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Analytical Review of Land Use Changes by Remote Sensing and GIS Techniques in District Gujrat, Pakistan

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Abstract: Assessment of changes in land use and land cover through remote sensing and GIS is very important and key analysis. Urbanization has been continued by the rapid growth in the world economy so; it is the key study with regards to agriculture and urbanization. The aim of this study is to determine the loss of agriculture land and effects of increasing urbanization on surface temperature. For urban temperature impact analysis, distinctive time series of Landsat images have been chosen. Temporal analysis for different time series shows the decrease in agriculture land and increase in built up area. Urbanization increased the temperature up to 2^0C. Positive correlation is found between built-up area and temperature and negative correlation is found between green spaces and temperature. Unplanned urban sprawl and lack of proper irrigation system according to population are major problems in study area. Recent study will be helpful for decision makers to develop the sustainable environment policy in future.

Keywords*:* Normalized Difference Vegetation Index (NDVI), GIS, land use, urbanization, and variations*.*

Introduction

Land is apparently a victor between the most significant features of assets, meanwhile all the formative activities of life are focus to it. Land use (LU) is an indispensable parameter to study the general land status of the surface (Fernandez, 1992).

Change in land use, land spread and economic activities influence the environmental change in and around the urban societies. There are different causes which are steady for urban/country temperature like change in the physical features of the zone (warm limit, albedo, heat conductivity) like less vegetation as a result of cement and black-top, change in also the rate of evapotranspiration and radioactive changes because of complex geometry of elevated construction and roads and anthropogenic warmth removals (Zubair, 2006).

The most oppressive issue in urban regions is rise in surface temperature. At the point when vegetative areas are changed over in-built-up lands, it influences the surface temperature by most extreme retention of sun-based radiation, dissipation rates, heat build-up stocks, contradicting wind and huge changes in the close surface climatic states of the urban communities (Weng, et al., 2004).

Vegetation is an essential component of worldwide condition. It adjusts the biological system through water conservation, earthbound soil consistency and barometrical flow. It likewise supports equality of biological system noticeably. Fast development of urban communities decreases the vegetation regions. Topographic changes incorporate loss of wood lands, reduction of horticultural lands expansion of infertile land due to the developed region (Kumar et al, 2012). These are contributing elements which increase the temperature in urban areas (Takeuchi et al., 2010)

In human history, urbanization expanded when the change of land started with the development of population and financial exercises. Development of structures or roads has an incredible effect on atmosphere. Urban zones naturally hold the higher sunlight-based radiation. As a result, more heat is stored all the day and discharged in the evening time. Consequently in general, urban areas are experiencing higher temperature as compared to its adjoining calm areas. Transportation, industries and inner-city houses are responsible for the high temperature. Changes of temperature between the rural and urban areas are typically moderate. It is nearly 2 to 3, to a few degrees in urban climatic and topographical conditions which are responsible to increase temperature.

Landsat 7 ETM+ and Landsat 8 OLI/TIRS are broadly used to detect the land use variations and build models for monitoring the biophysical structures. Thermal band of the Landsat images is used to monitor temperature variations. To control the atmospheric conditions, a model can be built by calculating the radiation spending plan. The data about land temperature are very critical to deal due to numerous factors, like different human activities, urban climatology and worldwide ecological changes. Previous researchers (Weng, 2001; Elsayed, 2003; Alavipanah et al., 2007) reused the remotely distinguished pictures for outline Landsat pictures to consider the LU variations and produce landuse guide and surface temperature map. A few analysts considered the effect of LULC on temperature of land

(Carlson, 2000; Chen, 2006 and Xiao, 2007) that was observed to be decidedly corresponded among LULC and temperature. Researchers surveyed the relationship between the abundance of plant and land temperature (Weng et al., 2014). Normalized difference vegetation index (NDVI) was used to signify the vegetation abundance. The outcomes sustain the negative relationship between NDVI and land surface temperature (Owen et al., 1998). In recent study, principal focus is to feature the reality of striking deterioration of vegetation cover due to fast urbanization and its effects on urban microclimate and surface temperature.

