SIMPLE MEASURES TO IDENTIFY & MITIGATE URBAN HEAT ISLAND

Options for Dhaka North City Corporation

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Content

Glossary

BBS – Bangladesh Bureau of Statistics

DNCC – Dhaka North City Corporation

GIS – Geographic Information System

LST – Land Surface Temperature

LULC – Landuse Landcover

NDVI – Normalized Difference Vegetation Index

RAJUK – Capital Development Authority

SVF – Sky View Factor

UHI – Urban Heat Island

Executive Summary

Dhaka, the capital and the central economic and administrative hub of Bangladesh, is undergoing rapid population growth and further uncontrolled spatial development. As a result, temperature has increased over the decades. The major driver behind such increase in temperature is the rapid transformation of natural surface such as vegetation and waterbody by paved surfaces.

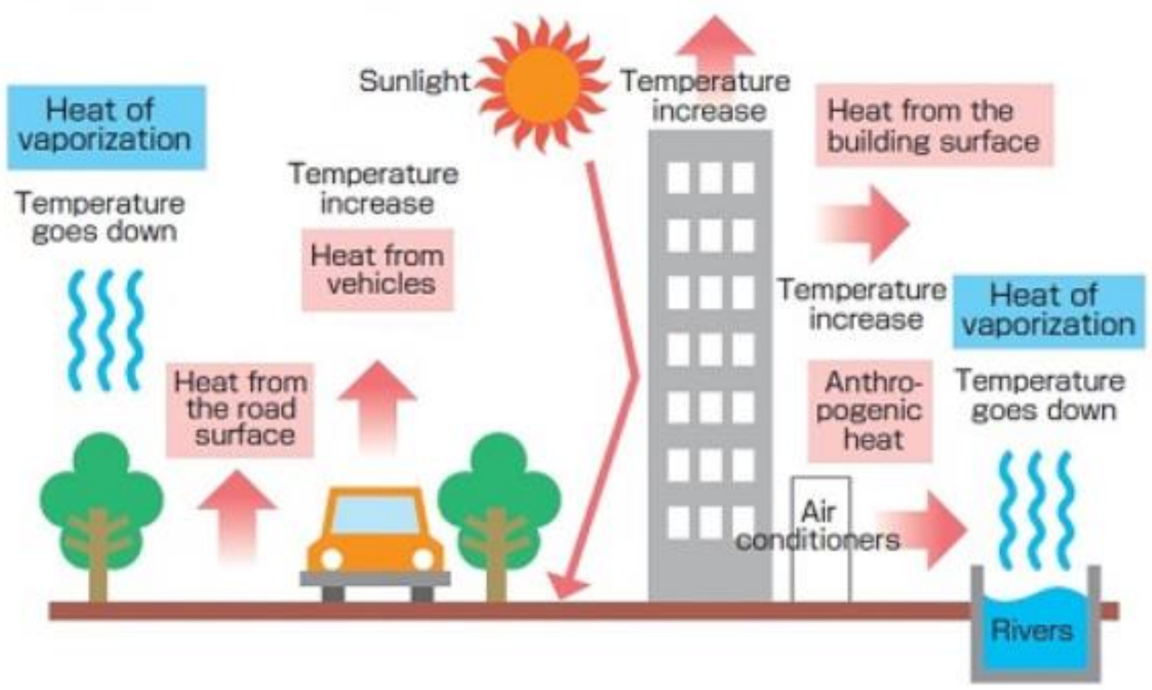
This study identifies zones of surface temperature increase in urban area of Dhaka North City Corporation. The study identifies the kind of Landuse Landcover transition causing the highest increase in surface temperature and how socio-economic and physical factors play an important role in temperature change. Based on spatial and factor analysis, the present study suggests Thana-wise Heat Mitigation Strategies to support Climate Resilient Urban Development. The Mitigation Strategy recommends short-term coping capacity with existing cooling features and long-term strategic decision support based on composite socio-economic and physical heat index profiles of respective Thana area.

Driver of Urban Heat Island effect

Urbanization causes significant modification of local climates and triggers the phenomena of Urban Heat Island (UHI) effect. The percentage of world urban population is increasing rapidly and expected to reach nearly 70% by the year of 2050. At the same time, there is a continuous change of global climate at an unprecedented rate.

