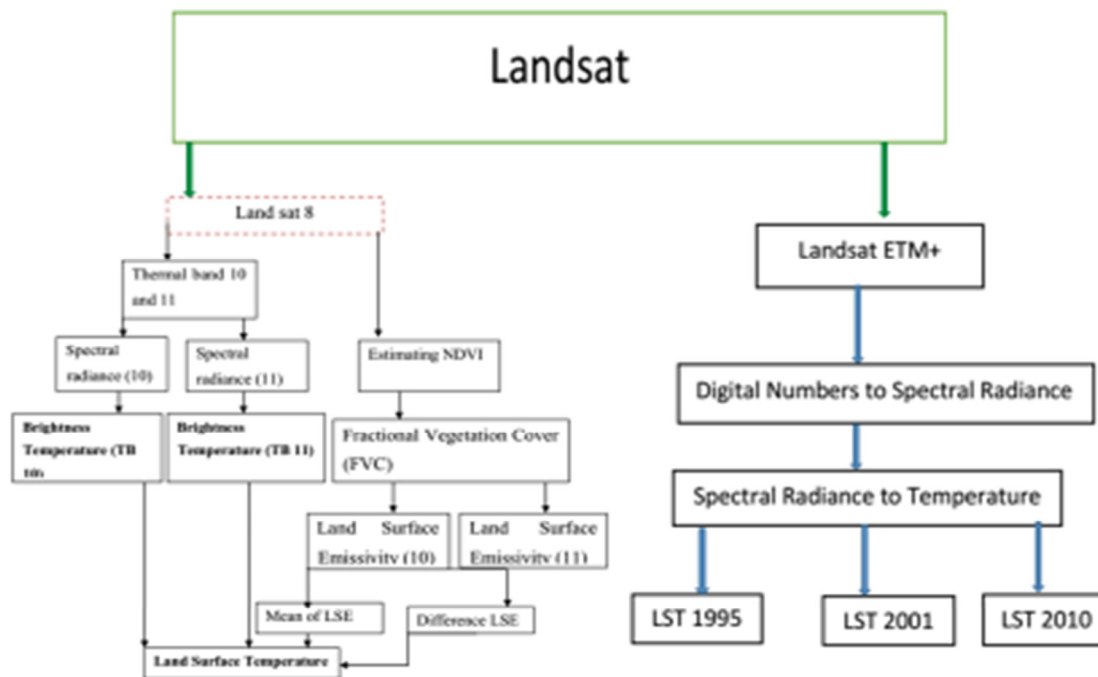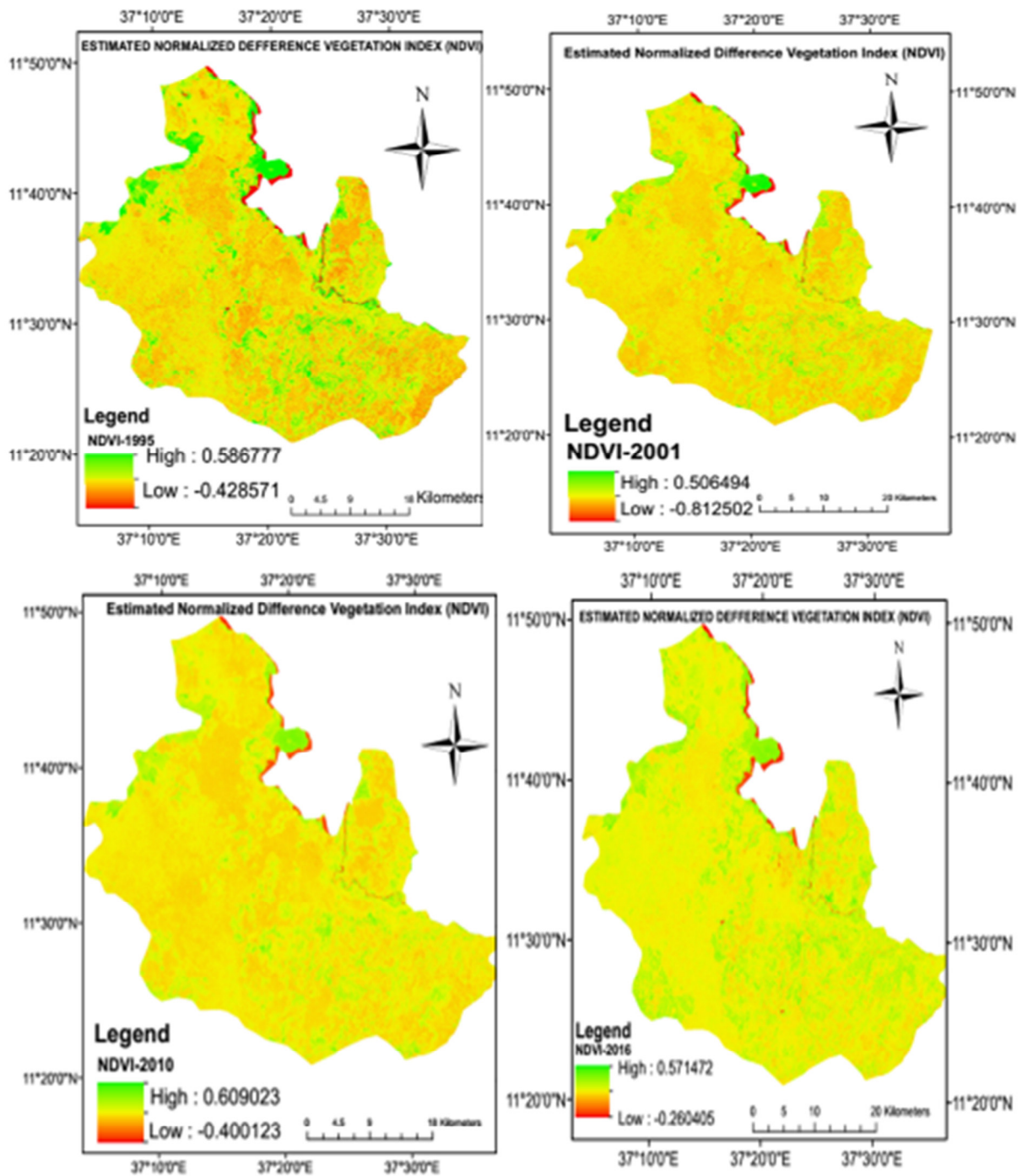
3. Results