Study Area

Gujrat is a district of upper Punjab, Pakistan. It is situated between 32.5731° N and 74.1005° E (Fig 1). Its elevation calculated by using ASTER digital elevation model (DEM) which is 233m or 764 feet. Gujrat district extends over an area of 3,192 km^2, it is surrounded by the Jhelum river in northwest on the west by Mandi Baha Uddin. Population of Gujrat district is 2,756,110 (Table 1). Its climate is moderate and temperature reaches up to 24-45 °C (June to September). The ordinary sleet at Gujrat is 67 cm and mean annual precipitation is around 629 mm consistently (PMC, 2017).

Table 1. Population of Gujrat district

Gujrat Population -2017			
District	**Region**	**Population**	**No of HH**
Gujrat	Total	2,756,110	442,399
	rural	1,928,714	308,668
	urban	827,396	133,731

Source: Pakistan Bureau of Statistics, 2017

Materials and Methods

Data Collection

In recent study, satellite images of 2000, 2010 and 2018 were downloaded from the website of United States Geological Survey. Detailed description about the methodology used in study is shown in Table 2.

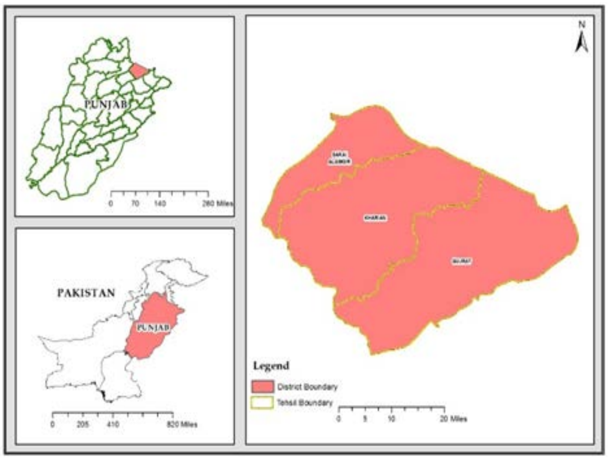

Fig. 1 Location map of study area.

Image Classification Process

From satellite images of Landsat5, 8 OLI/TIRS acquired the training sets for classes of built up, vegetation, water and barren land. These representative samples were based on spectral signatures. For digital image classification, software determines each class on the resemblance basis mostly in the training set. Supervised classification technique was selected and calculated the results.

Table 2. Details of satellite data and its purpose

Data Type	Source	Description	Resolution	Purpose
DEM	Department of Geomatics CEES, PU	ASTER DEM	30 meters	Geospatial Analysis
Satellite Images	Earthexplorer.usgs.gov	Landsat 5, 8 OLI/ TIRS	30 meters	LU/LC Classification

Estimation of Normalized Difference Vegetation Index (NDVI)

Vegetation which is active to the degree of photosynthesis has less estimations of reflectance in red bit of EM spectrum (Jensen, 2005). NDVI is the best tool to compute the quality and amount of vegetation on the selected surface (Lillesand, 2004). For this purpose, satellite images are required.

$$NDVI = \frac{(NearInfraRed - Red)}{(NearInfraRed + Red)} \quad \text{(Eq. 1)}$$

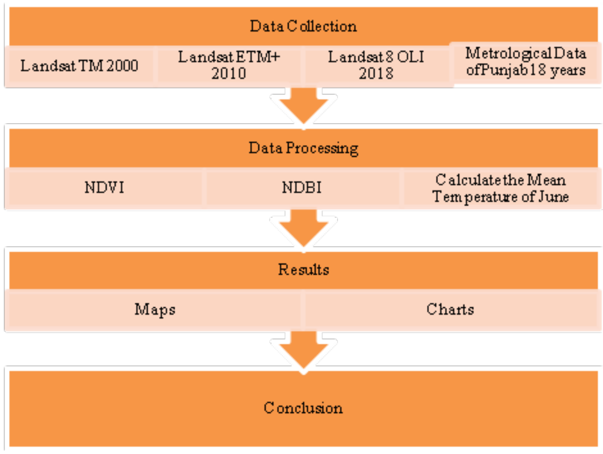

Fig. 2 Methodological framework of study

NIR and Red bands from Landsat 5 and Red and NIR bands from Landsat 8 are used to compute NDVI. Normally, strong vegetation throw back a larger part of the near-infrared and captivate the greater part of the visible light. Deficient or undesirable vegetation reflects less near infrared and more visible light area. In contract, bare soil modestly reflects the infrared and red parts of electromagnetic radiations. (Lillsand, 2009) and result will be zero. The standardized esteem is between 1<=NDVI<= - 1 to record the changes in warmth and surface gradient. In present study, NDVI results are derived from the Landsat TM, ETM+ and OLI/TIRS images for the years of 2000, 2010 and 2018.

