International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

Assessment of Biophilic urbanism elements in Thiruvananthapuram city to mitigate urban heat island effect

Anjana J Nair, Anjana Murali
[1]*Student (M plan), Department of Architecture, Tkm college of Engineering, Kollam, Kerala*
[2]*Assistant Professor,Department of Architecture, Tkm college of Engineering, Kollam, Kerala*

Date of Submission: 19-05-2023 Date of Acceptance: 23-06-2020

ABSTRACT: A rising number of people are realizing how important everyday exposure to nature is for leading fulfilling lives. The study outlines major pathways through which biophilic urbanism improves climatic conditions. The urban heat island (UHI), which is defined by temperature differences between urban and rural regions, is a prime example of micro-climate changes brought on by urbanisation. The destruction of vegetation as a result of recent expansion has resulted in the loss of vegetation land cover. This study aims to create a framework by interrelating the parameters of biophilic urbanism and urban heat island for Thiruvananthapuram city.

KEYWORDS: Biophilic urbanism, Climate Change, Urban heat island, green cover, Built Density, Land surface temperature

I. INTRODUCTION

In recent years urban areas have been growing as a result of population expansion, which has increased the danger of overheating and produced unmanageable microclimate conditions in the urban region. Urban regions and cities will therefore be substantially warmer than the neighbouring rural areas.[1] Meanwhile, research is emphasising the importance of maintaining a balance between such density and urban nature in order to improve climatic conditions and to decrease the negative consequences of densely inhabited, impermeable metropolitan areas on the environment and the economy.

In 1973, German psychotherapist Erich Fromm coined the word "biophilia," which he described as "love of life." Humans have an innate need to interact with nature and the natural world, according to later research on this topic by E.O. Wilson. "Biophilic urbanism" was introduced as a new approach to urban planning and architecture that intended to integrate nature into the urban fabric in a methodical way to transform lifeless urban landscapes into regenerative and liveable spaces.[2] A metropolis that is much warmer than the rural areas around it is referred to as an urban heat island, or UHI which was coined by Howard, an urban climatology pioneer.[3]

The main objective of biophilic urbanism is to strengthen the bond between urban residents and urban nature as well as to promote nature as an essential element of daily urban life.[4]

II. NEED FOR THE STUDY

- Draft master plan-2040 flags lack of green areas in city.[7]
- AMRUT project in the city included four initiatives for parks and green spaces that would have cost Rs 5.85 crore.[8]
- Thiruvananthapuram have been listed as one of the highly vulnerable districts among the four as per SAPCC.[6]
- Micro-climatic changes in three cities of Kerala have been identified and a study to be undertaken by the Institute for Climate Change Studies (ICCS), Kottayam considering Thiruvananthapuram as one among the three cities.[7]
- As per the latest report of Kerala Forest Department, there is decline forest cover in three districts of kerala in which 23 sq km decline of forest cover in Thiruvananthapuram. [7]

III. METHODOLOGY

Methodology of the study is followed by the need of BU elements in Thiruvananthapuram city and the effect of UHI in the study area which can be mitigated with Biophilic urbanism. The analysis of the Biophilic urbanism elements and Urban heat island parameters for the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

framework and case study analysis of Singapore, Toronto, Hyderabad are carried out in the secondary study. The analysis of Multitemporal Landsat images of LC, LST maps of various years extracted using Qgis for the study area and the elements identified in the framework are accomplished. Finally, the quantitative analysis of the identified biophilic elements in the framework in the study area is achieved to determine the cause of urban heat islands of Thiruvananthapuram city to provide with the strategic plans and proposals.