3.1 NDVI of Bahir dar city and Zuria

The study area is classified in to agricultural area, vegetative, settlement and urban center. The level of the vegetation coverage also have factor for the temperature increases. The value of NDVI is divided into non-vegetated, semi vegetative and vegetated area. Generally the value of NDVI is range from negative values which is -1 and positive value 1. The middle values which is approximately zero value represent non-vegetated land while positive values represent vegetated land. The following figure illustrates the continuous images of normalized difference vegetation index results to display the distribution of vegetation in Bahir dar and Zuria. The following figure shows the vegetation coverage of 1995, 2001, 2010 and 2016 respectively.

The NDVI values estimated are in the range of -0.42857 to 0.58677 for 1995, -0.8125 to 0.50649 for 2001, while 2010 having a range of -0.4256 to 0.60902 and -0.2604 to 0.57147 for 2016 .This result show that 2010 has the highest maximum value while the result in 2001 indicates that the minimum value. The reason behind less NDVI values in 2001 in recent time wetland around Lake Tana also dryad. NDVI is related with surface emissivity. High land surface emissivity was found in along the side of Lake Tana and Bahir Dar University main campus, along the Abay River, whereas low land surface emissivity was noticed in city center and bare land around the city.

3.2 Land Surface Temperature of Bahir Dar city and Zuria

The main result of this research is to estimate the land surface temperature of Bahir dar city and Zuria. On the figure below shows that the spatial variation of land surface temperature the study area. On the basis of the results derived, it is seen that land surface temperature of the study area showed a substantial increase over the city and Zuria between 1995 and 2016. A gradual increase can easily be identified from 1995, 