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Importance of Local Climate Zones and Urban Heat Island study in Nepal

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ABSTRACT- Various scientific research and literatures have documented the effect of urbanization on local climate**.** Urban rural temperature and humidity difference i.e. Urban Heat Island (UHI) and Urban Dry Island (UDI) respectively have been reported for cities and regions worldwide, mostly with local field sites that are extremely diverse in their physical and climatological characteristics. Generally, the UHI study relies on simplistic descriptors such as "urban" and "rural". While these descriptors may be evocative of the landscape, they are insufficient in providing information like its site properties which have direct impacts on the surface layer climate. To fulfil the gap and for the clarity "local climate zone" (LCZ) classification is a very good tool. Each classification is unique in its combination of surface structure, cover, and human activity. The standard framework for each zone helps to classify an area for reporting and comparing field sites and their temperature observations. The LCZ not only helps in UHI and UDI study but also helps in planning smart environment and human friendly cities, landscape, and global climate change investigation. Nepal now being a federal state, many states having smart developmental drive of cities focusing only on physical infrastructure without considering UHI effect must incorporate study of cities by LCZ for sustainable urbanization.

KEYWORDS- Urban Heat Island; Local Climate Zone; Surface Fraction

1. INTRODUCTION

The land surface interface is a key component of the climate system since it provides coupling between land and atmosphere. The urban land surfaces are largely composed of buildings and paved roads, therefore clearly distinguished from natural surfaces (e.g. grassland, forest) by mechanical, radiative, thermal, and hydraulic properties. This surface is heterogeneous due to natural ecosystem diversity (e.g., vegetation), complex morphological features (e.g., infrastructure, topography), variability in soil characteristics (e.g., soil texture and color), anthropogenic activities (e.g., urbanization, deforestation and agricultural practices) and climatic forcing (e.g., precipitation) (Chormanski *et. al*., 2008, Grossman-Clarke *et. al*., 2010, Weng *et. al*., 2009).

The faster-growing populations towards the cities and the climate change are one of the biggest problems. The cities are increasing and are highly concretized and compacted with tall buildings to accommodate the growing population. The population

Table 1. LCZ divided into built types and land cover types LCZ (Stewart and Oke, (2012))

S. No	Building Type	LCZ	Land cover types
1	Compact high-rise	A	Dense trees
2	Compact midrise	B	Scattered trees
3	Compact low-rise	C	Bush,Scrub
4	Open high-rise	D	Low plants
5	Open midrise	E	Bare rock / paved
6	Open low-rise	F	Bare soil/sand
7	Lightweigh t low-rise	G	Water
8	Large low-rise		
9	Sparsely built		
10	Heavy industry		

and built up has become one of the indexes of the development of cities.

Such built structures and the cities are related to the increase of urban temperatures, energy consumption rate, waste production, raw material use, pollution agricultural to urban land conversion, biodiversity loss and shortage of water). As a result, the surface characteristics vary on a wide range of spatial scales and exert significant impact on energy, water balance as well as local microclimate (Akbari *et. al*., 2001; Cleugh *et. al*., 2005; Oke, 1997). Cleugh & Grimond (2012) summarizes the composite effects of urbanization and their modified physical parameters on urban climate. The overall effects of urbanization on urban climate result in the urban heat island (UHI) and are reported for many cities (Grimmond & Oke, 1986; Lee *et. al*., 2010; Sun *et. al*., 2012). The negative impacts of the UHI are well known and include increased energy consumption, compromised human health and comfort, and intensified carbon dioxide emissions (Rizwan *et. al*., 2008; Vanos *et. al*., 2010; Xu, 2010).

The terms urban and rural are too ambiguous to define. They do not have definitive criteria to explain their boundaries. Some studies consider certain sized of cities as the urban area and the other studies consider other sized as the urban area. The general image of the rural area is an area not having man-made structure and mainly covered with plants and vegetation. However, the type of vegetation is not defined within rural areas studies. Despite the number of previous UHI/UDI studies (Fujimori, 2005; Mikami, 2005; Moriwaki, 2013; Sakakibara, 1996), the study has lacked a proper standard to categories urban and rural areas. Hence, this has created the variation in the results and it is difficult to compare the individual urban / rural related studies from one city to another. In order to deal with such kind of problem (Stewart & Oke, 2012) have introduced a contextual and relevant solution by dividing various microclimatic environments into a particular zone known as Local Climate Zone (LCZ). The LCZ is mainly divided inti-built types and land cover types. Built types are further divided into zones based on fabric coverage and metabolism. Likewise, land cover types are further divided into seven zones as shown in the Table 1. The combination of different zones can be used as a classification, depending on the actual field situation.