IV. STUDY AREA

The capital and largest city of the Indian state of Kerala is Thiruvananthapuram, sometimes referred to as Trivandrum. The population of the city is 957,730, while there are 1.68 million people living in the nearby metropolitan region. As of 2015, 55% of Kerala's software exports came from Thiruvananthapuram, a significant IT centre in India. On India's west coast, not far from the country's southernmost point, is the city of Thiruvananthapuram. The 2192 sq. km. district as a whole is classified as a single revenue division.[5]

- Thiruvananthapuram is an Urban Agglomeration falling under the category of Million Plus UA/City, according to information provided by the Government of India for the Census of 2011.
- The entire area of green space available in the city is around 2.2 square kilometers. This represents only 0.01% of overall land use.[8]
- Thiruvananthapuram's per capita availability of green spaces is only 2.23sq m, much below the 10- 12sq m/person standards set by the Ministry of Housing and Urban Affairs' guidelines for urban and regional development plans formulation and implementation.[5]
- The unstructured green spaces are being turned into built-up land as the city grows. Due to urbanisation, a large portion of the green spaces that the city was once proud of have been lost, except for the grounds of museums and zoos, Veli and Akkulam, the city does not have many designed green spaces, according to the draft plan.[8]
- Comparing the urban location, where the peak cooling rate was only 1.5 degree C/hr., the rural area reported a peak cooling rate of 3.4 degree C/hr. The highest value of 2.4 degrees C in the city centre indicates medium intensity UHI.[9]

THIRUVANANTHAPURAM CORPORATION (STUDY AREA)

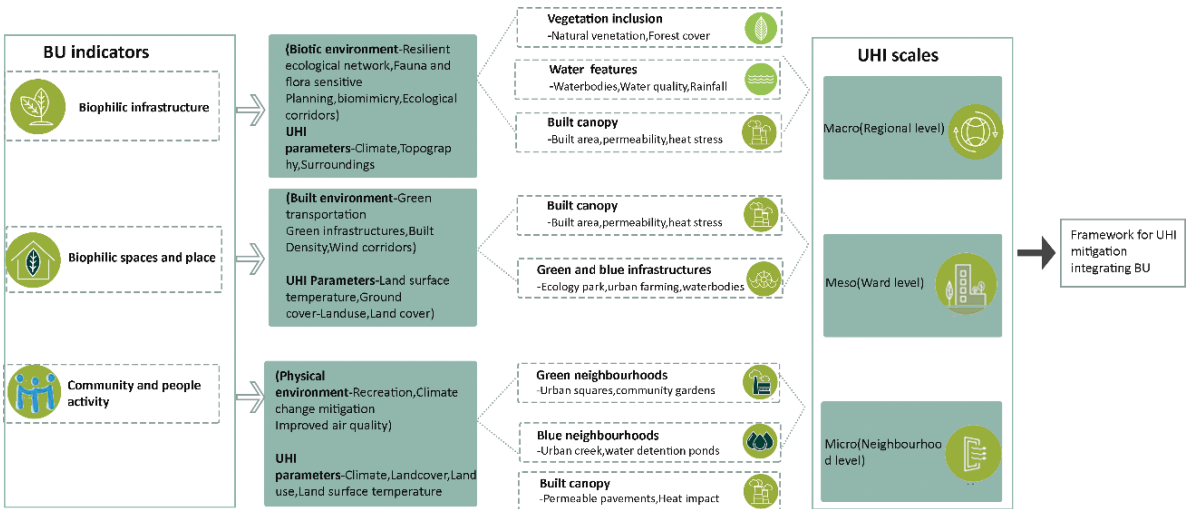
International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

V. BIOPHILIC URBANISM ELEMENTS AND URBAN HEAT ISLAND PARAMETERS

Streets	Neighbourhood	Regions
Green streets	Stream restoration	Riparian systems
Sidewalk gardens	Urban forests	Regional green space system
Vegetated swales	Ecology parks, Neighbourhood parks, Pocket parks	City tree canopy
Edible landscaping	Greening grey and brown fields	Community gardens
High degree of permeability	Low impact development	Ecosystem restoration

The city radius	Wind velocity	Warm ambient air temperature
Urban morphology	Cloud cover	Vegetative surfaces
Tree coverage	Sky view factor	City tree canopy
Anthropogenic heat from vehicles	Land surface temperature	Heat production from materials
Air and water pollution	Presence of waterbodies	Built Density