Urbanization process inevitably replaces impervious surfaces and causes difference in thermal energy balance. Artificial urban fabrics such as buildings, roads, and other infrastructure absorb and re-emit the solar radiation more than landscapes such as waterbodies and vegetation. This causes comparatively higher temperature in urban areas - around 0.6-3.9 °C (day) and 1.1-2.8 °C (night), as estimated by US EPA. There are several climatic, physical and socio-economic factors which are influencing UHI intensity in particular zone of urban area.

"Tackling the combined effects of global warming and urban heating is one of the biggest challenges to be faced by world sustainable thinkers"



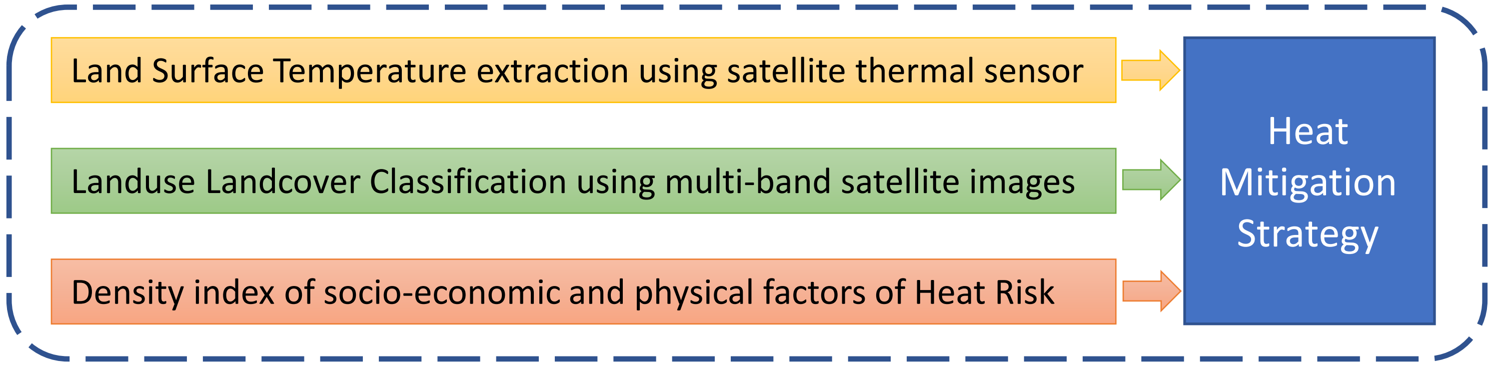
Threat of UHI effect in Dhaka…

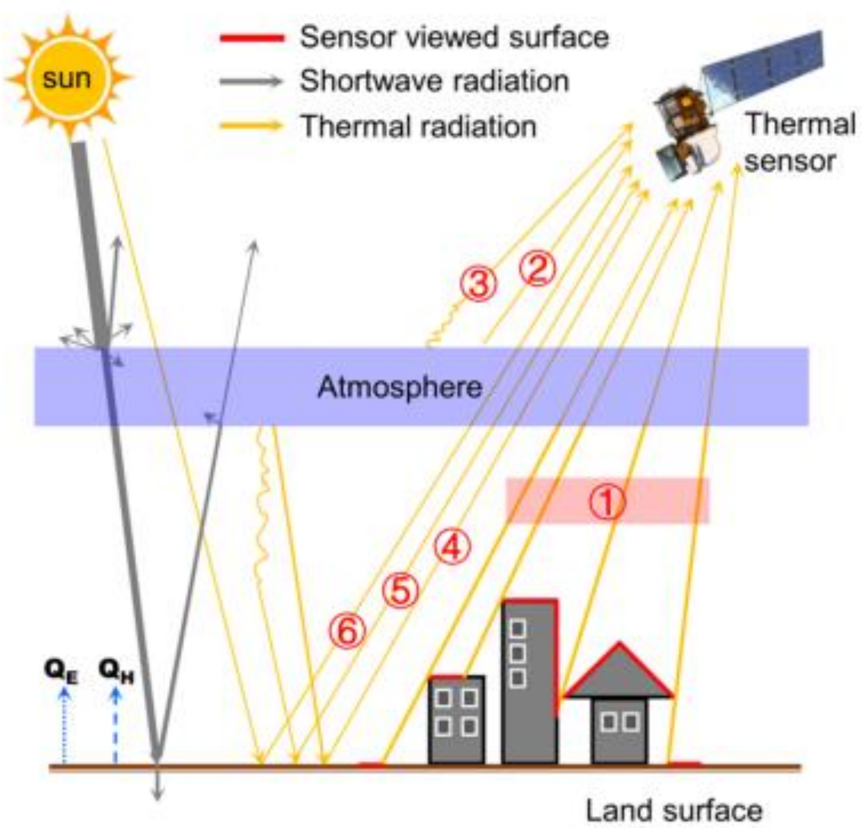
Dhaka the primate city and capital of Bangladesh has been experiencing rapid population and spatial growth since independence. The urban population of Bangladesh has grown by nearly ten times after independence, as much as a third of which has taken place in Dhaka. At the same time, Dhaka has witnessed a rise in temperature of almost 3 degrees Celsius in the last 20 years. The Dhaka Structure Plan 2016-2035 report indicates an increase of 0.5 °C annual average temperature in Dhaka by the last 100 years. Economists have warned that, cities might lose up to 11% of economic output due to UHI effect. Apart from adverse environmental effect, the phenomena also cause harm to human health and well-being in terms of heat-related morbidity and mortality. Therefore, to control the increasing pattern of UHI effect an immediate action needs to be taken by concerned authorities through strategic and climate sensitive urban development plan.

