Ecological Cooling Network Planning for the Bonifacio Global City Watershed Through Biotope Mapping

Abstract

This study assesses the ecological structure of the 979.12-hectare Bonifacio Global City sub-watershed in Metro Manila and develops an Ecological Cooling Network Plan to address rising land surface temperatures and fragmented vegetation in a highly urbanized environment. Biotope mapping identified twenty-one (21) biotopes and fifty-one (51) units derived from land cover, landform, and soildata. These were evaluated using the Period of Development (D), Area (A), Rarity (R), and Habitat (H) criteria to determine their ecological and cooling value. Built-up biotopes dominated the landscape, occupying more than ninety-four percent (94%) of the total area, while green biotopes such as Level Green Spaces, Undulating Green Spaces, and Rangelands accounted for only small, scattered patches. These remaining vegetated areas were classified as cooling cores due to their relatively high cooling value, while the Pasig River corridor and its vegetated segments functioned as cooling corridors linking isolated patches. Heat-intensive built-up zones with limited vegetation were designated as priority areas for cooling interventions. Management strategies included Creative Management for areas requiring the introduction of vegetation, Improvement Management for biotopes with moderate cooling potential, and Conservation Management for the few high-value green spaces. The Ecological Cooling Network Plan proposes the expansion of cooling nodes, enhancement of vegetated corridors, and strengthening of connectivity across the sub-watershed. The study highlights the importance of biotope mapping and remote sensing in understanding thermal patterns and guiding nature-based planning to improve urban resilience in rapidly developing districts.

Keywords: urban heat, biotope mapping, ecological planning, cooling network, geographic information systems, Metro Manila

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I. Introduction

1.1 Background

Urbanization continues to reshape the landscape of Metro Manila and has resulted in significant alterations to local microclimates. As built-up areas expand, natural land covers are replaced with impervious materials such as concrete, asphalt, and glass (Aghazadeh et al., 2025). These surfaces absorb and store heat during the day and release it slowly at night, which intensifies the Surface Urban Heat Island (SUHI) effect. Recent research shows that highly urbanized districts experience higher land surface temperatures because of reduced vegetation, increased building density, and concentrated human activities (Xie et al., 2024).

Dense commercial districts such as Bonifacio Global City (BGC) and the Ortigas to Makati are expected to exhibit elevated SUHI intensity. These areas contain extensive impervious surfaces and high-rise developments that limit airflow, reduce shading, and minimize opportunities for natural cooling. Similar patterns have been documented in other Asian megacities where land cover composition, urban morphology, and local climate zones strongly influence surface temperature variations (Moazzam et al., 2024).

Understanding heat distribution in rapidly developing metropolitan regions benefits from a watershed-scale perspective. A watershed is an integrated environmental system that connects landform, hydrology, soil conditions, and ecological structure. This perspective allows researchers to analyze how biophysical features interact with urban development to influence microclimates. Recent studies emphasize that examining SUHI within a landscape and watershed framework captures spatial heterogeneity more effectively and helps identify potential cooling corridors along rivers, open spaces, and green structures (Yang, 2024).

In Metro Manila, the Pasig River and its tributaries influence local temperature patterns by providing blue and green infrastructure corridors. However, the cooling potential of these waterways depends on the continuity of vegetated riverbanks, the permeability of surrounding land covers, and the level of ecological connectivity within the urban landscape. A watershed perspective therefore provides a more holistic understanding of heat distribution in highly developed areas such as the Bonifacio Global City(BGC) and Ortigas to the Makati region.

1.2 Ecological and Urban Challenges

The study area experiences rising land surface temperatures due to rapid urban expansion and the spread of impervious surfaces. Studies in Metro Manila and other tropical cities consistently show that dense built-up areas record higher surface temperatures because of reduced natural cover and increased heat retention (Magnaye&Kusaka, 2024).

In addition, the loss of vegetation further intensifies heat. Reduced tree cover limits shading and evapotranspiration, both of which are essential for cooling, and research confirms that declining green cover directly increases urban heat exposure. Existing cooling spaces within the sub-watershed are highly fragmented. Small parks and isolated patches of vegetation lack connectivity, which weakens their collective cooling performance across the landscape. As a result, urban heat tends to accumulate in major commercial districts such as Bonifacio Global City (BGC) and surrounding mixed-use areas, which consistently appear as thermal hotspots in local heat island analyses (Purio et al., 2022).

Finally, the condition of the Pasig River corridor limits its potential as a cooling feature. Although rivers can moderate urban temperatures, studies in Metro Manila show that hardened riverbanks and insufficient riparian vegetation reduce the effectiveness of blue-green networks in providing cooling benefits (Ibañez, 2024).

1.3 Biotope Mapping

Understanding urban heat within a rapidly developing watershed requires an integrated spatial approach that considers the interaction of land cover, landform, soil type, and hydrology. Remote sensing and geographic information systems (GIS) provide the analytical foundation for assessing these conditions at a landscape scale, allowing a holistic understanding of how built-up density and natural features influence thermal patterns in the study area.