VI. FRAMEWORK



INDICATORS AND ELEMENTS FOR FRAMEWORK

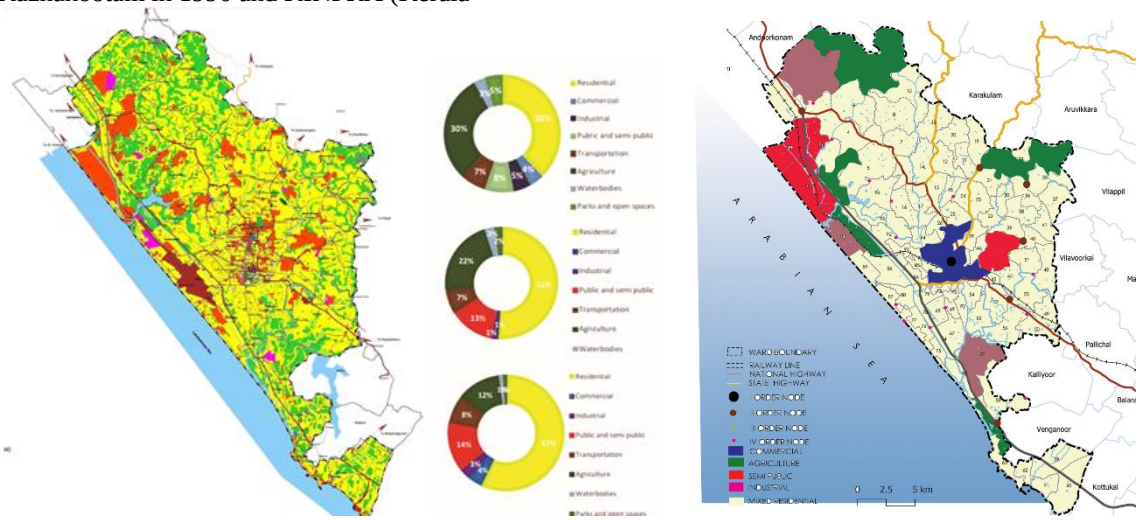
International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

VII. STUDY AREA ANALYSIS

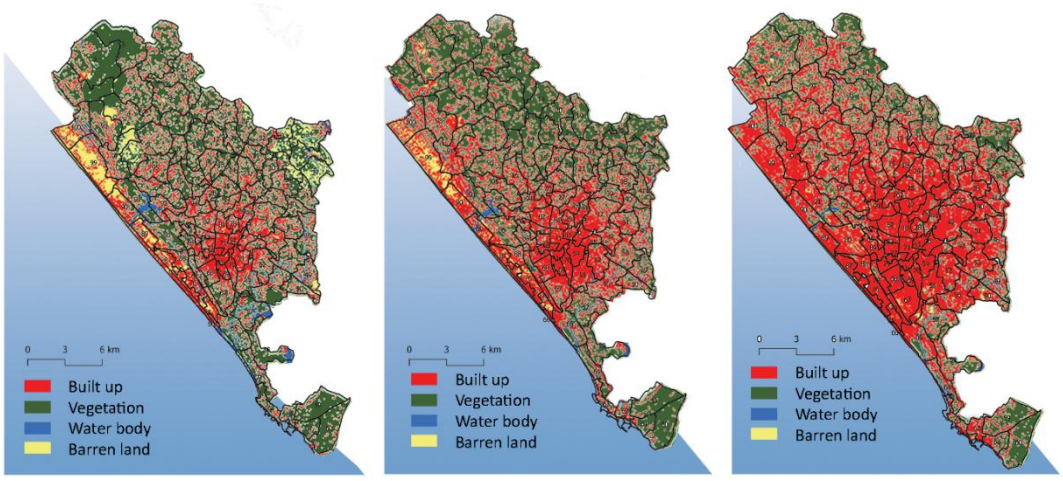
The change over the years is notable that the percentage of waterbodies had a huge shrinkage and also the green cover and agricultural areas has been affected due to the growth and urban sprawl in the city. Most of the areas has been converted to build use where encroachment due to urbanisation occurred over the years.

Although Thiruvananthapuram acts as a service town, where people are primarily engaged in government and institutional activities, post-1990, there has been tremendous growth in industrial units within the UA. The establishment of Technopark at Kazhakootam in 1990 and KINFRA (Kerala Industrial Infrastructure Development Corporation) in 1993 developed small industries park at Thumba and a film and video park at Kazhakoottam.