Temperature Variations

Temperature change with the passage of time. Present study shows that temperature in 2000 and 2010 is lower than 2018. Temperature interval rises in summer which is an effect of global warming. Annually mean heat of June is considered in this study and interpolation technique (IDW) is used to monitor the temperature variations. Formula for IDW is shown in equation 2.

$$z_p = \frac{\sum_{i=1}^{n} \left(\frac{z_i}{d_i^p}\right)}{\sum_{i=1}^{n} \left(\frac{1}{d_i^p}\right)} \quad \text{(Eq. 2)}$$

In equation 2, sigma represents the means including any kind of number which is interpolated and thermal band calibration remains constant.

Results and Discussion

The key purpose of this research was to identify the variations in built-up areas, plants and surface temperature due to expansion of district Gujrat. The values of NDVI and temperature were also calculated for the years of 2000, 2010 and 2018.

Effects of Urbanization in Different Time Periods

In 2000

Analysis of satellite image for 2000 in the month of June shows the different classes of land use: plants, water, built up and bare soil. (Fig 3a). Study shows that, in June 2000, 2.02 sq.km region was covered by water, 123.91 sq.km was covered with plants, 71.79 sq. km with uncovered Soil and developed area was about 2.39 sq.km. (Fig 3b).

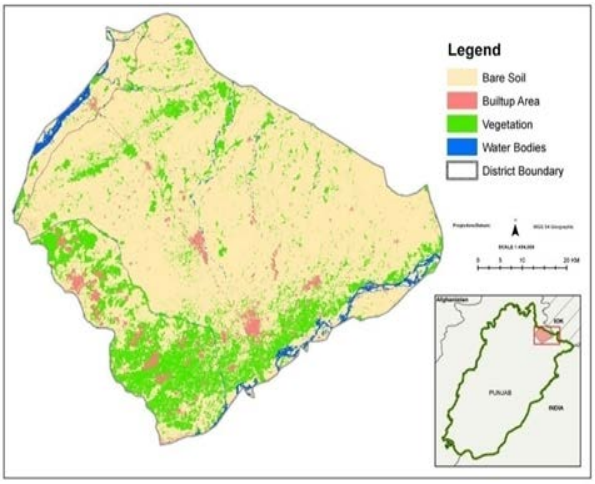

Fig. 3(a) Map of land use classification in 2000.

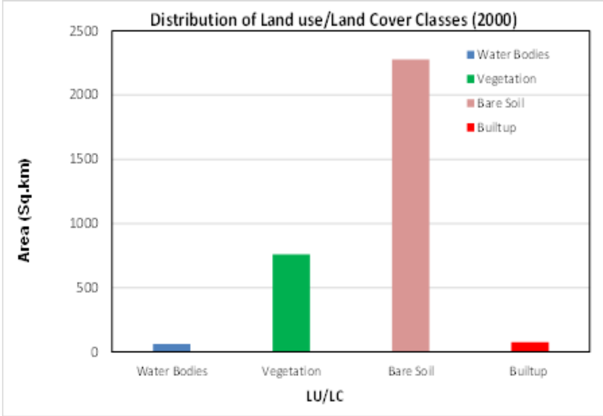

Fig. 3(b) Distribution of LU/LC classes for the year 2000.

In 2010

In June 2010 area protected with vegetation and water was 1382 sq.km and 26 sq.km respectively. The 1634 sq.km zone was found with unproductive area and built-up zone was about 133 sq.km. Area of each class in the middle of June 2010 was indicated in Figures 4(a, b).

In 2018

In June 2018, water coverage was 67sq.km. Vegetation cover was 2321 sq.km. 2680 sq.km part was revealed as unproductive land and built-up area is covered by 196 sq.km.