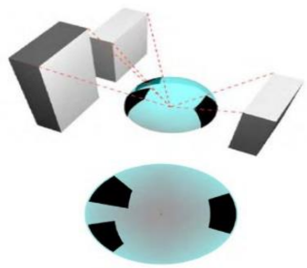
Approach & Method

This study aims to provide Thana level information for the urban area of DNCC to Mitigating UHI effect. The study investigates the impact of LULC transition pattern, socio-economic and physical factors associated with surface temperature change. Based on the type and level of contribution by these parameters, the study suggests mitigative measures to reduce the UHI Risk in the DNCC urban area.

The objectives of the study are 1) to address what types of Landuse changes are causing surface temperature increase and 2) to find the relative influence of socio-economic and physical factors and 3) to propose mitigation strategies for Heat Risk Reduction. The analysis includes extraction of LST & LULC types using thermal & multi-spectral band of Landsat satellite imagery. Information about Socio-economic & physical variables have been collected from BBS statistical database report (2001 & 2011) and RAJUK updated GIS database.







Data and Information

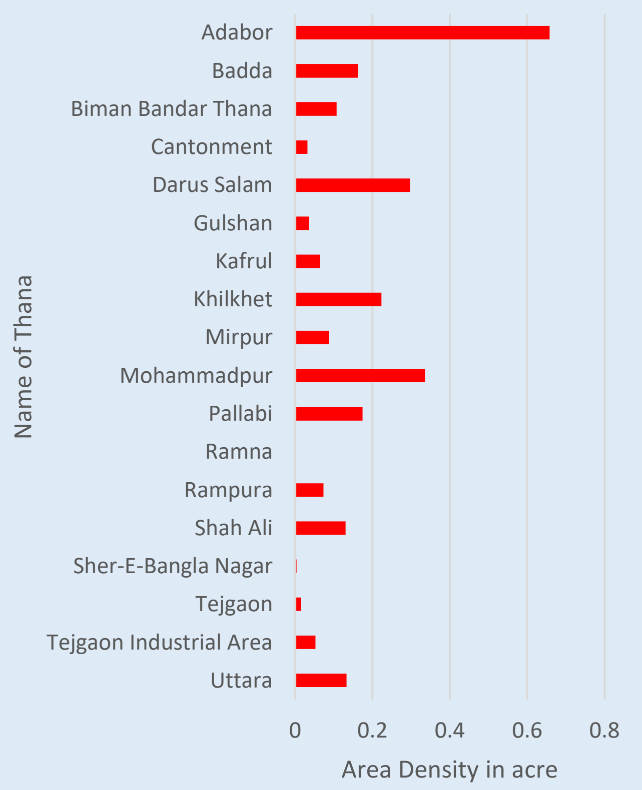
Parameter	Variables	Indicator
Landuse Landcover	Built-up, Waterbody, Vegetation, Bare land	Spatio-temporal change of human behavior on land surface at 30 meter areal expansion during 2001 to 2021.
Climate	LST	Surface temperature at 30 meter spatial resolution as a direct indicator for Urban Heat Island (UHI).
Socio-economic	Decadal Growth Rate	LST increases with an increase of decadal growth rate
	Population Density	LST increases with an increase of population density.
	Density of community facilities	Higher number of community facilities influences anthropogenic activity and emission.
	Percentage (%) of Affordable Household	Affordable households tend to consume more resources and energy.
	Average Household size	Larger Household size indicates less per capita consumption of existing facility and resources.
Physical	Building Density	Large amounts of building surface absorb more short-wave solar radiation and release higher long wave radiation.
	Waterbody Density	Because of latent heat properties, areas with higher waterbody density experience less surface heat exposure.
	NDVI	Surface Heat intensity is negatively correlated with NDVI. An increase of NDVI decreases surface temperature.
	SVF	High sky view factor helps to release longwave emitted radiation from surface which goes back to atmosphere and hence causes less surface temperature increase.
	Percentage of Shadow Area	The coverage of shadow causes inaccessibility of solar short-wave radiation to the shaded area. Although it has a cooling effect at micro scale but might indirectly increase surface temperature.