2001, 2010 and 2016, in fact, there was highest land surface temperatures overall years. In 2010, some what the LST is less when compared with the other year, but the land surface temperatures were still higher than those of 1995. The maximum temperature was 36°C in 1995, 41°C in 2000, 36°C in 2010 and 40 °C in 2016.The average temperature rise from 1995 -2016 by 3°C this increment is between 11 years.

According to Rasul G, Mahmood A, Sadiq A, and Khan SI. (2012) during the 20th century, they estimate that temperatures will increase further between 1.4°C and 5.8°C by 2100 year. From this results the temperature increase by 3 degree centigrade this realize that the increment is between climate projections

indicates that at least a 1.4 to 5.8 °C. This is high climate variability in Ethiopia due to climate change and rise of temperature. In the past, few years Bahir dar city and surrounding land is covered with vegetation, for the expansion of industrial area most land converted to building this is problem to increase the land surface temperature. According to Joshi JP, Bhatt B, 2012 the densification of the vegetation lowers the temperature as it enhances the evapotranspiration that maintains the heat flux. In general for the gradual increment of temperature in Bahir dar city there are many factor to increase the temperature and some factor to limit the increment of the surface temperature. The first factor is Due to its proximity to Lake Tana and secondly, because of its rapid urbanization especially over the past few decades is main factors. Natural factors such as water body such as Lake Tana has a moderation effect on a climate factor such as temperature on account of its current inertia. The following slide address the probable factors for the impact of rise of land surface temperature in Bahir dar and Zuria.
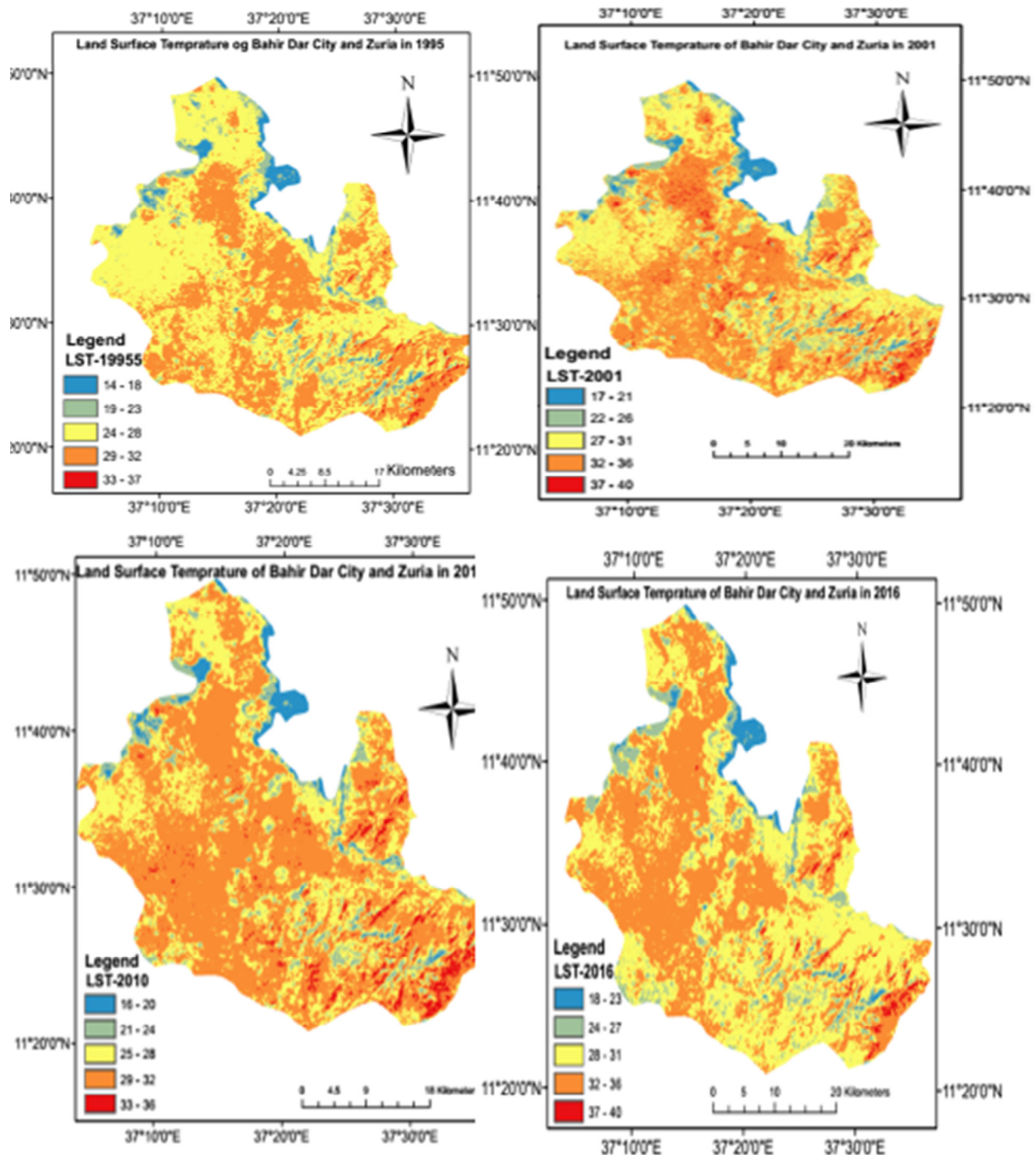
3.3 Probable Cause rise of temperature in Bahir dar city