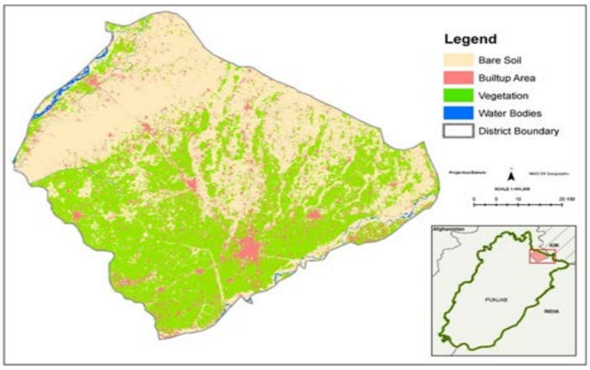

Fig. 4(a) Map of land use classification in 2010.

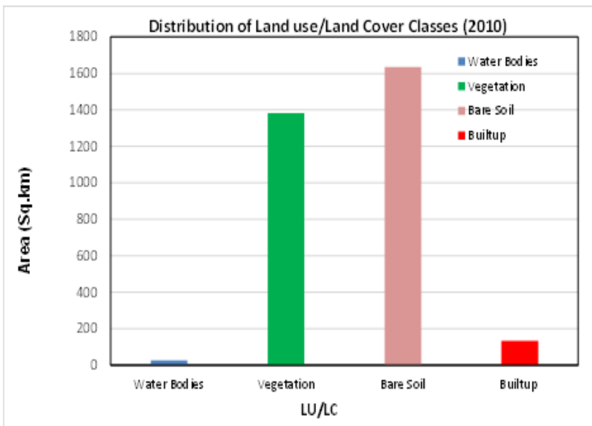

Fig. 4(b) Graph of LU/LC classification in 2010.

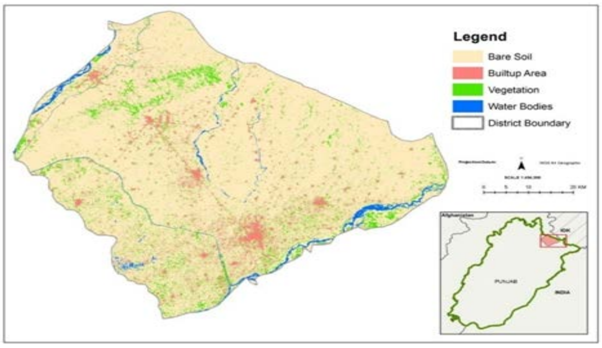

Fig. 5(a) Map of LU classification in 2018.

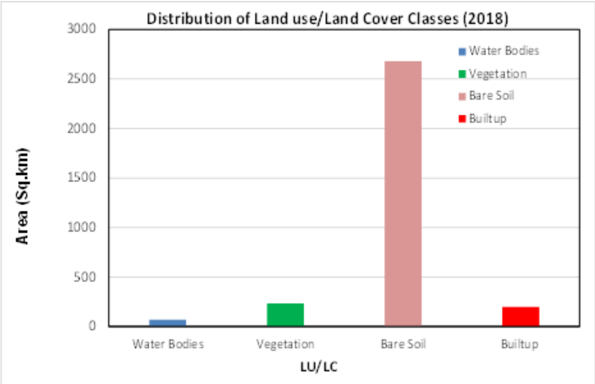

Fig. 5(b) Graph of LU/LC classification in 2018.

Effect of Temperature in 2000

Figure 6 demonstrates the estimated mean monthly temperature of June 2000. Red area shows high temperature with the range of 37 to 38 °C, orange shows between 36-38 °C, yellow area reflects 34 to 36 °C and green shows the base temperature of the Punjab. Central Punjab generally experiences more temperature equal to 37 or 38 °C and northern Punjab experiences less temperature as compared to central Punjab. The study area in north side has experienced relatively higher temperature ranging between 31 to 34 °C in 2000.

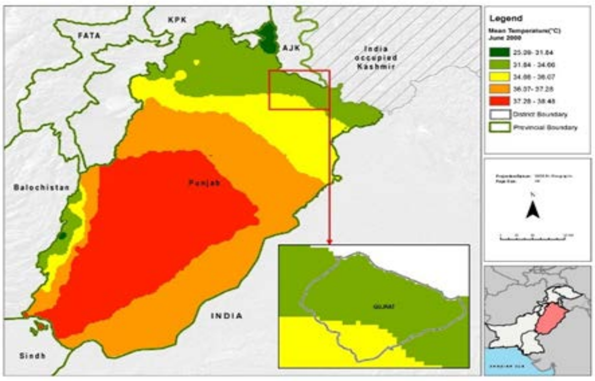

Fig. 6 Temperature map of Gujarat district.