Heat Increasing Pattern in DNCC

88% of total land surface area in DNCC is estimated to have increased surface temperature over 20 years since 2001. Correlation with LULC shows that, increase of Built-up and Bare land class causes temperature increase. Whereas vegetation and waterbody help in reducing the effect of UHI.

The study shows, built-up area has increased at a decadal growth rate of 5% & 21% during 2011 and 2021 respectively. On the other hand, waterbody and vegetation have an overall decreased rate of 103% and 42% respectively since 2001.

Figure 2: Thana wise Area Density of High-Moderate Surface Temperature Increase Zone (2001-2021)



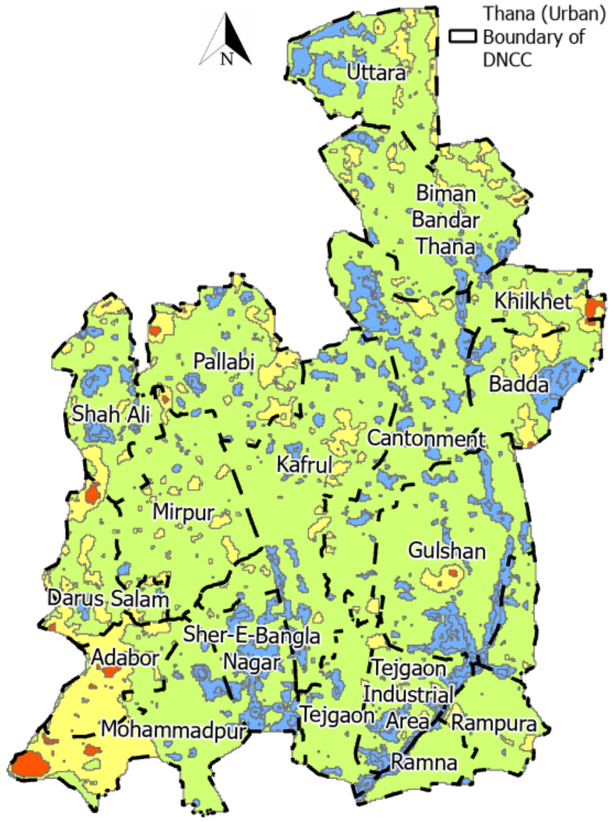


Figure 1: Surface Temperature Change Map (2001- 2021) in DNCC Urban area

Adabor, Mohammadpur, Darussalam and Khilkhet are the most 4 Heat Center Zone from 2001 to 2021 (fig 2). It appears that socio-economic factors contribute more to heat increase than physical factors. However, higher intensity of physical factor could help reduce the effect of UHI.