From it nature it is observed that the vegetation cover and water body areas which act as heat sink have relatively lower temperatures. One of the most regulator of local climate variability is wetland, Lake Tana basin there are different forms of wetlands. The wetlands in the Lake Tana basin comprise one of the largest wetlands in Ethiopia. They are mainly located surrounding the Lake and are flooded during the rainy season. According to (BNWI Report 2014) LULC change between 1986 and 2013 has indicated a total of over 52% of wetlands is converted to other land use forms. About 1259.1 ha (19.6%) is converted to farm villages with trees and cultivation. About 1388.9 ha (23.4%) is converted to intensively/moderately cultivated land. About 233.2 ha (3.9%) is converted to natural/plantation forest (this could be trees in swamps), about 193.52 ha (3.27%) is converted to water body (this could be the Lake is regulated by Chara-Chara weir). about 501.23 ha (8.46%) is converted to woodland. Level of Lake Tana drops during the in dry season, the shore area become available for agriculture. This drive farmers to cultivate this area in surrounding the tana side. The wetland areas are severely degraded due to siltation, conversion into cultivation and overgrazing. Therefore this type of change response negative feedback for the land surface temperature in local area. Even for climate variability and also affects the water balance of Lake Tana.

3.4 Forest coverage in the study area

Conversion of natural forest land to other land uses resulted in damaging effects on soil moisture content in the soil. According to Wubneh and Goraw, (2013) land use land cover of Lake Tana area report unpublished document. According to this report in Lake Tana basin a total of about 116358.5 hectare of forest was lost or converted to another land cover during the period 1986–2013. The existence of vegetation or forest on the surface of the earth is very important for the moderation of land surface temperature also monitoring the climate variability. Forest also very crucial role in to absolve the CO_2 from the atmosphere. However, the above report asses the land cover of tana basin converted to agricultural land and other type of land, this speed up the increment of land surface temperature.

According to Atalel Getu Sahalu. (2014) there was an increased expansion of built up areas in the last 25 years from 1.5% in 1986 to 4.1 % in 2001 and 9.4% in 2010 at the expense of agricultural areas. In the study are in different direction of peri-urban of Bahir dar city is converted to urban area. The construction material also have matter of the surface reflectance in industrial zone in our city, steel used in industrial zone also great contribution on the increment of LST.So that we have to consider the type of land to convert for industrial area and type of constriction materials. Around yibab campus, Bahir dar university the surface of the land is covered by white material this surface have negative reflection for the radiation from the sun, However rapid Urbanization on the other hand, has the effect of creating urban heat island (UHI), which increases LST. This contribute great for the increment of the LST.

