Blue Green Infrastructure Planning: Approaches, Integration in Society and Implementation

Rounak Biswas[1], Deepti Sagar[2]

[1]*Student, Faculty of Architecture & Planning, AKTU, Uttar Pradesh, India*
[2]*Assistant Professor, Faculty of Architecture & Planning, AKTU, Uttar Pradesh, India*

---***---

Abstract - *With rapidly declining environmental conditions in the urban scenario, the current times demand for not just grey interventions, but more focus on nature based solutions for overcoming the fate of the modern times. Studies show major Indian cities are rapidly losing green cover in the current decade, which must be arrested with efficient approaches. This is extremely important for maintaining resilience in the urban setting. Cities should be resilient to protect its ecology and residents from the aftermath of major disasters. This resilience can be built by a functioning integrated layout of nature based interventions interlinked with planning. This paper is focused on understanding blue green infrastructure, its approaches, how it has been used in various projects in the country and the world to solve certain relevant environmental issues related to the context. The understanding has been tried to be achieved by studying relevant researches and implemented projects. The studies discuss about a range of aspects like geospatial analysis to achieve a network of blue green infrastructure, identifying various service demands and conducting land suitability assessment, identifying the stakeholders involved and on-ground implementation strategies, involvement of the community and the public spaces availability. Thus finally, the research is aimed towards getting an in-depth understanding and in the near future implementing this understanding towards successful integration into a thesis in a selected site context.*

Key Words: **Blue green infrastructure, resilience, disasters, planning, service demands, land suitability assessment, public spaces, community, nature based solutions**

1. INTRODUCTION

Blue-green infrastructure can be defined as "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity" (Driver, 2021).

According to the Intergovernmental Panel on Climate Change, global CO2 emissions will need to decline by about 45 percent below 2010 levels by 2030 and reach net zero by 2050 to keep the overall temperature increase within the 1.5°C limit by the end of the century. In India, average temperatures have increased by 0.7°C between 1901 and 2018 due to excessive greenhouse gas emissions. Even at the most optimum rate of immediate emissions mitigation, India's temperature will still rise by 2.7°C by 2099; in the worst scenario, it will rise by 4.4°C by the end of the century (Driver, 2021).

Several Indian cities have seen a decline in green and blue features due to rapid urbanization, with studies on land-use transitions indicating environmental losses. Early approaches of compensating natural losses involved creating 'grey' infrastructure—artificially engineered solutions adapted to deal with climate emergencies related to water, such as wastewater treatment plants, water pumping stations in flood prone zones, pipelines, dams and reservoirs. Infrastructure planning must become more sensitive to ecological considerations by developing and adapting nature-based solutions to meet climate and sustainability goals, a purpose served by blue-green infrastructure.

2. STUDIES FROM COMPLETED RESEARCHES

2.1. Blue-green network planning as a spatial development and climate-resilient strategy - the case of Belmopan, Belize

Authors - Marcus Mayri, Clara Alonso and Chandra Rouse

Brief - UN-Habitat in collaboration with the Belmopan City Council and other local stakeholders, identified a blue-green network planning approach for the capital city of Belize, Belmopan. They developed a masterplan for the city that provides new strategies for managing urban flood risk, enhances the garden city character and promotes economic development in this newly developed city (Marcus Mayri, 2017). Given the geography of the area, the city-wide strategy is based on the network of existing natural systems, multi-modal transit systems and public spaces in order to improve connectivity spatially and socially.

Approach - The first steps of this planning approach were to identify the current public spaces, agricultural areas and protected areas, and study how to spatially link them. This layer focuses on developing more spaces and improving connectivity between the spaces using three scales: city scale, neighbourhood scale and community scale.

City scale: At the city scale, the network includes open spaces along creeks and primary roads, spaces designed for particular activities such as the riparian recreation areas, bicycle lanes, pedestrian walkways, forests, city parks, botanical gardens, stadium, city market, urban agriculture production and tree planting along the roads.