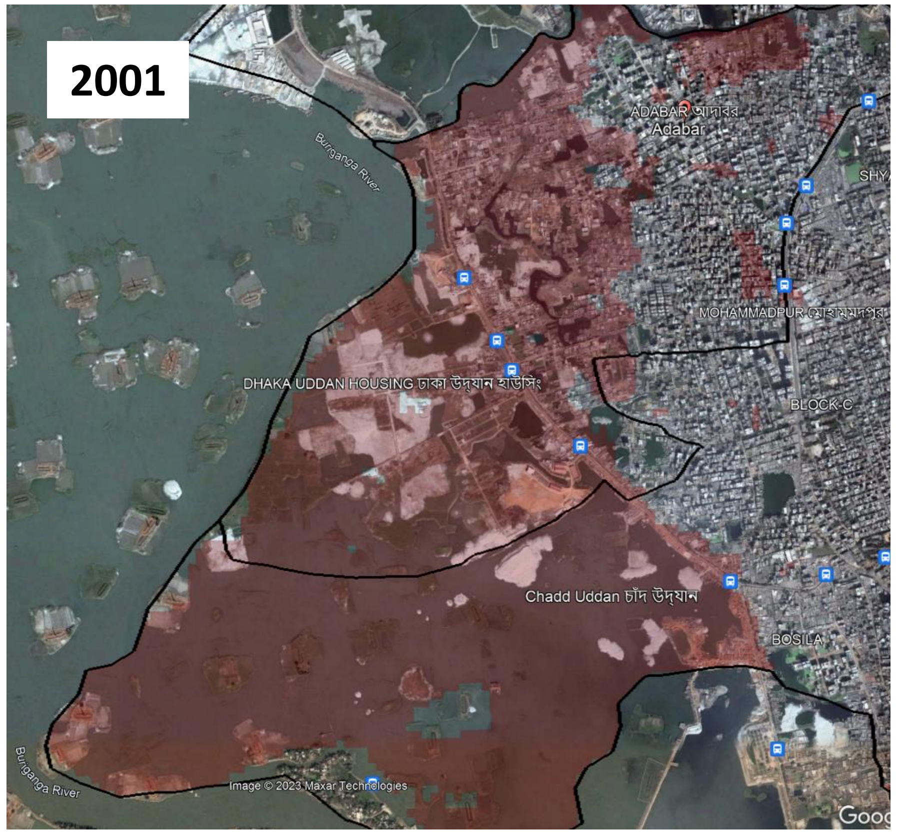
Decadal growth rate, population density and number of community facilities are the socio-economic variables cause heat increase in respective Thana area of DNCC.

Although, building density influence temperature increase, but analysis finds that, sparsely distributed building (higher SVF) helps to reduce the UHI effect. Building shadow can be helpful during day but at night its surface releases absorbed heat.

Challenges...

By 2041, only 14.4% of the total urban area of DNCC will be free of surface heat risk

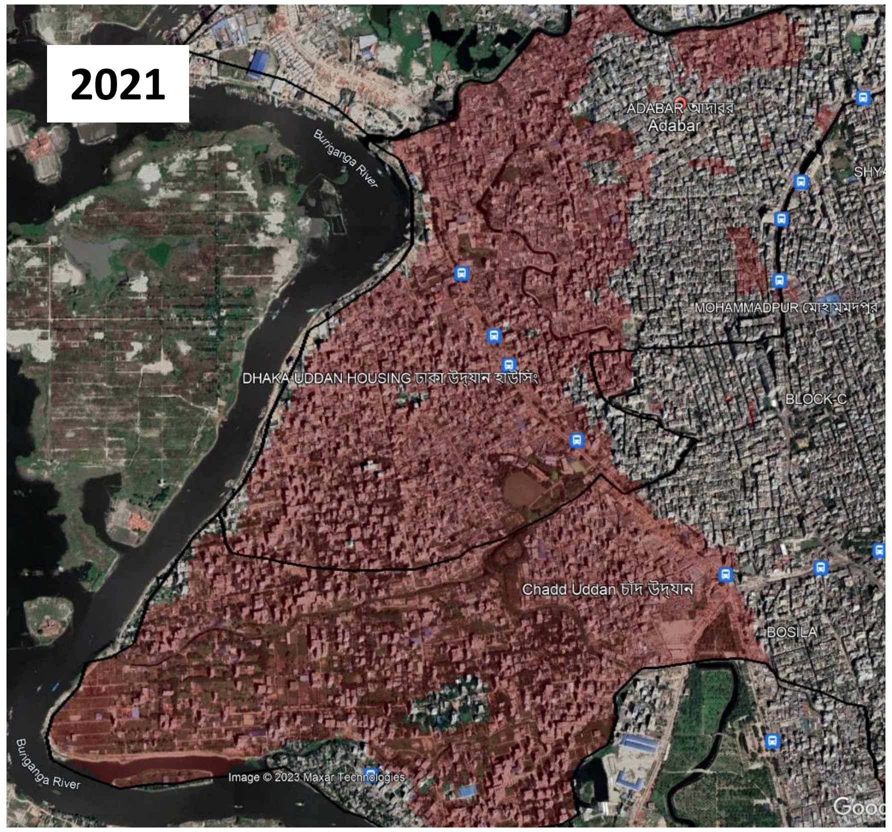
A rapid spatial transformation from remaining non-built-up landcover class to built-up class will happen by 2031



The 2001 and 2021 images show the same location of Adabor and Mohammadpur Thana with the zone of high surface temperature increase as highlighted in red . The visual comparative analysis shows spatio-temporal changes occurred within the red color zone, where built-up class grew replacing waterbody and vegetation.