3.5 Mean temperature

Even if the Bahir dar city is regulated by it natural gift of Lake Tana and different wetland around the city, land surface temperature increased according to this study. The above discussed problem is causes the increment of the mean temperature of the city and Zuria. For different reason the temperature in Bahir dar city is increasing from 1995 to 2016 According to this study results the mean temperature was 25.7°C in 1995 which became 25.9°C in 2001 and down to 26.4°C in 2010, the temperature in 2016 estimated 28.7°C. Result shows that land surface temperature gradual increased from 1995 to 2016. On this Lake Tana and wetland in Lake Tana has great role to regulated land surface temperature tana. The following graph shows that the time series of and surface temperature within the study period.

Mean Temprature of Bahir Dar City and Zuria

$y = 0.1293x - 232.66$
$R^2 = 0.762$
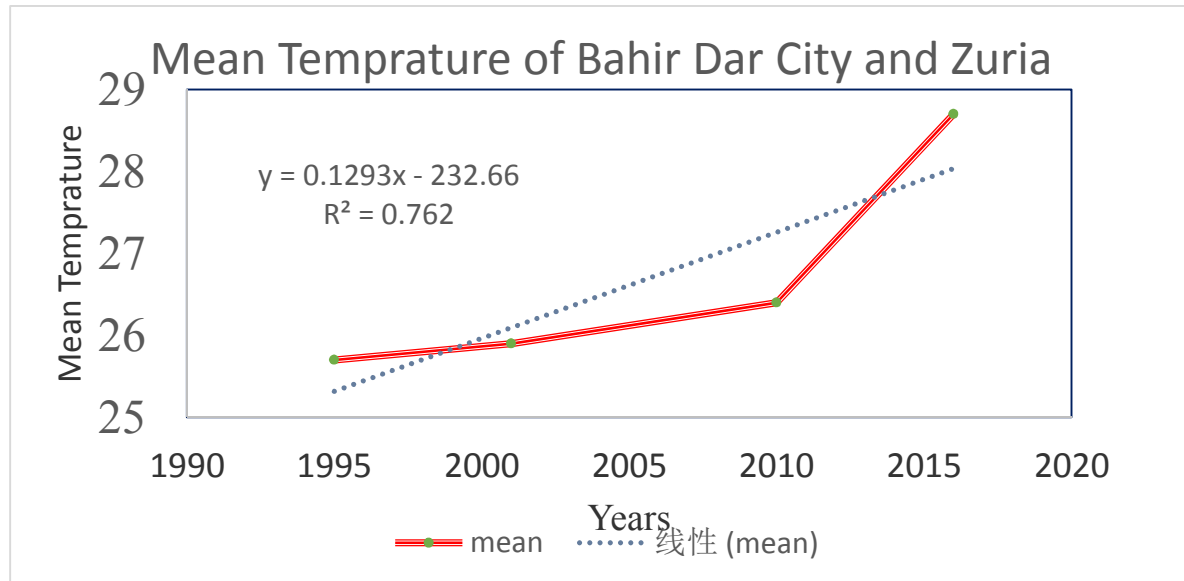
## 3.6 Correlation of LST from Remotely sensed data and air temperature