Neighbourhood scale: For the neighbourhood scale, the network features recreational spaces along the secondary roads. These spaces include sports fields, multi-purpose spaces, markets, plazas, urban agriculture, water parks, schoolyards or waiting rooms for public transport; all of which are spaces designed to be upgraded and provide services to small groups of citizens.

Community level: Finally, at the community scale, the network features small public spaces with uses like pocket parks, urban playgrounds, street micro-interventions, seating spots or reading areas. This enables people to easily make of their immediate urban surrounding a place to go, stay and interact with others. (Marcus Mayri, 2017)

Eco-mobility plan: A city-wide accessibility through eco-mobility was a main goal of the masterplan and a tool for an adequate design of the Blue-Green network. Proximity plays a key role in this strategy and so the network was planned based on walkable and bikable distances. Enabling walkability and cycling improves public health. The design of this infrastructure not only focuses enabling sustainable mobility but also place-making and creating liveable urban spaces.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

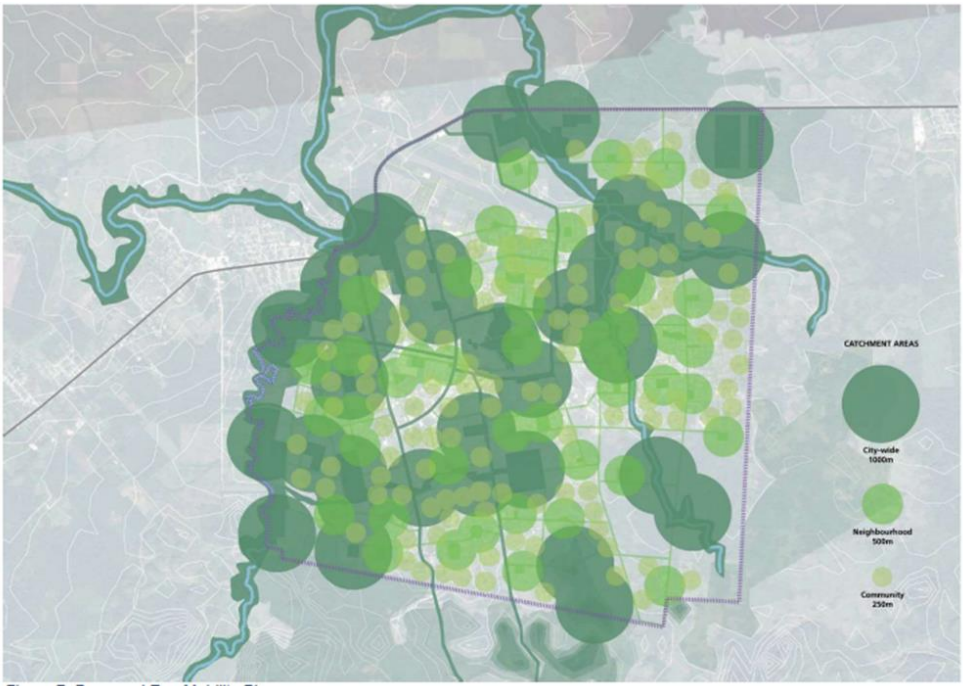

Fig-1: Proposed Eco-Mobility Plan (Marcus Mayri, 2017)