What to do...

Ensure a balance between Socio-economic and Physical factors while undertaking Development Plan and Policy



Beat the Heat

Short Term…

Conservation of existing resources supportive to reduce heat risk is the primary coping strategy to beat the heat. This includes preserving existing coverage of vegetation and waterbody along with maintaining space between buildings by following floor area ratio and building code. Considering the historical pattern of spatial growth, it is urgent to stop further destruction of green & blue infrastructure.

Although, the study analyzed impact of surface waterbody , it is necessary to ensure seamless provision of water and electricity supply for those areas that fall under the zone of high-moderate heat increase specially during summer (fig 1).

Long Term…

Long term strategy comprises of balancing growth between social and physical development in DNCC urban area. In the existing scenario, there is noticeable discrepancy between areas in per capita consumption of vegetation and waterbody, as well as intensity level of variables causes heat risk. Such inequality causes failure to ensure governance in risk mitigation.

Quadrantal graph in figure 4 illustrates a model on balancing further growth between social and physical index for respective Thana. Ideally the position of thana should be as close to the center point as possible, to Beat the Heat.

Conservation of Green & Blue Infrastructure

Figure 3 shows a coping capacity map for DNCC urban area to illustrate readiness of each Thana to mitigate heat with its existing level of resources. The areas with low coping capacity should not be considered for further growth of population (housing/apartments etc.) and urban functions (school/hospitals/shopping centers/offices etc.), without establishing further space for greenery and waterbodies. Considering the necessity of future growth of Dhaka, further spatial development should be undertaken in those areas which have comparatively higher level of cooling factors, to ensure livable environment for resident of Dhaka North City.