The highest gain in urban sprawl typologies during 2001–2021 had occurred in scatter development, i.e.,11.91 km2.Overall scatter development was the dominant urban sprawl typology prevailing in the peri-urban areas of Thiruvananthapuram UA.

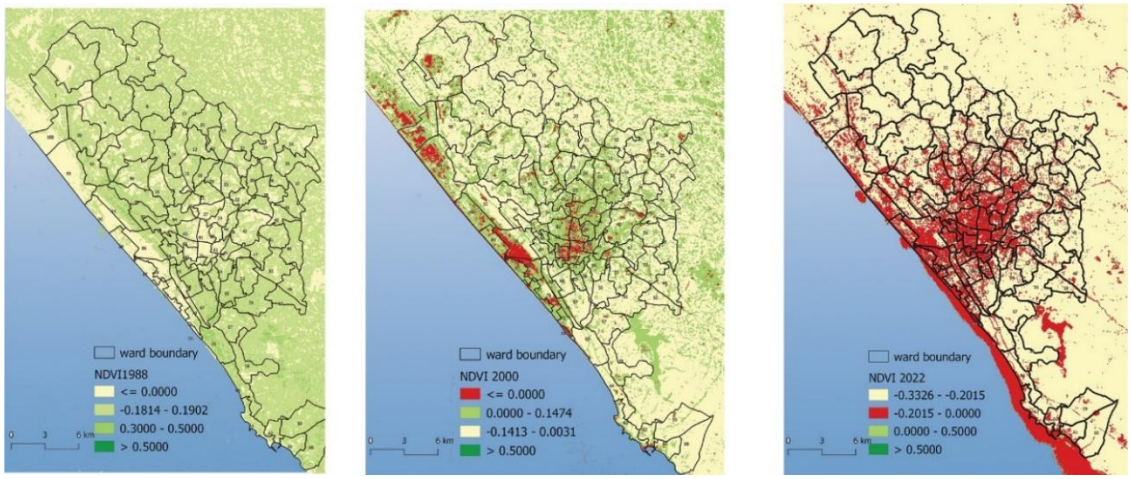


(A)LAND USE MAP (2012), (B) LANDUSE BREAK UP OF 2001,2012,2017(C)SPATIAL STRUCTURE



LANDCOVER MAP (1988,2000,2022)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252



NDVI MAP (1988,2000,2022)

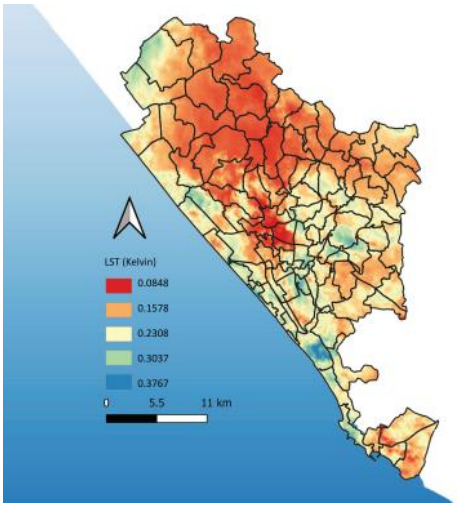
The built density increased covering the open and green spaces causing reduction in the non-built area. The built is more concentrated in the city center due to the spatial structure of the city as Thiruvananthapuram corporation is the first order settlement.

As of 2022, the vegetative land cover had decreased from 143.13 km2 in 1988 to 54.34 km2. Between 1988 and 2022, the built-up area rose from 102.08 km2 to 163.23 km2.The built area increased due to the urbanisation and population growth vegetation reduced immensely due to the increase in built.

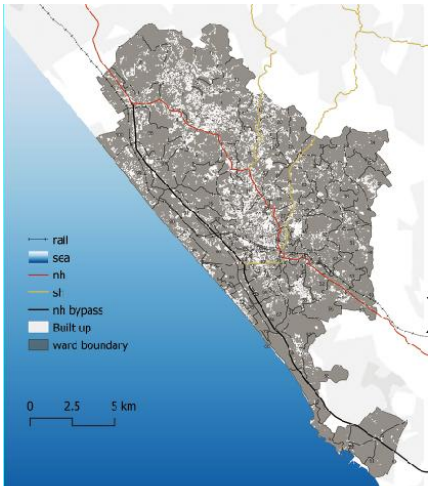
NDVI maps of 1988 and 2000 shows a remarkable spatial increase of low NDVI values indicates the increase of impervious surfaces. Similarly, the NDVI value of 2022 also shows decreasing trend.