Central to this study is the use of biotope mapping, which classifies the landscape into ecologically meaningful units. This method allows detailed examination of the condition and ecological role of different spaces while enabling a structured interpretation of how each biotope contributes to thermal regulation.

Recent applications of biotope mapping demonstrate its effectiveness in analyzing ecological structure in both densely urbanized and transitional landscapes, identifying areas with potential cooling benefits and areas vulnerable to heat accumulation. Used in Philippine planning studies, such as urban greening assessments in Pasig City and ecological structure mapping in the University Belt, showed that spatial analysis and biotope-based classification can guide local climate resilience strategies (Ibañez, 2024; Sibayan, 2025). International studies also support this approach, including UHI network mapping in Nanjing and green space cooling analyses in Guangzhou (Wang & Hu, 2025; Zhang et al., 2025), both of which emphasize how spatial configuration and ecological connectivity influence land surface temperature. Together, these demonstrate that integrating biotope mapping with land surface temperature and spatial analysis can effectively inform urban heat mitigation planning.

1.4 Research Goals

This study aims to evaluate the existing thermal and ecological conditions within the Bonifacio Global City (BGC) sub-watershed and surrounding barangays by applying biotope mapping and ecological management and networking. Through this approach, the study seeks to respond to increasing land surface temperatures, fragmented green spaces, and degraded river corridors in a highly urbanized district.

Specifically, the goals of this study are (1) to identify the existing biotopes and ecological structures in the study area, (2) to determine the ecological value of each biotope using modified D–A–R–H criteria, and (3) to develop an ecological plan that enhances cooling networks, strengthens connectivity, and supports climate-adaptive urban development. This study hypothesizes that an integrated ecological planning approach can improve thermal regulation while supporting urban resilience and climate adaptation in Metro Manila.

II. Methodology

2.1 Delineation of Site Boundary

The extent of Bonifacio Global City (BGC) and its surrounding barangays was first used to establish the minimum area of interest for the study. From this baseline, the sub-watershed was delineated by identifying local high points in the terrain and mapping natural runoff flow toward the Pasig River, which serves as the main drainage outlet for the area.

This process outlined the surfaces that drain into the river, forming a sub-watershed within the larger Pasig River Basin. The final delineation covers approximately 979.12 hectares and consists mainly of dense built-up zones and limited green areas that influence the urban heat conditions of the site.

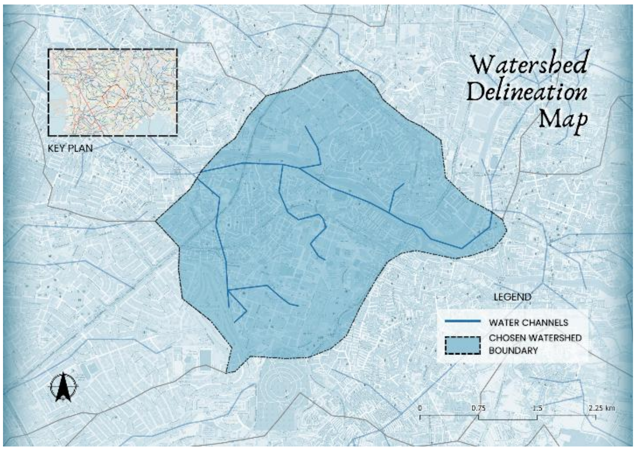

Figure 1. Watershed Delineation of the Study Site.

2.2 Biotope Mapping Approach

Biotope maps can be generated from the overlay of three (3) land classification maps: soil map, landform map, and land cover map which indicate hydro-geological features, soil and vegetation characteristics, urban development, and remaining open spaces. In this study, soil classifications were obtained from the Philippine Geoportal (NAMRIA), landform data were derived from the SRTM Digital Elevation Model accessed through USGS Earth Explorer, while land cover classifications and urban green space features were obtained from Philippine Geoportal and OpenStreetMap datasets.

To incorporate thermal conditions, a Land Surface Temperature (LST) map was generated using the Thermal Infrared Bands of Landsat 8/9 imagery, processed to obtain annual mean LST values. The LST layer was then integrated with soil, landform, and land cover maps in a GIS environment to delineate distinct urban heat biotopes within the Pasig River sub-watershed.

Table 1. Summary of data sources for each land classification map type.

Map Type	Acquired Data	Data Source
Soil Type Map	Soil Classifications	Philippine Geoportal (NAMRIA)
Landform Map	Topography Data	USGS Earth Explorer– SRTM
Landcover Map	Land cover classifications; Land use green spaces	Philippine Geoportal (NAMRIA); OpenStreetMap (OSM)
Land Surface Temperature Map	Annual mean LST values	Landsat 8/9 Thermal Infrared Data (USGS)

2.3 Biotope Assessment

The ecological value of each biotope identified in the biotope map was assessed using four (4) criteria: Period of Development, Area, Rarity, and Habitat (Jarvis & Young, 2005), with parameters modified to suit the urban conditions of the study area. A rating value ranging from one (1) to five (5) was assigned for each criterion, and the total score was used as the basis for determining the cooling value and priority management of each biotope.