This step aimed to validate the results of land surface temperature obtained using the remotely sensed data. The data used in the analysis included meteorological data from 4 stations (Bahir Dar, Tiss-abbay and Zegie) found in the study area. In addition to this Merwai station is used for the correlation. For the validation of the study 1 station outside Bahir dar Zuria is added is used namely Merhawi, Tiss-abbay, Bahir dar and, Zegie. All Data were collected from all station January 1995, 2001, 2010 and 2016. The following figure shows the station used: Statistical regression analysis was used to establish a relationship between the estimated Land surface temperature from Landsat image values and the measured air temperature values from weather station within the study area of Bahir dar city and surrounding.
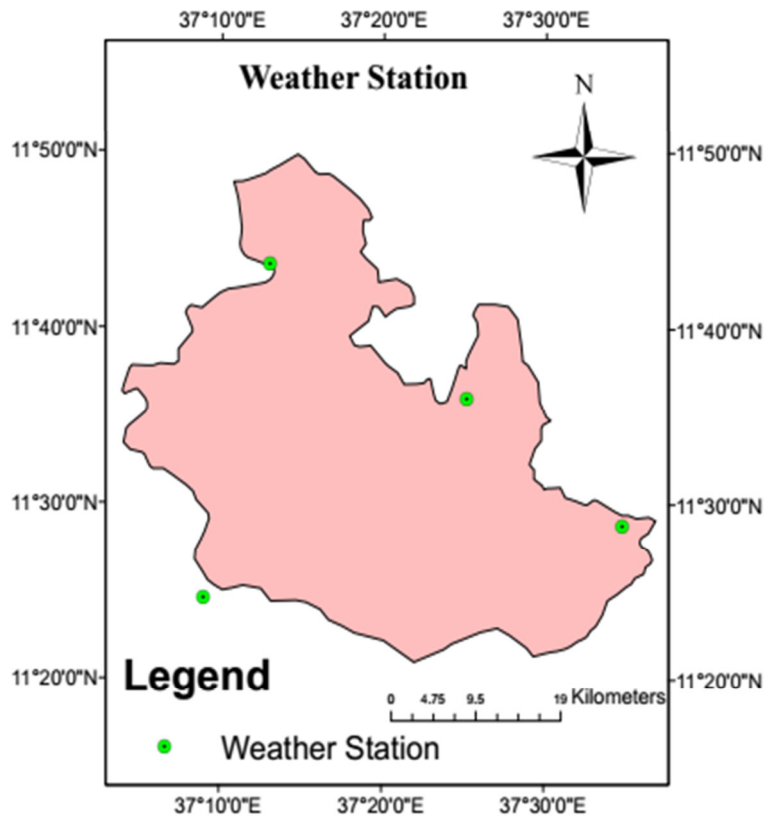
Although it is not possible to establish a direct link between air temperatures and land surface temperatures due to unrecorded of data in some stations processes affecting land surface temperatures. An

analysis of air temperatures can provide information about the changes in general climatic conditions in the basin. For the years included in the analysis (i.e., 1995, 2001, and 2010). The only station have full of data were in 2016 all station have full of data so that 2016 is used to validate the correlation between the data type. Based on this information from this correlation, we can say that the changes detected in air temperature data at three stations were similar to the range of changes detected with LST data over the basin. The highest air temperatures observed in LST values over the basin were most probably related to January of 2010 being much hotter than that of other years.

To summarize the finding, climatic conditions in the Bahir dar city and Zuria showed some changes during the 1995–2016 period. The resin that why the air temperature rise in the city as discussed above section. The results obtained with weather data support the findings obtained from the analysis of satellite images data.
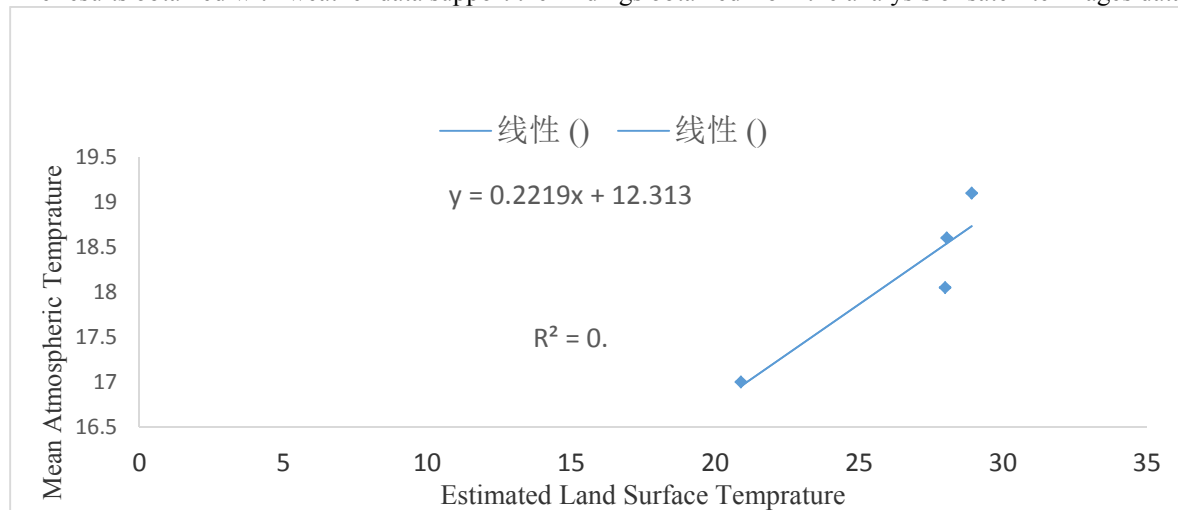
4. Conclusion