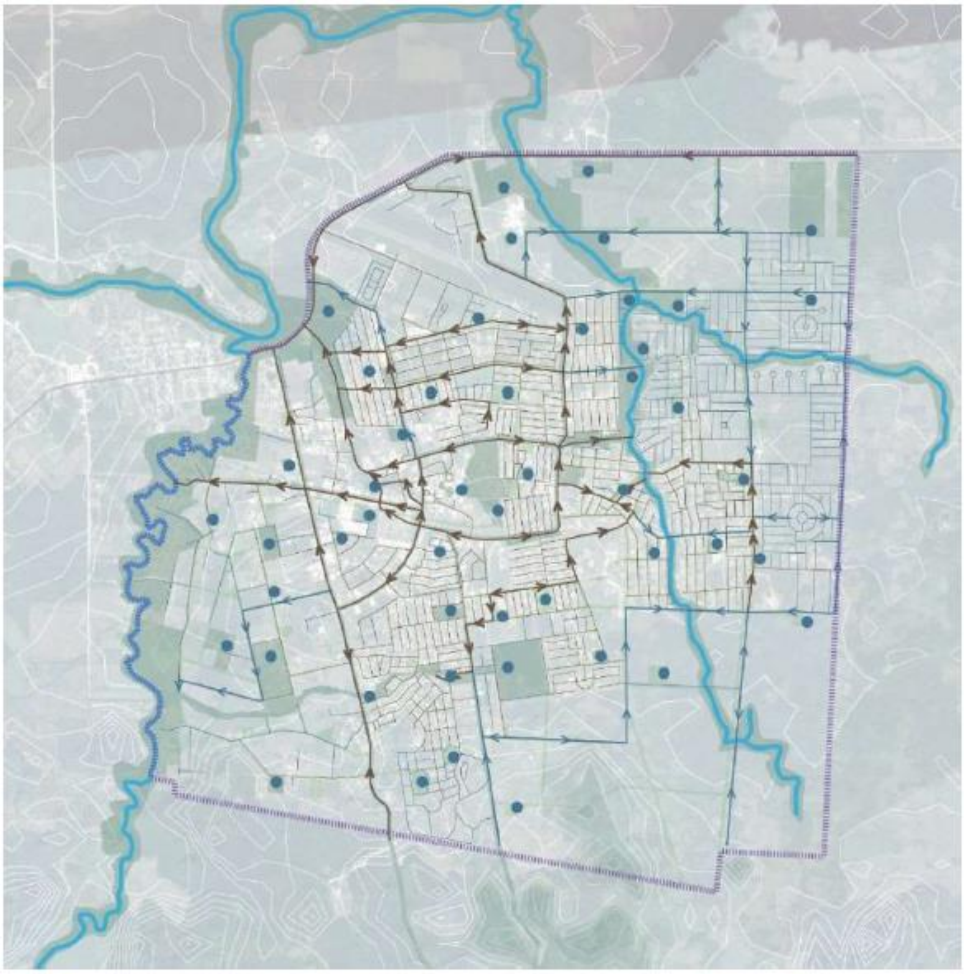

Fig-2: Existing and Proposed Drainage System and Flow (Marcus Mayri, 2017)

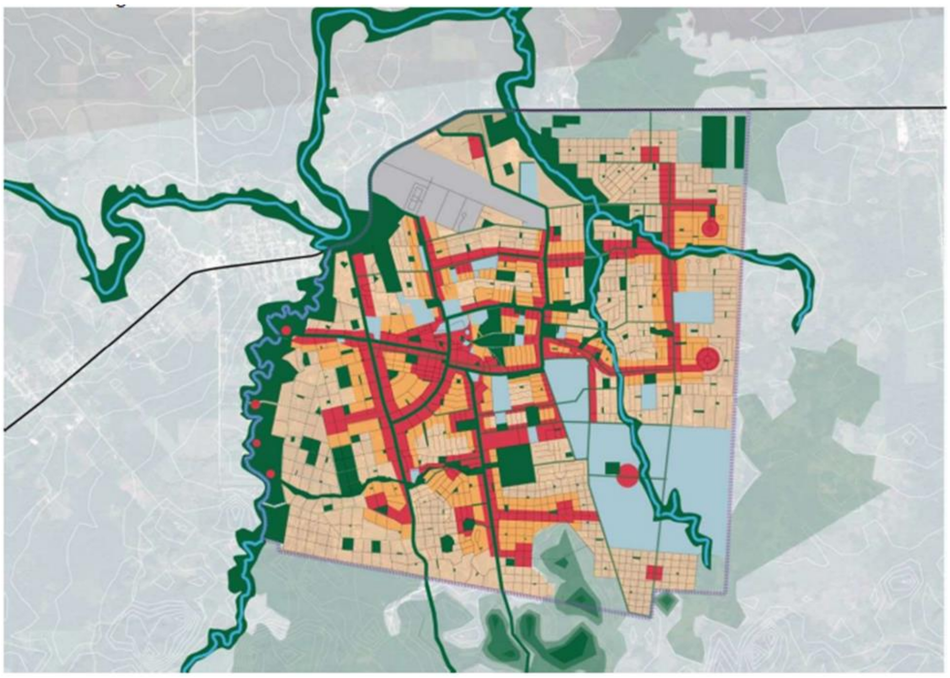

Fig-3: Proposed Integrated Resilient Master Plan (Marcus Mayri, 2017)