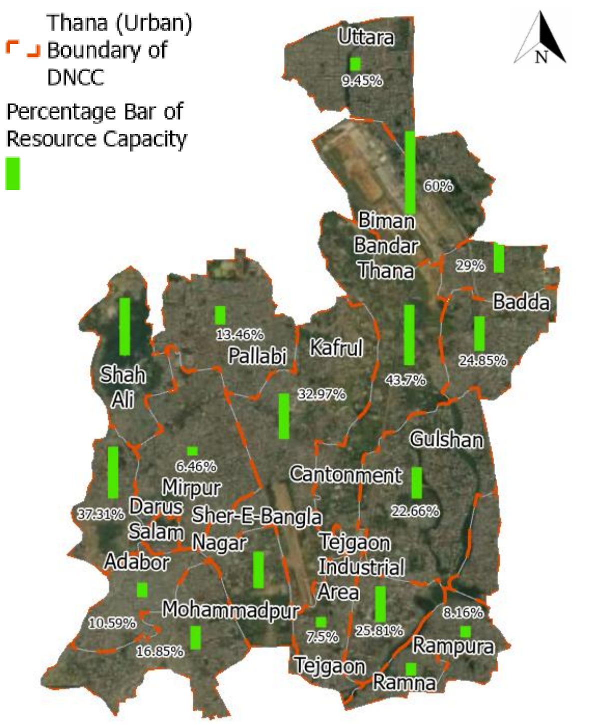
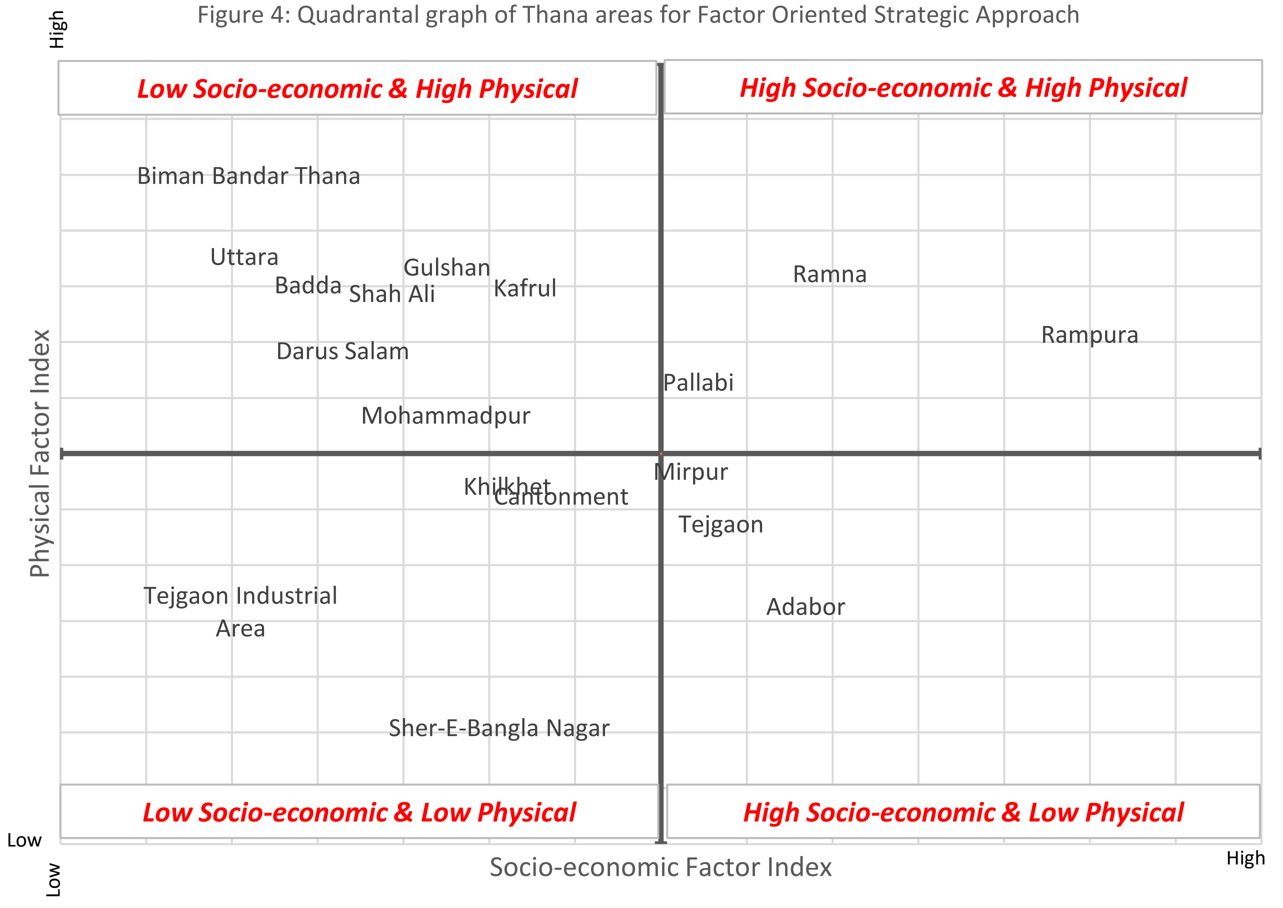


Figure 3: Area wise Heat Coping Capacity Map of DNCC

Figure 4: Quadrantal graph of Thana areas for Factor Oriented Strategic Approach



A Balanced Strategic Approach for Future Spatial Growth

High socio-economic & Low physical category areas are highly susceptible to heat increase and further population growth should be restricted. Mixed-use type may be encouraged to maximize the per capita use of land. Due to low physical properties, these areas have low coping capacity for heat mitigation with existing resources such as vegetation.

Areas under High socio-economic & High physical are suitable for utilizing physical spaces for mitigation action such as rooftop greening and albedo increase. At the same time necessary measures need to be taken to minimize population growth & building use for community services and facilities.

Areas under Low socio-economic & High physical category are suitable for utilizing physical spaces for rooftop greening and increasing albedo. These areas are most suitable for increasing population density & increasing building capacity for urban use. However, existing green-blue infrastructure needs to be preserved and SVF maintained.

Low socio-economic & Low physical category areas also have less mitigative capacity. However, they are suitable for both population and physical growth. Apart from preserving blue-green infrastructure and sufficient space between buildings for uninterrupted heat release to atmosphere and air flow.

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