According to the Findings show that land surface temperature of the Bahir Dar City increased during 1995-2016 due to human activities and natural causes. The LST of the Bahir Dar City shows a strong differentiation in LST between urban and more vegetated areas. The overall, this study found that very high temperatures in the highly urbanized areas and Low temperature in side of Lake Tana, wetland and vegetated areas. Green vegetation have shown to have moderating effects on LST temperatures. Higher LST directly affect human comfort levels and energy use. The study showed that green spaces help urban areas adapt to the impact of climatic change. However, land use and land cover trends in the study area show that vegetated areas are increasingly being converted to industrial zone in the study area .Especially the preservation and increase of open space within the city Centre, next to protecting the peri-urban green zone, should be promoted in helping adaptation. Clear guidance is needed for local and provincial authorities and other practitioners on how best to manage public urban productive green spaces in order to respond to climate change.

5. Recommendation

In General, the results indicate that lower LST observed in wetland, vegetation but, agriculture land or bare land has higher LST. Urban area or settlements have highest temperature in both Landsat 8 and Landsat 5 and 7 ETM+ land surface temperature.

Depending on the result of this investigation the recommend the following recommendation.

- Wetland also very important to regulate the land surface temperature.
- By keeping the wetland water body and vegetation we have to mitigate climate variability, other ways the variability changed to climate change in long time variability.
- Increasing the green space in city center is a rational approach for adapting to climate variability in city.
- To help mitigating the effects of future climate, and benefit human wellbeing by improving water and energy use efficiency.

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Notes

Note 1. This is an example.

Note 2. This is an example for note 2

Table 1. The capitals, assets and revenue in listed banks

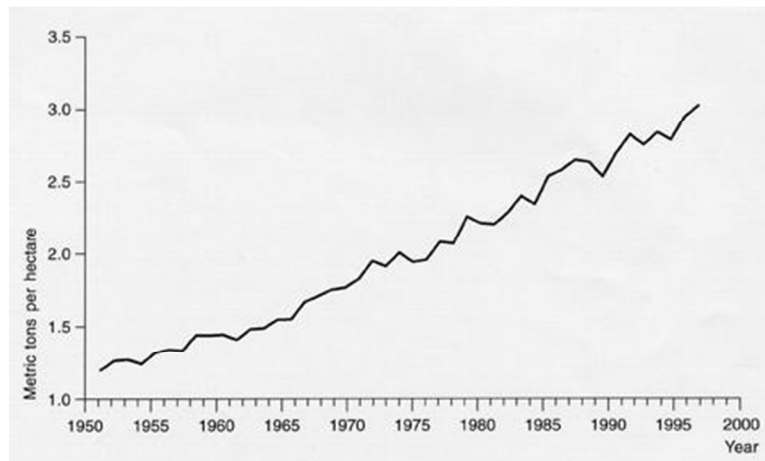|	Total capital stock	Income of main business	Total assets
Pudong Development Bank	39.2	214.7	5730.7
Bank of China	459.4	3345.7	59876.9

Description for the above table.

Figure 1. The Trend of Economic Development
Description for the above figure.