On the basis of the strategies of urban connections, system of public places and mixed-use development, the city-wide Master Plan for Belmopan was developed. As previously mentioned, it serves as a guidance document on how to spatially define and articulate the future urban development in the city based on the linkages between the blue-green network, the mixed-use development corridors and the residential areas.

Inference - The goals are to promote infiltration where possible and convey excess runoff when necessary, while improving the aesthetic appeal, functionality, and safety of pedestrian spaces. Bioswales are proposed for lower density residential areas where there is adequate space to create wider, vegetated channels without obstructing access to public or commercial spaces (Marcus Mayri, 2017). The map also identifies potential temporary or permanent storage opportunities at the neighbourhood and city scales that can help prevent streams from overflowing during peak flows by retaining water onsite while providing recreational and aesthetic benefits to the parks.

2.2. Blue-Green Infrastructure (BGI) network in urban areas for sustainable storm water management: A geospatial approach

Authors - Ravnish Kaur, Kshama Gupta

Brief - The paper discusses the challenges posed by urbanization, which replaces natural landcover with impermeable surfaces, leading to stormwater mismanagement and flooding in cities. It introduces the concept of Integrated Blue-Green Infrastructure (BGI), which utilizes networks of blue and green spaces (like permeable pavements and wetlands) as an alternative approach to conventional stormwater management, offering multiple environmental benefits. The primary objective of the paper is to develop a geospatial approach for identifying a BGI network in Ahmedabad, India, using graph theory and a gravity model (Ravnish Kaur, 2022).

Approach – The various parameters relevant for the study have been considered and analysed.
Slope: Slope degree is one of the most crucial factors for determining BGI suitability as it defines the capability of each BGI practice to manage run off in the event of a rainfall. BGI practices such as permeable pavements and bioswales should be constructed on slopes less than 5%. However, for some BGI strategies such as rain gardens, a gentle slope of 5% is ideal but in some cases surface slopes of less than 10% and no greater than 15% can also be considered.

Drainage density: High drainage density areas are more prone to water logging and therefore, highly suitable for BGI installation. Potential Drainage Density (PDD) of the study area is calculated using line density analysis tool in GIS environment on drainage network layer, which is derived from a DEM (30 m resolution SRTM DEM) using the hydrology tool. The resulting potential drainage density is then expressed into five classes: very low, low, medium, high and very high.

Land cover: Land cover data provides spatial information on both natural and built-up environments and this information can be used to decide the perviousness and imperviousness of the land. Supervised classification using maximum likelihood classifier is performed on Sentinel 2A satellite imagery to define four land cover types, i.e., Built- Up, Barren, Vegetation and Water.

Soil: Soil has a natural tendency to slowly allow water to pass through it and different soil types have varied drainage capacities. The United States Department of Agriculture (USDA) Natural Resource Conservation Service have classified soils into four hydrologic soil groups based on the infiltration rates; A, B, C and D. Group A soils have the highest infiltration rates and the lowest run off potential, and Group D soils have the lowest infiltration rate and highest run off potential. The soil types within the AMC boundary are classified into two types: coarse loamy and fine loamy, belonging to hydrologic group A and C respectively.

Road network: long term success of identified BGI network and for this study, public owned lands were considered more appropriate over private lands. The roads and transportation Right-of-Ways (ROW) provide easier access for implementing and maintaining varied BGI practices.