The Period of Development (D) refers to the time required for a biotope to establish structural complexity. Biotopes with longer development time (such as mature tree canopy or established vegetation) were given higher scores due to their greater cooling capacity and structural stability. Area (A) indicates the total spatial extent of the biotope, where larger biotopes are valued higher because they function as potential cooling cores and can influence wider thermal conditions. Rarity (R) represents how unique or scarce a biotope is within the sub-watershed; biotopes that are limited in number or isolated from similar types were given higher ratings due to their irreplaceable cooling role in dense urban settings. Lastly, Habitat (H) refers to vegetation structure and functional capacity. Biotopes with complex vegetation that provide shade, evapotranspiration, and thermal regulation were rated higher than biotopes with simple or low-vegetation structures (such as built-up areas). The resulting Value Assessment totals allowed the identification of high, medium, and low value biotopes, which informed the proposed ecological cooling strategies and network planning within the study area.

Table 2. Biotope assessment criteria.

Criterion	Description	Rating
Period of Development (D)	Duration the community will take to establish itself elsewhere.	D1= 0-10 years
		D2= 10-20 years
		D3= 20-30 years
		D4= 30-50 years
		D5= >50 years
Area (A)	The larger the area the greater potential of cooling cores for the thermal conditions.	A1= 0-1 ha
		A2= 1-10 ha
		A3= 10-50 ha
		A4=50-200 ha
		A5=200+ ha
Rarity (R)	Uniqueness of the said biotope.	R1= Many similar biotopes occurring
		R2= 4-5 similar biotopes within 500 -1000 m
		R3= 3-2 similar biotopes within 2 km
		R4= One equivalent biotope
		R5= No equivalent biotopes
Habitat (H)	Quantity of vegetation structure found.	H1= No kind of Vegetation Exist
		H2=Almost a uniform vegetation structure
		H3= 2 Different vegetation structure
		H4= 3 Different vegetation structures
		H5= Several vegetation structures

2.4 Ecological Planning

The existing ecological structure within the chosen sub-watershed is identified from the assessment of each biotope and the major biotope categories. Biotopes with the highest value were designated as cores, representing areas with strong vegetative structure and higher thermal-regulating potential. Existing riverbanks along the Pasig River, linear elements, such as streets and pathways, were identified as corridors, which can connect cooling spaces across the urban fabric and support ventilation flows within the densely built areas of the study site.

After identifying the existing cores and corridors, an ecological plan was developed to enhance cooling capacity and improve network connectivity. Management strategies were assigned based on the value assessment scores of each biotope using four levels: Creative (0–5), Improvement (6–10), Conservation (11–15), and Preservation (15–20). These strategies guide appropriate planning actions from creating new cooling spaces in thermally vulnerable areas to improving vegetation in medium-value biotopes, to conserving and preserving high-value cooling spaces. Thereby strengthening the ecological cooling network within Bonifacio Global City and surrounding barangays.

Table 3. Biotope Management Strategies and Corresponding Score Range.

Management Strategies	**Description**	**Range of Biotope Assessment**
Creative	Establishment of new cooling spaces and green structures in areas with minimal vegetation and high surface temperature	0-5
Improvement	Enhancement of existing biotopes with moderate cooling value through vegetation addition, shading elements, and landscape interventions that increase cooling performance.	6-10
Conservation	Protection and enhancement of high-value cooling spaces that provide significant shading, evapotranspiration, and connectivity, allowing only limited intervention.	11-15
Preservation	Strict protection of the most critical cooling cores with minimal human intervention.	15-20

2.5 Scope and Limitations

This study was designed to evaluate urban heat conditions and ecological structure using a remote-sensing–based biotope mapping approach. Field validation and on-site ecological surveys were outside the scope of the research, and the analysis relied entirely on satellite-derived and secondary spatial datasets. While this method enables consistent and efficient assessment of the sub-watershed at a landscape scale, it also presents limitations, as previous biotope mapping studies emphasize the importance of ground verification to confirm vegetation conditions, land cover classifications, and microclimatic variation.

The accuracy of results may be affected by factors such as satellite resolution, seasonal variations in land surface temperature, and the influence of high-rise structures on thermal readings in the dense urban districts.