Taking Nepal as an example, recently on Saturday, 25 April 2015 at 11:56 local time, a 7.6 magnitude earthquake as recorded by Nepal's National Seismological Centre (NSC), struck Barpak in the historic district of Gorkha, about 76 km northwest of Kathmandu. After incident, Nepal

government established Nepal reconstruction authority which helped victims rebuild their houses. Destruction from this quake has resulted on massive infrastructure construction which is rapidly urbanizing Nepal. This has led to unmanaged urbanization resulting in changes in its urban climate and environment. However, there are limited applied urban climatic studies in urban

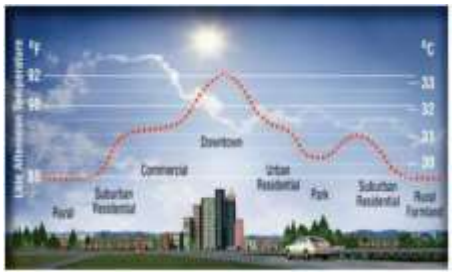

Figure 1. Urban Heat Island

planning and development in Nepal. The key reason for this is a lack of studies on the impact of urban development intensity on local climatic conditions. Thus, by applying LCZ classification to Nepalese cities like Kathmandu, urban morphology information assists for urban climate study and evaluation. It will provide a robust quantitative measure of land use dynamics, which will help urban planners and researchers to make assessments of landscape development and change. Thus, there should be increasing focus on growing cities which remains as a nexus for many problems including urban environmental conditions, living quality and climate change.

2. RESULTS AND DISCUSSIONS

Nepal has planned to build many new cities including some smart ones. In May this year, the Government decided to make four smart satellite cities in Kathmandu Valley. Nepal has also decided to create 10 cities along the Mid-hill Highway that will turn emerging bazaars in relatively flat lands into modern urban centers. Similar plans are there to develop 10 cities along the Hulaki Highway in the Terai, southern plains. If 8 megacities are created as proposed, most of these and other existing cities will be incorporated into the framework; in papers, more people will live in urban areas. Understood literally, majority of us will be enjoying a city life, with acceptable minimum modern facilities.

As being an example Kathmandu Valley of Nepal epitomizes the growing urbanization trend. This metropolitan valley has experienced a significant transformation of its landscapes in the last four decades resulting in substantial land use and land cover (LULC) change; however, no major systematic analysis of the urbanization trend has been conducted on this valley since 2000. The most striking change is that agriculturally productive peri-urban areas are now being encroached upon by rapid housing development that is expanding outward in a typical concentric zone fashion. The built-up area is expanding rapidly mostly at the cost of agricultural lands. In last three decades, built-up areas increased by 412%, while agricultural land encountered a 31% loss Ishtiaque (2017). This change has transformed not only the physical landscapes of the valley, but it also has altered the ecosystem services provided by agricultural lands and open space.

Urbanization over here has shown change on microclimate, effect on urban heat island that includes the change on land surface temperature and attendant emissions of pollutants. Much study has been conducted on

Kathmandu Valley regarding the urbanization. These studies were mainly focused on classification based on Land use and land cover, which classifies the land type into urban and rural. These studies have many limitations such as not having the proper definition of the urban and rural areas. So to overcome such limitations, study based on LCZs classification which is divided into built types and land cover types. Built types are further divided into zones based on fabric coverage and metabolism. Likewise, land cover types are further divided into seven zones. The combination of different zones can be used as a classification, depending on the actual field situation.

The LCZ map can indicate the possibility of Urban Heat Island (UHI) effect. Since the LCZ scheme has been developed based on urban morphology's impact on temperature variation, LCZ classifications can be used for climatic sensitive planning. The LCZ map visualizes the spatial characteristics and distribution of potential UHI patterns and can be a useful reference for architects and planners for making better designs and decisions provides technique for alternative urban growth allocations in the future, which are very valuable for planning and policy. Modelling process presented is transparent and easy to replicate when necessary, can be used for the analysis of urban growth and land cover changes in various cities where the amount and quality of geographic information very limited and helps in the study of seasonal variation considering the Local Surface Temperature.

The LCZ has been used to study urbanization various cities such as Beijing, Budapest. Chicago, Coimbra, Colombo, Dublin, Guangzhou, Hamburg, Houston, Khartoum, Kolkata, Medellin, Milan, Nantes, Sao Paolo, Vancouver, Vitoria and Wageningen by classifying them. Likewise, by applying LCZ classification to Nepalese cities, urban morphology information can be quickly extracted based on Landsat data and software for urban climate study and evaluation. It will provide a robust quantitative measure of land use dynamics using remotely sensed data for the last decades of the 20th century, which will help urban planners and researchers to make assessments of landscape development and change.

Overall, the use of LCZ in quantifying the UHI magnitude of the various cities of Nepal not only helps to understand the present situation but also helps in planning new/old urban cities. This approach should be widely applied to more objectively investigate the UHI phenomenon, particularly in the bigger cities. It also helps for the comparison of UHI intensity of different cities for the better understanding of UHI around the globe.

3. CONCLUSIONS

In this article, the importance of UHI study and LCZ classification has been presented. The global temperature of urban areas compared to the surrounding countryside has been confirmed. The UHI intensity is significant especially during warm periods although there are cases where the daily maximum UHI intensity was observed in all seasons except the winter. There increases in both the minimum and maximum temperatures have been recorded. City size, land use, topographic factors, vegetation, urbanization and industrialization of the area, season of the year and time of day as well as prevailing meteorological conditions etc. are some of the factors which effect the

variation of UHI effect in different areas. Various researches have shown that UHI is developed in areas with high percentage of water-resistant, non-reflective surfaces and low vegetation.

The LCZ is a scientific classification of land use by which the study related to UHI and UDI from various part of world can be compared. This not only helps in categorising the existing cities into various zones but also helps in visualizing and developing new urban areas incorporating smart, sustainable, and environmentally friendly atmosphere. From the perspective of holistic urban development and management, this may be a major hindrance in the future that needs urgent attention from government and other stakeholders.

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