LST values are clustered at central core of the study area. Central region is characterized with the traditional urban growth of the center of the city whereas north-western part represents the recent growth due to IT park implementation.It can be observed that the mean temperature of waterbody, vegetation and open area shows more or less constant trend.

The absence of green cover and the built density in the central core is visible from landcover and built density maps.The built density increased covering the open and green spaces causing reduction in the non-built area. The built is more concentrated in the city center due to the spatial structure of the city.



LAND SURFACE TEMPERATURE MAP,2022

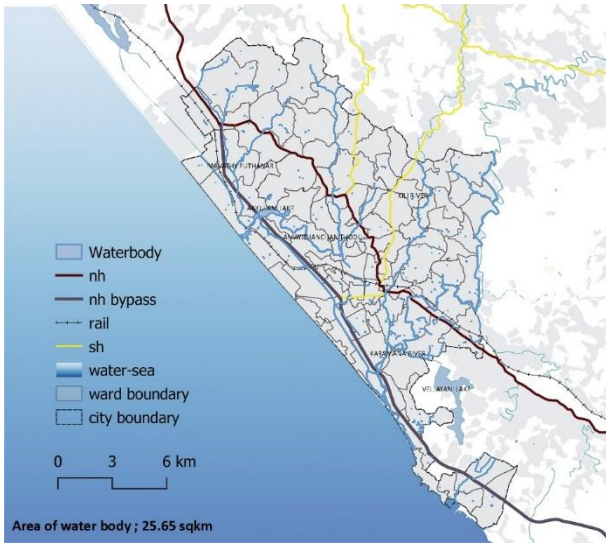


BUILT DENSITY MAP,2022

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

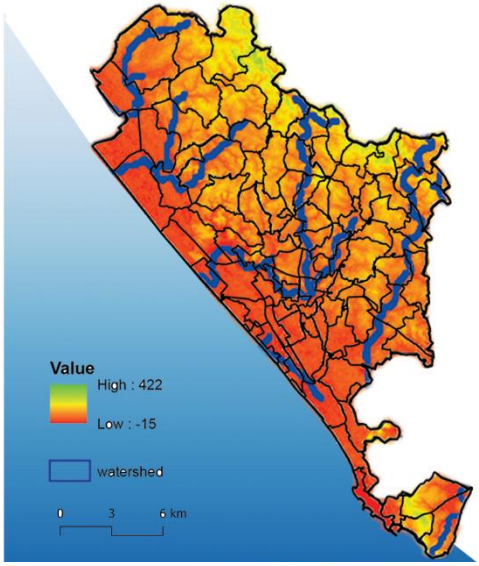
Most of the waterbodies and flood plains are having a landuse change due to urbanization. The width of the drains and the flow are getting blocked and affected due to the inappropriate constructions and landuse over the years.

Even if the area has a sufficient number of waterbodies, the impact of climate change from the waterbodies is diminished due to poor management and an increase in the sediments that clog drains.



WATER BODIES IN THE STUDY AREA,2023

Study area is having a gentle slope towards the central city (<25%). The drainage network of the city consists of two rivers, a few canals (thodus), their feeders and lakes. The rivers are Karamana and Killiyar which flow through the city area. Flood plains of Killi river and Karamana river are reclaimed and occupied by residential houses.