III.Results and Analysis

3.1 Soil Map

The soil map reveals a mix of clay, clay loam, clay loam adobe, silt loam, and several areas labeled as undefined soil. Clay and Clay Loam Adobe soils dominate the portions of the site, particularly in built-up districts. Although clay-based soils retain moisture, its infiltration potential becomes limited when sealed by pavement, which contributes indirectly to higher surface temperatures. Clay loam and silt loam soils, still seen on the built-up areas, appear lesser on the northeastern region of the site. These soil types indicate opportunities for strengthening cooling vegetation in parks, roadside planting strips, and remaining open areas. Although soil type has less influence on thermal behavior than land cover, it still provides important insight into where cooling-oriented planting is feasible.

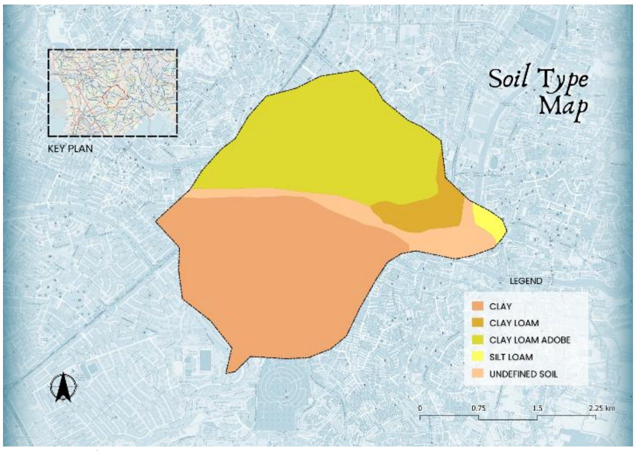

Figure 2. Soil Type Map

3.2 Landform map

The landform map shows that the study area is predominantly level terrain, with smaller portions classified as rolling, undulating, and mountainous. A distinct linear riverbank zone follows the alignment of the Pasig River. This topographic pattern reflects the condition of the site as a low-lying sub-watershed, where surface runoff naturally flows toward the Pasig River.

In relation to urban heat, level built-up areas frequently exhibit elevated land surface temperatures because of extensive impervious surfaces and limited airflow. Meanwhile, rolling and undulating pockets, although small in extent, can influence micro-level ventilation. Riverbank landforms also present natural linear pathways that may function as potential cooling corridors once supported with adequate vegetation.

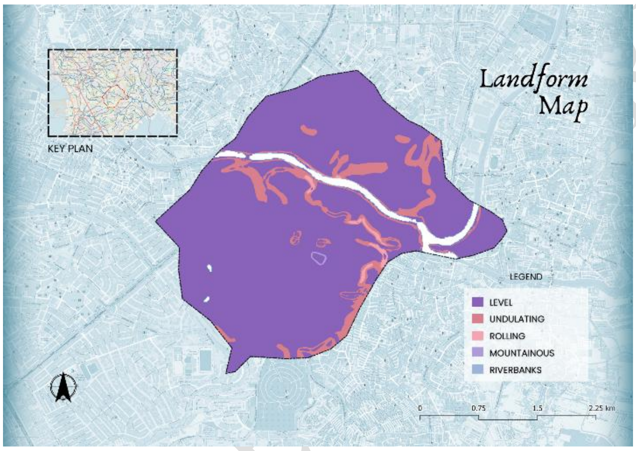

Figure 3. Landform Map.

3.3 Landcover Map

The land cover map indicates that the study area is primarily built-up, reflecting the presence of Bonifacio Global City and adjacent high-density barangays. Green spaces occur as isolated patches, with rangeland and other vegetated areas appearing in fragmented clusters. Water cover consists almost entirely of the Pasig River.

The overwhelming presence of built-up surfaces makes the area highly susceptible to surface urban heat island formation. Fragmented green spaces limit the development of larger cooling cores and reduce ecological connectivity. The few existing green patches, such as small parks and open spaces, offer localized cooling benefits but remain insufficient for broader thermal mitigation.

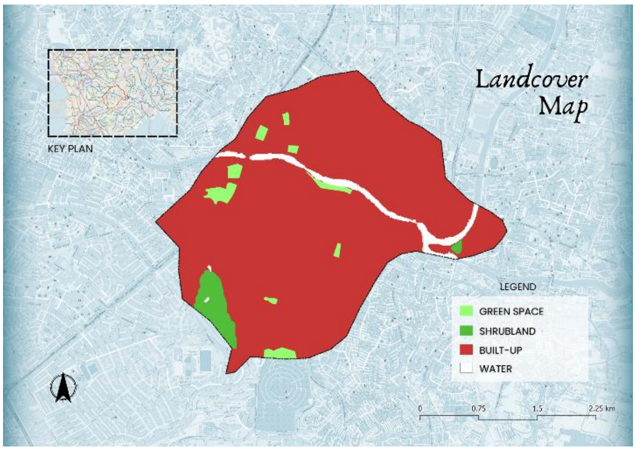

Figure 4. Landcover Map

3.4 Biotope Map

A total of twenty-one biotopes were identified within the 979.12-hectare sub-watershed, revealing a landscape overwhelmingly dominated by built-up surfaces. Natural and semi-natural green biotopes appear only in small and scattered patches throughout the study area.