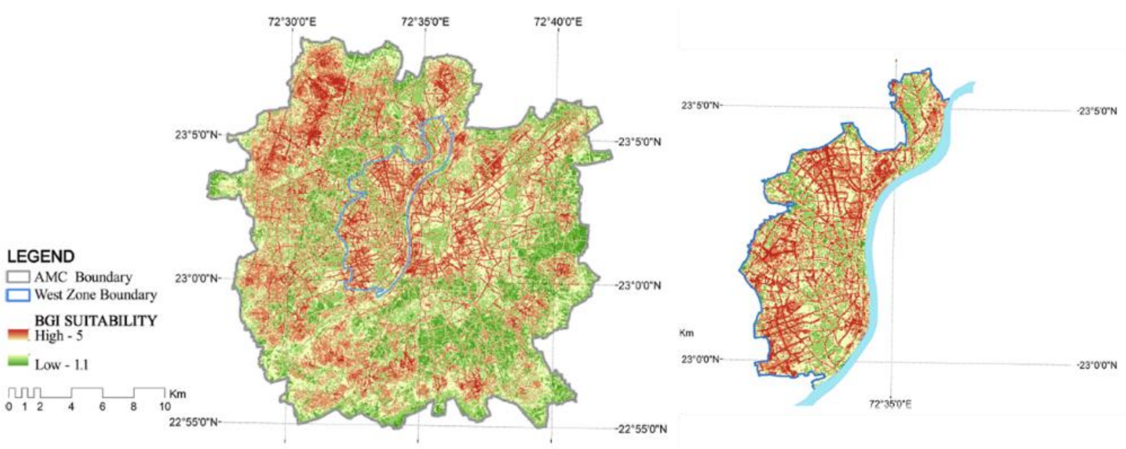

Fig-4: Blue-green suitability map (Ravnish Kaur, 2022)

Finally, the Blue-Green suitability map is generated. Five layers are identified (Slope, Hydrologic Soil Group, Potential Drainage Density, Land Cover, and Proximity to Roads), ranked and weighed to determine most suitable sites for implementation of BGI in the city of Ahmedabad. The final suitability map, which integrates all the five criteria, shows overall suitability for blue-green infrastructure implementation in the study region.

Core patch identification is executed to select blue-green areas larger than 2 hectares. Based on this criterion, a total of 48 urban blue and green spaces are selected as core patches. Gravity model is used to prioritize the 561 corridors into a sustainable network of corridors between the nodes that will ensure the landscape connectivity in the most effective manner for stormwater management (Ravnish Kaur, 2022). The gravity model calculated the interaction value between the nodes along the corridors and only the corridors with interaction value $G < 0.1$ are considered for the final network, which resulted in 120 potential corridors of the total 561 corridors.

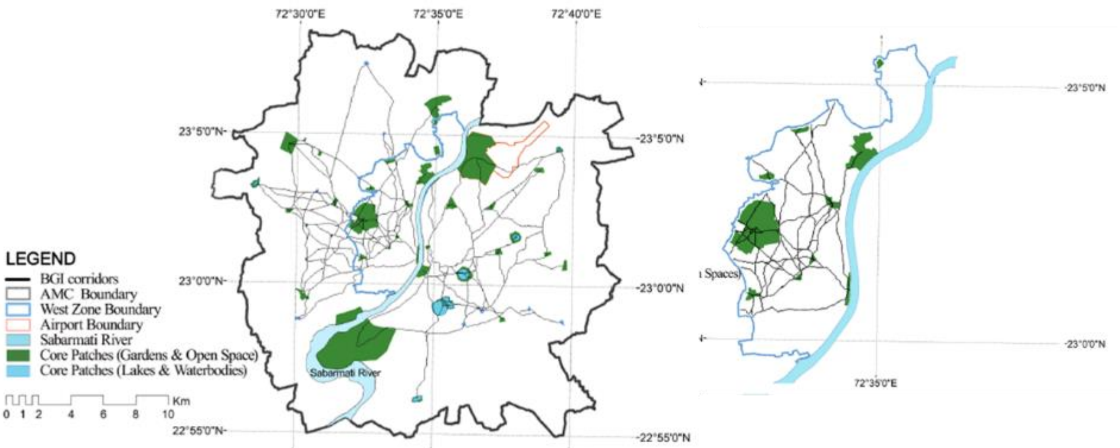

Fig-5: Final network of Blue Green Infrastructure after core patch identification and gravity model implementation (Ravnish Kaur, 2022)