DRAINAGE MAP,2023

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

VIII. DEVELOPED FRAMEWORK

ELEMENTS AND SUB ELEMENTS		SUB INDICATORS	ASSESSMENT CRITERIA	ASSESSED VALUE	REQUIRED STANDARD	MAP/DATA REQUIRED	INFERENCE
Vegetation inclusion	Natural vegetation	Percent of natural vegetation	(Total area of natural vegetation Total area of study area)x100	(34.34/214.84) x 100 =15.2%	According to National Forest Policy of India, the ideal percentage of total geographical area under forest should be atleast 33% to maintain ecological stability(Kerala Forest Survey of India,2019)	Landcover map, Landuse map,NDVI	The percentage of vegetation is less as per the required standard which cause disturbance in the ecological stability in the study area
	Forest cover	Percent forest canopy coverage	Very dense forest+Moderate dense forest+Open forest ÷ Percentage of Geographical area of study area				
Water features	Waterbodies	Percent of waterbody with in the regional level study area which cause reduction in heat	(Total area of waterbody ÷ Total study area)x100	(21.62/214.83) x 100 =11.93%	Water body area proportion / Air temperature (Degree c) 0.15 / 34.234 0.25 / 34.129 0.35 / 33.234 0.49 / 33.125 0.64 / 33.042 0.64 / 33.042	Surface water map	The percentage of waterbody is less as per the required standard which cause high temperature in the study area
	Water quality	Surface water quality	PH : 6.5-8.5 Total coliform organisms (MPN*/100 ml) shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6 mg/l or more, and Biochemical Oxygen Demand 2 mg/l or les	Monsoon-6 to 6.88 Pre monsoon-6 to 7.72 Post monsoon-Less than 6.5	0-4.4 Poor 4.5-6.4Weak 6.5-7.9 Moderate 8.0-9.4 Good 9.5-10 Excellent (Central Pollution control Board World Health Organization(WHO))	Central Ground water board	The water quality is at a moderate scale as per the study
		Ground water quality					
	Rainfall	The category of rainfall in the study area	Annual rainfall(mm) w.r.t to temperature reduction	The month with the most rain is June, with an average rainfall of 10.1 inches and the least as 0.7 inch .0.30inch rainfall is considered as heavy rainfall	Heavy rainfall may experience a reduction in surface temperature of approximately 0.3 K compared to days with light to moderate rainfall(European geoscience union)	Rainfall data	Rainfall is sufficient as per the reports asthere is average rainfall which can reduce the heat
Built Density	Built area	Percent of built up in the study area	(Total built area ÷ Total study area)x100	(163.23/214.83)x100=75.9%	The temperature difference between a city and its surrounding rural area can be as much as six degrees C (World resource institute)	Built up map,Landcover map	The concentration of buildings are in the central core area as seen in map and the percentage of built occupied is high
	Permeability	The drainage pattern of the study area	Percentage of waterbodies /Total area The drainage pattern of the area to be assessed	(21.62/214.83) x 100=11.93% Drainage pattern=mild and low land	The temperature difference between urban areas and surrounding vegetated land due to the presence of impervious surfaces(NASA) A reduction of UHI intensity by 2.3 °C was observed for every 10% increase of the average core water surface ratio(Huang, 2017)	Drainage map,Surface water map	Percentage of water body is very less Permeability is low that the study area has gentle slope which drains away the storm water. Flood plains are reclaimed and occupied by residential houses
	Heat stress	The land surface temperature of the study area	Land surface temperature change over years	LST is directly proportional to built area	Urban green spaces can help maintain micro-climate conditions and improve thermal comfort by lowering the urban heat is land effect(World resource institute)	Land surface temperature map	LST varies with change in LULC.More green cover required.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 1, pp: 01-05www.ijaem.net ISSN: 2395-5252

IX. STRATEGIES ANDPROPOSALS

- **Establishing afforestation and plantation strategies**-Five cents on the Kanakakunnu Palace premises where the Miyawaki method of afforestation has been replicated has transformed into a luxurious mini-forest in just 16 months. This project is a short-term program under the state tourism department.The areas where afforestation program can be implemented where already exists the green areas but not specific to any flora or a period of time. The Miyawaki program can be extended to several parts of Kanakakunnu and zoo.

- **Conservation and reclamation programme in vegetated lands**-Conserving the agricultural land by the application of transferable development rights and building byelaws.Green infrastructure on agricultural properties can support farming production and provide additional ecological goods and services.

  Buffers and hedgerows protect agricultural lands from wind erosion, provide connections to the natural heritage system and vital habitat for wildlife, including pollinators

- **Revival of waterbodies and conservation**-A waste plant with more capacity can be provided within the existing one to accumulate more garbage.
  Sewers should not be opened to the waterbodies from residential and commercial areas
  The tree planting along the edges of waterbody can create a natural filter preventing waste and unwanted substances flowing to the river (hedges, bushes etc.), community must be involved in those activities to promote clean water.