Level Green Spaces consist of three biotope types and cover a combined 20.58 hectares, equivalent to only 2.10% of the sub-watershed. These include Level Green Space Clay (8.41 ha, 0.89%), Level Green Space Clay Loam Adobe (8.01 ha, 0.85%), and Level Green Space Undefined Soil (4.16 ha, 0.44%). These biotopes appear primarily in parks, planted open areas, and isolated pockets of vegetation within the built-up zone.

Undulating Green Spaces are represented by a single biotope, Undulating Green Space Clay Loam Adobe, covering 2.66 hectares or 0.28% of the study area. Although very limited in extent, this biotope provides vegetated structure along slightly elevated topography and contributes localized cooling within its immediate surroundings.

Rangeland Biotopes form the largest green biotope category, with a combined area of 28.94 hectares or 2.95% of the study site. These include Level Rangeland Clay (25.92 ha, 2.75%), Level Rangeland Undefined Soil (1.45 ha, 0.15%), and Undulating Rangeland Clay (1.57 ha, 0.17%). Despite their relatively small coverage, these rangeland biotopes exhibit higher vegetative complexity and represent some of the most valuable cooling areas within the sub-watershed.

In contrast, built-up biotopes occupy more than 926 hectares, representing over 94% of the entire sub-watershed. The largest built-up category is Level Built-up Clay, which covers 398.26 hectares or 42.28% of the total area. This is followed by Level Built-up Clay Loam Adobe with 283.94 hectares (30.14%) and Level Built-up Undefined Soil with 59.29 hectares (6.29%). Other built-up categories include Level Built-up Clay Loam (35.41 ha, 3.76%) and Level Built-up Silt Loam (9.50 ha, 1.01%), further emphasizing the dominance of impervious surfaces.

Additional built-up biotopes occur along varying terrain, including Rolling, Undulating, and Mountainous Built-up types. These biotopes cover smaller areas, such as Rolling Built-up Clay (5.08 ha, 0.54%) and Mountainous Built-up Clay (1.09 ha, 0.12%), along with several Undulating Built-up variants ranging from 6.21 to 48.00 hectares. Although these categories reflect elevation changes near the watershed boundaries, they remain highly urbanized and maintain minimal vegetation presence.

Riverbank Built-up biotopes, covering 3.74 hectares (0.39%), represent hardened edges of the Pasig River, including Clay Loam Adobe and Undefined Soil variants. These units exhibit low habitat scores due to sparse riparian vegetation and reflect a heavily engineered river corridor with limited natural cooling capacity.

With this, the biotope distribution shows that the sub-watershed is a densely urbanized landscape with very limited vegetated structure. Built-up biotopes dominate the area both spatially and functionally, while green biotopes remain small, isolated, and fragmented. This pattern highlights the urgent need to strengthen ecological connectivity and develop new corridors to mitigate the intense urban heat conditions observed in the study area.

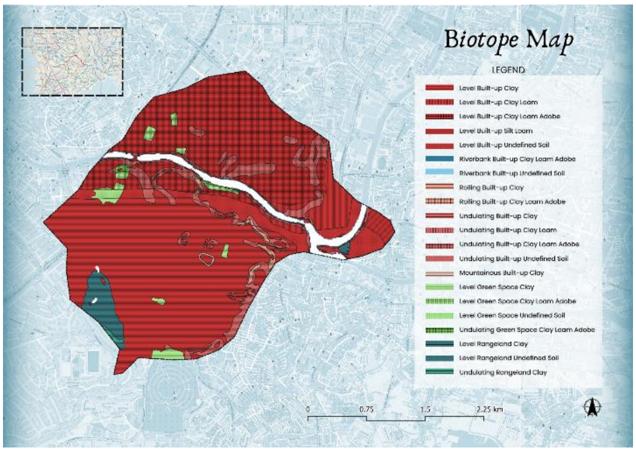

Figure 5. Biotope Map

Table 4. Biotope Matrix.