Inference - The map highlights that 38% of the area is susceptible to be affected by flooding situation due to the natural topography and further exacerbated by the change in land cover which is most dominated by impervious surfaces. It has also been deduced from the map that among 55% of the area under AMC's west zone is flood- prone and are at high risk. The final BGI network covers an area of about 37 sqkm (8.2% of the study area). The core patches covering an area of 26 sqkm account for 70.27% of the total network. The 11 sqkm of developed corridors covers 29.73% of the total blue-green network (37 sqkm) and amounts to 2.45% of the total study region.

2.3. A Planning Support Tool for Layout Integral Optimization of Urban Blue–Green Infrastructure

Author - Conghui Zhou and Yun Wu

Brief - This study introduces a Planning Support Tool for Layout Integral Optimization (PSTLIO) focused on integrating Urban Blue Infrastructure (UBI) and Urban Green Infrastructure (UGI) within the built environment. Using Hekou City, China, as a case study, the research assesses service demands and suitable land for UBGI development through Geographic Information System (GIS) mapping. The study delineates potential UBGI development areas based on these assessments. PSTLIO offers a solution by structuring UBGI networks, defining component functions and service patterns, and guiding component scale determination. Demonstrating its efficacy, PSTLIO serves as a quantifiable decision-making tool for optimizing UBGI layout in urban settings (Wu, 2020).

Approach –
Identification of UBGI service demand: The work of identification of UBGI service demand includes establishing a set of service demands, assessing demands, and processing and mapping the results. According to existing studies, service demands for UBGI development are diverse and dynamic due to their multifunctionality and regionality. In the case of Hekou, 6 types of demand were identified. Among them, storm water management and drainage (SMD), ecological connectivity promotion (ECP), and heat island effect mitigation (HIEM) belong to the category of environmental services, while recreation opportunity creation (ROC), public vitality enhancement (PVE), and city identity interpretation (CII) are included in the category of public services.

Fig-6: Mapping of the UBGI service demands (Wu, 2020)

Thus, with the budget allocation and the drive to boost industrial development and production in the nation, actions were taken to set up these large scale industries and for supporting these industries, arose the need to set up planned industrial towns to generate and sustain the human resources required for running the industries. For a functional planning and design to take place, some key issues are addressed.

Following the addressal, the foundation for a well planned industrial area is laid. The various issues identified were:
- A site suitability assessment.
- The pollution potential of the proposed industries were studied and accordingly categorization and zoning was done based on the prevalent restrictions on degree of pollution contributed by the industries.
- The necessary widths of the infrastructure corridors according to industrial development norms and the environmental regulations were taken into consideration. These also included aspects like green corridors for seamless transportation of goods and services for industrial activities.
- Planning of the various mandatory infrastructures which include logistics and transportation, water supply and waste water, energy, waste management, blue-green infrastructure, security, disaster management, etc.
- Climatic conditions and accordingly efficiency of the units.

Assessment of land suitability for UBGI development: In keeping with the requirements for the UBGI development, six variables are selected to assess land suitability, including policy-related and physical factors. Potential for land use conversion (PLUC) is used to demonstrate the potential for converting the entirety of an existing land parcel. Potential for space integration (PSI) and potential for facilities replacement (PFR) are used to describe the potential for partial land use conversion of an existing parcel (Wu, 2020). Elevation, slope, and the intensity of natural runoff (IOR) are finally selected, following a review of the variables used in existing.