- **Transforming waterbodies to beautification assets**-The waterfront development can be achieved in this location (Travancore Island resort) as the area is focused on tourism through the development the polluting factors can be avoided.

- **Rainwater harvesting/catchment area**-The catchment areas can be provided in Sreekanteswaram park, Ponnara Sreedhar park (Thampanoor round about), temple pond in Sree Sakthi temple near chenkalchoola colony.

- **Ecological corridors/park connectors**
- **Protecting the existing waterbodies, ponds**-Sreevaraham pond in a very dense built area act as a heat reducing element. Therefore, to protect it from deterioration BU elements like wind breaks and plantation along the banks should be done to avoid soil erosion.
- **Increasing permeable pavements**
- **Redevelopment of recreational areas**-Ensuring the per person requirement of open spaces by providing green loops including vegetated paths, community gardens etc. at the possible vacant

lands in walkable distance in high density residential zone. The implementation can be carried out as a smart city project.

- **Promoting community engagements and nature club activities**

- **Green buffer zones around high density-built areas**
  Street trees, buffer zones, green wall, green streets

- **Creating urban creeks and recharge pits-** Urban creeks through high density-built areas can reduce heat to an extent. The existing pond can also act as recharge pits. This can be attained through community participation among the residence association etc.

X. CONCLUSION

This study makes the argument that the notion of biophilic urbanism may be expanded upon by incorporating it into urban heat islands. The proper management of above-mentioned elements of biophilic urbanism (Vegetation inclusion, Water features, built density) can mitigate the heat stress of a region highly vulnerable to climatic conditions. To preserve ecological stability, there will be a 25% increase in green cover, a 33% increase in waterbodies, and a meeting of the per-person requirements for green space. The value of each of these biophilic elements may grow due to the growth in BU components in accordance with the given standards. The strategies and proposals for biophilic urbanism planning can satisfy the urban heat island parameters and dimensions of biophilic urbanism in Thiruvananthapuram city and to inspect the presence of representative biophilic elements that contribute to adapt urban heat island parameters.

REFERENCE

[1] Anusha Krishnan. (2022, April 13). What are urban heat islands? Retrieved from Mongabay: https://india.mongabay.com/2022/04/explainer-what-are-urban-heat-islands/

[2] Totaforti, S. (2020, July 7). Emerging Biophilic Urbanism: The Value of the Human–Nature Relationship in the Urban Space. Performance-Oriented Integrative Sustainability Approaches to Architecture, Urban Design and Landscape Architecture), 6(13). Retrieved December 2022

[3] National Geographic Organization. (2020). National Geographic. Retrieved December 2022, from Heat Island effect: https://education.nationalgeographic.org/resource/urban-heat-island/

[4] Cabanek, A., Zingoni de Baro, M.E. & Newman, P. Biophilic streets: a design framework for creating multiple urban benefits. Sustain Earth 3, 7 (2020). https://doi.org/10.1186/s42055-020-00027-0

[5] Town and country planning. (2011). District urbanization report. Government, Town and country planning office. Thiruvananthapuram: Government of India. Retrieved December 2022

[6] The New Indian Express. (2020, January 1). New Indian express. Retrieved December 2022, from newindianexpress.com: https://www.newindianexpress.com/states/kerala/2020/jan/01/amid-growing-forest-cover-shrinking-canopy-in-three-districts-worries-kerala-2083438.html

[7] The New Indian Express. (2017, December 31). The New Indian Express. Retrieved from https://www.newindianexpress.com/states/kerala/2017/dec/31/major-study-to-focus-on-micro-climatic-changes-in-three-cities-of-kerala-1740773.html

[8] Kumar, A. J. (2021, July). The Times of India. Retrieved from India times: https://timesofindia.indiatimes.com/city/thiruvananthapuram/draft-master-plan-2040-flags-lack-of-green-areas-in-city/articleshow/84125401.cms

[9] S. Ansar. (2012). A study of urban/rural cooling rates in Thiruvananthapuram, Kerala. Atmospheric Science division of the Centre for Earth science studies.