Effect of Temperature in 2010

Figure 7 shows the estimated mean monthly temperature of June in the year 2010. The results show that the southern part of Gujarat has encountered more temperature ranging up to 36 to 37 °C, whereas northern part of Gujrat experienced high temperature (31 to 34 °C) in 2010.

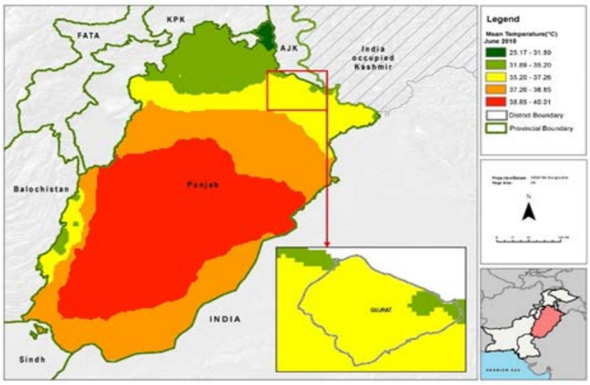

Fig 7: Temperature map of Gujrat district – 2010

Effect of Temperature in 2018

Figure 8 shows the month to month mean estimation of hotness in June 2018. This figure demonstrates the lower temperature that is with the range of 31 to 35 °C and higher temperature with the scope of 35 to 37 °C Hence, the south side of Gujarat area experienced high temperature of 35 to 37°C, which appears in shading yellow and polar side of Gujarat had more temperature with probability of 31 to 35°C which is shown in green colour.