Code	Landcover	Landform	Soil Type	Biotope Type
B-L-C	BUILT UP	LEVEL	CLAY	Level Built-up Clay
B-L-CL	BUILT UP	LEVEL	CLAY LOAM	Level Built-up Clay Loam
B-L-CLA	BUILT UP	LEVEL	CLAY LOAM ADOBE	Level Built-up Clay Loam Adobe
B-L-SL	BUILT UP	LEVEL	SILT LOAM	Level Built-up Silt Loam
B-L-UND	BUILT UP	LEVEL	UNDEFINED SOIL	Level Built-up Undefined Soil
B-R-CLA	BUILT UP	RIVERBANK	CLAY LOAM ADOBE	Riverbank Built-up Clay Loam Adobe
B-R-UND	BUILT UP	RIVERBANK	UNDEFINED SOIL	Riverbank Built-up Undefined Soil
B-RL-C	BUILT UP	ROLLING	CLAY	Rolling Built-up Clay
B-RL-CLA	BUILT UP	ROLLING	CLAY LOAM ADOBE	Rolling Built-up Clay Loam Adobe
B-U-C	BUILT UP	UNDULATING	CLAY	Undulating Built-up Clay
B-U-CL	BUILT UP	UNDULATING	CLAY LOAM	Undulating Built-up Clay Loam
B-U-CLA	BUILT UP	UNDULATING	CLAY LOAM ADOBE	Undulating Built-up Clay Loam Adobe
B-U-UND	BUILT UP	UNDULATING	UNDEFINED SOIL	Undulating Built-up Undefined Soil
B-M-C	BUILT UP	MOUNTAINOUS	CLAY	Mountainous Built-up Clay
G-L-C	GREEN SPACE	LEVEL	CLAY	Level Green Space Clay
G-L-CLA	GREEN SPACE	LEVEL	CLAY LOAM ADOBE	Level Green Space Clay Loam Adobe
G-L-UND	GREEN SPACE	LEVEL	UNDEFINED SOIL	Level Green Space Undefined Soil
G-U-CLA	GREEN SPACE	UNDULATING	CLAY LOAM ADOBE	Undulating Green Space Clay Loam Adobe
R-L-C	RANGELAND	LEVEL	CLAY	Level Rangeland Clay
R-L-UND	RANGELAND	LEVEL	UNDEFINED SOIL	Level Rangeland Undefined Soil
R-U-C	RANGELAND	UNDULATING	CLAY	Undulating Rangeland Clay

3.5 Land Surface Temperature Map

The Land Surface Temperature map shows clear temperature variation within the study area, with values ranging from approximately 37.08°C to 38.91°C. The highest temperatures appear in the most intensely built-up portions of the sub-watershed, particularly in areas with limited vegetation. These locations contain large expanses of impervious surfaces, minimal tree cover, and dense high-rise development, all of which contribute to elevated surface temperatures. Moderate temperatures occur in built-up zones that contain small vegetated patches or cooling cores. However, their influence remains limited due to their small size and fragmented distribution.

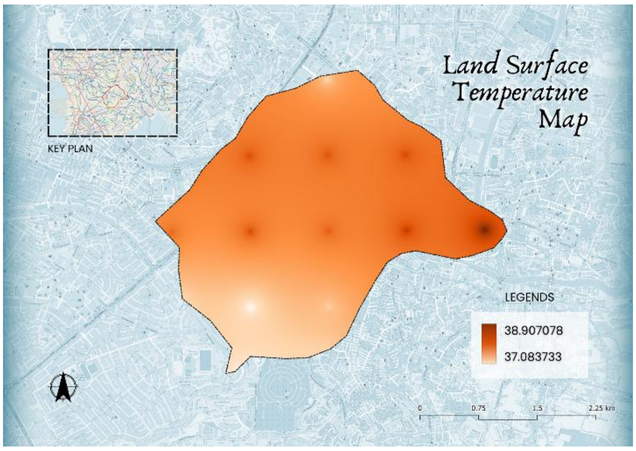

Figure 6. Land Surface Temperature Map

3.6 Ecological Management Map

The ecological assessment revealed clear differences in cooling value across the fifty-one (51) biotope units, shaped by variations in land cover, vegetation structure, soil type, and urban density. The creative management (0–5 points) represent the lowest scoring units, concentrated in the most densely built-up portions. Moreover, their low Period of Development and Habitat scores indicate the absence of meaningful ecological structure, supporting the recommendation to create new cooling spaces. These biotopes exhibit the greatest potential for transformative cooling improvements.

Next, the improvement management (6–10 points) shows moderate ecological value, typically consisting of areas where vegetation exists but remains insufficient, fragmented, or weakly connected. These include landscaped areas and isolated green pockets; their moderate scores indicate that these biotopes provide some cooling benefits but require enhancement to maximize their ecological function.

Only a few biotope units qualified under the conservation management (11–15 points). These include rangeland patches and selected green spaces with more mature vegetation, greater habitat complexity, and relative rarity in the urban landscape. Although they cover only a small portion of the sub-watershed, these biotopes serve as important cooling cores that maintain ecological function and provide essential thermal relief.

Overall, the ecological management assessment shows that most of the sub-watershed falls under Create and Improve management, indicating widespread heat vulnerability and limited vegetation. Only a few biotopes qualify for Conserve management, emphasizing the scarcity of high-value cooling areas. This distribution highlights the need to expand green infrastructure, strengthen ecological connections, and protect the remaining vegetated patches to build an effective cooling network across the study area.