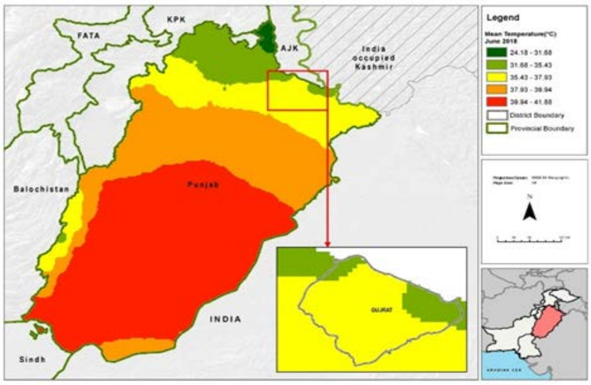

Fig 8: Temperature map of Gujrat district – 2018

Difference between NDBI, NDVI and Temperature values

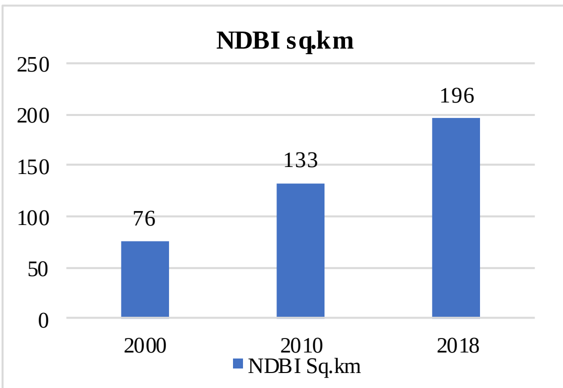

Fig 9 Minimum and maximum value of NDBI during 2000, 2010 and 2018

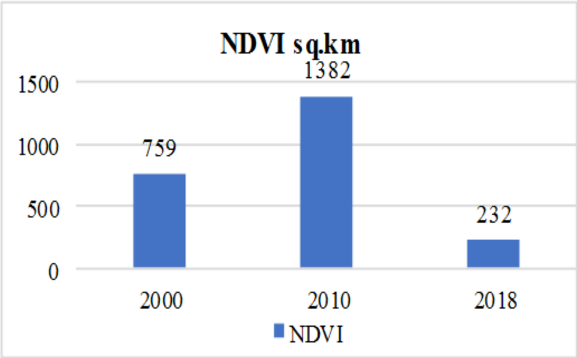

Fig 10: Minimum and maximum value of NDVI during 2000, 2010 and 2018

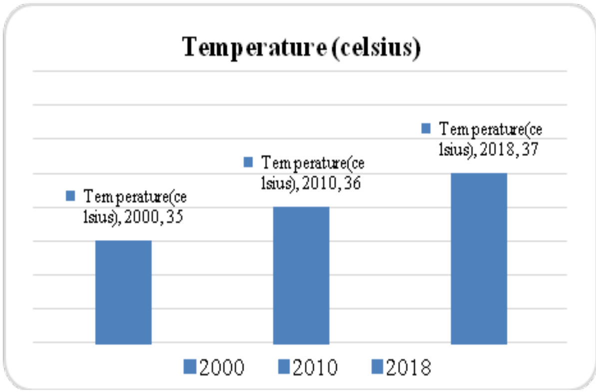

Fig 11: Average Temperature in 2000, 2010 and 2018

Correlation between Temp and Vegetation of District Gujrat

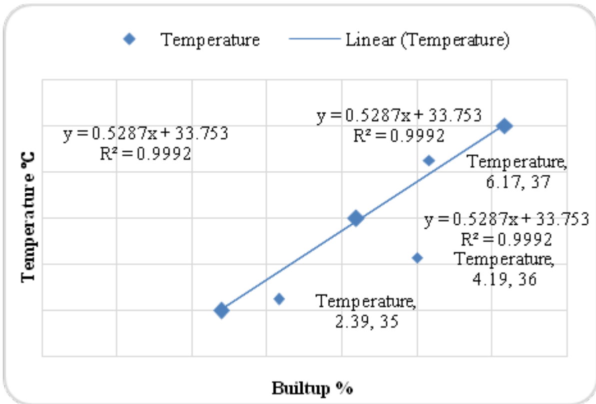

Fig. 12 Linear regression analysis between built-up and temperature in Gujrat.

Correlation between Temperature and built up of district Gujrat

Figure 12 shows strong linear relation which is divided by the regression model for three years (2000, 2010, and 2018). The linear regression showed the positive relation between the expansion in the developed area and surface temperature. This reflection is basic, as urbanization caused the high land surface temperature. Thus, the urban planners should consider the urban development with lower built-up and higher vegetation in future.

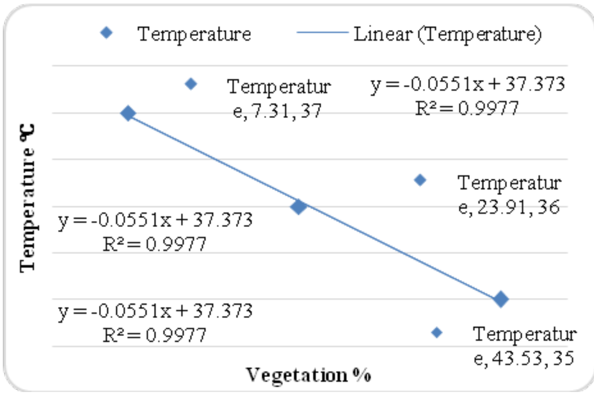

Fig. 13 Linear regression analysis between vegetation and temperature in study area.

Correlation between Temperature and Vegetation

Figure 13 shows that there is negative correlation in this linear regression analysis with diminishing green spaces, land temperature is increased. For the green spaces, a negative relationship is estimated between the two factors. Due to less vegetation, surface temperature increased.

Conclusion

The proposed NDVI and temperature values reflect the impact of urban development on study area. The surface temperature is increased because of settlement development, different types of economic exercises, decrease of vegetation covers and sudden climatic changes. NDVI value is found negative in urban areas. Basically the NDVI and temperature are the top applications to know the temperature of the district and NDVI confirms the area of the vegetation cover. Results show the deleterious link between temperature and NDVI and positive correlation between built-up (NDBI) and temperature. Less vegetation and increase in urbanised area lead to increase surface temperature. The central section shows higher emissivity value as settlement structures and surface of soil affect the temperature. Satellite data showed higher degree of temperature of area, where ground-based observations of temperature (PMD stations) were recorded. The results show an irregular pattern of temperature and vegetation in the study area.

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