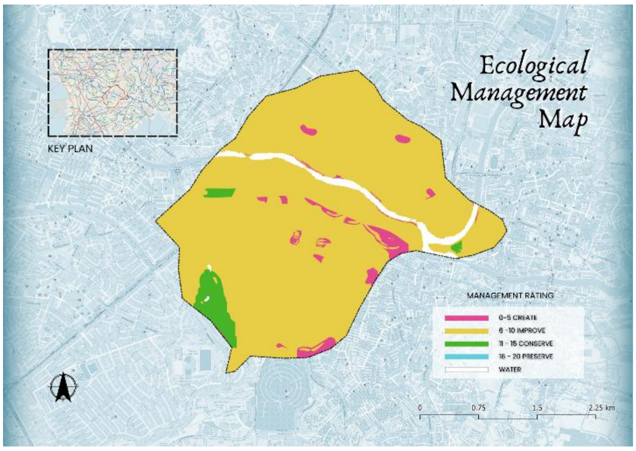

Figure 7. Ecological Management map

Table 5. Value Assessment Matrix.

Biotope Unit	Area (ha)	D	A	R	H	Total	Management
B-L-C-1	390.37	1	5	1	1	8	Improve
B-L-C-2	2.57	1	2	1	1	5	Create
B-L-C-3	5.32	1	2	1	1	5	Create
B-L-CL-1	31.19	1	3	2	3	9	Improve
B-L-CL-2	4.22	1	2	2	3	8	Improve
B-L-CLA-1	35.65	1	3	1	2	7	Improve
B-L-CLA-2	1.34	1	2	1	2	6	Improve
B-L-CLA-3	239.41	1	5	1	2	9	Improve
B-L-CLA-4	7.54	1	2	1	2	6	Improve
B-L-SL-1	9.5	1	2	5	1	9	Improve
B-L-UND-1	13.96	1	3	2	3	9	Improve
B-L-UND-2	8.39	1	2	2	3	8	Improve
B-L-UND-3	36.94	1	3	2	3	9	Improve
B-R-CLA-1	2.19	1	2	5	1	9	Improve
B-R-UND-1	1.55	1	2	5	1	9	Improve
B-RL-C-1	1.3	1	2	3	3	9	Improve
B-RL-C-2	2.07	1	2	3	3	9	Improve
B-RL-C-3	1.71	1	2	3	3	9	Improve
B-RL-CLA-1	1.22	1	2	5	1	9	Improve
B-U-C-1	1.67	1	2	1	1	5	Create
B-U-C-2	1.13	1	2	1	1	5	Create
B-U-C-3	4.44	1	2	1	1	5	Create
B-U-C-4	1	1	2	1	1	5	Create
B-U-C-5	7.6	1	2	1	1	5	Create
B-U-C-6	13.4	1	3	1	1	6	Improve
B-U-C-7	1.57	1	2	1	1	5	Create
B-U-CL-1	1.81	1	2	3	1	7	Improve
B-U-CL-2	5.51	1	2	3	1	7	Improve
B-U-CLA-1	14.4	1	3	1	1	6	Improve
B-U-CLA-2	1.74	1	2	1	1	5	Create
B-U-CLA-3	16.73	1	3	1	1	6	Improve
B-U-CLA-4	1.11	1	2	1	1	5	Create
B-U-CLA-5	12.4	1	3	1	1	6	Improve

B-U-CLA-6	1.62	1	2	1	1	5	Create
B-U-UND-1	6.21	1	2	5	1	9	Improve
B-M-C-1	1.09	1	2	5	1	9	Improve
G-L-C-1	1.00	1	1	2	2	6	Improve
G-L-C-2	1.14	1	2	2	2	7	Improve
G-L-C-3	1.31	1	2	2	2	7	Improve
G-L-C-4	4.96	1	2	2	3	8	Improve
G-L-CLA-1	1.21	1	2	2	2	7	Improve
G-L-CLA-2	1.30	1	2	2	2	7	Improve
G-L-CLA-3	1.41	1	2	2	2	7	Improve
G-L-CLA-4	1.97	1	2	2	2	7	Improve
G-L-CLA-5	2.12	1	2	2	2	7	Improve
G-L-UND-1	4.16	1	2	5	3	11	Conserve
G-U-CLA-1	1.23	1	2	3	2	8	Improve
G-U-CLA-2	1.43	1	2	3	2	8	Improve
R-L-C-1	25.92	2	3	5	4	14	Conserve
R-L-UND-1	1.45	2	2	5	4	13	Conserve
R-U-C-1	1.57	2	2	5	4	13	Conserve

3.7 Ecological Cooling Network Map

Firstly, the goal for creative managementis to generate new nodes and corridors to reduce thermal intensity and strengthen connectivity across the sub-watershed. Specific strategies are as follows:

3.7.1 Establishment of New Cooling Nodes.
Introducing pocket greens, planted open areas, or micro-cooling spaces that become new anchor points in the network and reduce the distance between existing cooling cores.

3.7.2 Creation of New Cooling Corridors.
Adding street tree alignments along primary and secondary roads to form continuous vegetated pathways that link fragmented cooling patches.

3.7.3 Reclamation of Idle or Impervious Spaces.
Transforming unused paved lots or excess road width into vegetated nodes that act as stepping stones within the cooling network.

3.7.4 Introduction of Riparian Greening Along Engineered Riverbanks.
Placing modular planters, vertical greening, or linear planting strips along hardened Pasig River edges to initiate a cooling corridor where continuous vegetation is otherwise not possible.

Secondly, the improvement management supports zones that require enhancement that function as effective corridors, intermediate nodes, or transition areas. Specific strategies are as follows:

3.7.5 Canopy Expansion.
Increasing canopy cover along streets, pathways, and green edges to elevate their cooling function and improve corridor continuity.

3.7.6 Enhancement of Fragmented Green Patches.
Upgrading isolated open spaces so they act as effective stepping stones that bridge cooling cores and other vegetated areas.

3.7.7 Vegetated Buffer Enhancement Along Built Edges.
Adding linear planting zones along buildings, walkways, and parking lots to soften thermal boundaries and support corridor formation.

3.7.8 Upgrading Existing Open Spaces into Functional Cooling Nodes.

Transforming underperforming landscaped areas into stronger cooling pockets with multi-layer vegetation, enabling them to serve as mid-point nodes in the network.

3.7.9 Incremental Riparian Vegetation Reinforcement.
Introducing or densifying vegetation in accessible riverbank sections to improve the continuity and cooling function of the Pasig River corridor.

Lastly, conservation management is for primary anchors of the system. The objective is to protect, maintain, and strengthen existing cores to ensure long-term thermal mitigation and ecological stability.

3.7.10 Habitat Maintenance and Structural Enhancement
Retaining existing vegetation while adding depth through understory and midstory layers, improving their microclimate function without altering the core structure.

3.7.11 Establishment of Protective Ecological Buffers
Creating low-disturbance peripheral planting zones around conserved areas to protect core vegetation and maintain the stability of the cooling node.

3.7.12 Integration as Primary Network Anchors
Designating conserved biotopes as the main hubs within the ecological network and ensuring corridors and improved areas are oriented toward strengthening their connectivity.

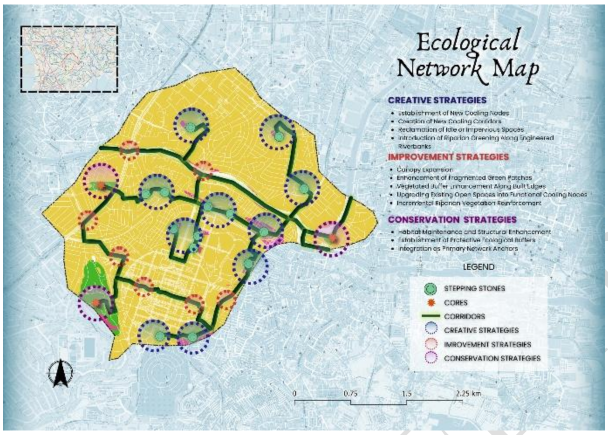

Figure 8. Ecological Network map.

IV.Conclusion

As dense urban districts continue to expand, highly built-up areas such as Bonifacio Global City and its surrounding barangays become increasingly vulnerable to intensified urban heat conditions. Through biotope mapping, the ecological structure of these heat-prone environments can be identified, allowing the development of a cooling network that supports thermal regulation and improves urban livability.

A total of twenty-one (21) biotope types and fifty-one (51) biotope units were identified within the 979.12-hectare BGC sub-watershed. Green biotopes, including Level Green Spaces, Undulating Green Spaces, and Rangeland units, occupied only a small portion of the site, while built-up biotopes dominated more than 94% of the area. Through biotope assessment, the remaining green biotopes were found to have the highest ecological value and were designated as the primary cooling cores of the ecological network.

The Pasig River corridor and vegetated segments along its banks formed the foundation of the cooling corridors, offering the only continuous linear feature capable of supporting large-scale cooling across the study area. Meanwhile, scattered patches of green space within the built-up matrix serve as cooling elements as well that can be strengthened to enhance overall network connectivity.

Building on these findings, three management strategies were recommended for the sub-watershed: Creative Management for heat-intensive zones with minimal vegetation, Improvement Management for areas with moderate cooling function, and Conservation Management for the remaining high-value green spaces. Together, these strategies informed the formulation of the Ecological Cooling Network Plan, which seeks to establish connected cooling routes, reinforce existing vegetated areas, and introduce new cooling nodes to mitigate heat stress across the urban landscape.

In moving forward, it is recommended that future research incorporate field validation to support and refine the remote-sensing-based assessments used in this study. Strengthening collaboration with local planners and community stakeholders would also help translate the Ecological Cooling Network Plan into actionable urban interventions. Moreover, expanding the analysis to adjacent sub-watersheds and integrating additional spatial metrics could further enhance long-term strategies for urban heat mitigation in Metro Manila.

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