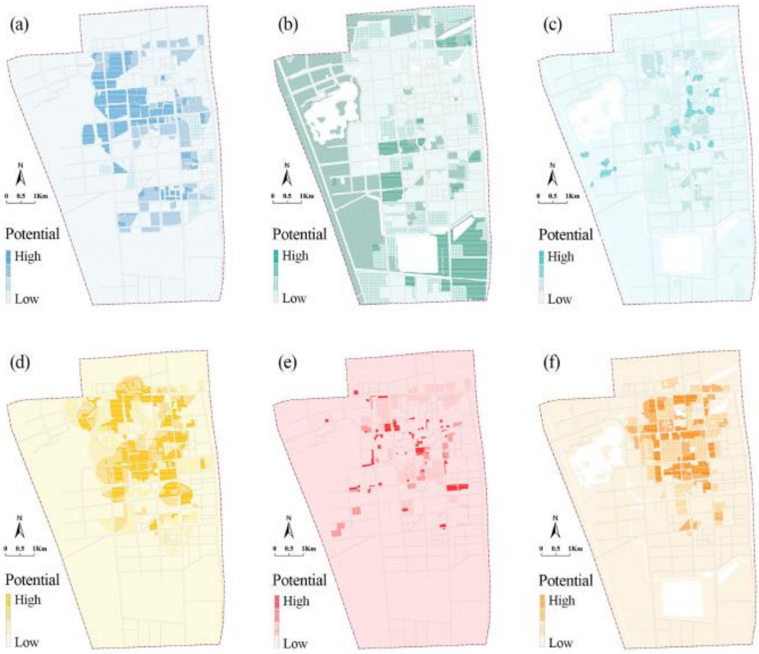

Fig-7: Mapping of the land suitability for UBGI development (Wu, 2020)

Potential areas for UBGI development: Potential areas for UBGI development were generated after mapping the assessment result of each service demand together with results related to land suitability. Six maps were generated to show areas that could be developed as UBGI based on specific service demands.

Integration into the existing and regional system: In addition to service demand and suitability, existing bodies of water and green spaces were given priority. They provided a basic framework for structuring the link network. For example, the outer ring of canals that connects the lake and the reservoir around the city was an important channel for water drainage at the urban scale. Moreover, the unconnected bodies of water and green space scattered within the inner city were also considered a valuable resource to be integrated within the link network.

Fig-8: Existing and regional green and blue systems (Wu, 2020)

Proposal and inference - In the case of Hekou, two methods were employed for distributing UBI or UGI. The first method calls for the integration of UBI and UGI. In such cases, the layout and scale of UBI was set first, and the UGI was subsequently installed along the UBI, in accordance with UBI layout and with the conditions of surrounding lands. The second method calls for UBI and UGI to complement each other. In this method, the flexibility of UGI was prioritized. In areas with strong demand for UBGI services but low feasibility for UBI installation, UGI was proposed as an independent solution that could complement UBI (Wu, 2020). In the final proposal of the UBGI layout planning of Hekou city confirmed by the commissioner, we can see the positions, sizes, and service patterns of the UBGI components were determined based on the results gained from planning support tool for the layout integral optimization (PSTLIO).

3. IMPLEMENTED PROJECTS ON BLUE-GREEN INFRASTRUCTURE

3.1. Madurai Action Plan for Blue-Green Infrastructure (2014)

Post-independence, the country saw an urgency for the industrial sector to be looked after and contribute to the economic upliftment of the nation. The Damodar Valley Corporation (DVC) was set up in 1948 with the primary aim of flood control, irrigation, power generation and navigation in the Damodar river. The long term plans of operating industries in Durgapur gave rise to the need for water and power generation in the factories. Thus the Durgapur Barrage was opened in 1955. It redirected and supplied water to the industries and the residences along with the other primary aims of keeping the flood under check and subsequently generation of hydroelectricity, currently capped at 1000 MW. Therefore, the major requirement of water in the industrial activities was solved and along channelizing the water for use, came the opportunity of generating electricity, which was successfully explored as well (Atkins, 2014).

Organisation – Atkins for Madurai Corporation

Aim –
- Mobilize action, target specific vulnerabilities and deliver change on the ground that will benefit a wide range of stakeholders, including those in multidimensional poverty.
- Address identified risks, including multiple risks to generate ‘win-win’ and ‘triple win’ environmental benefits.
- Catalyse economic development.

Approach –
- Building platforms for engagement.
- Reviewing the current position and creating an urban diagnostic.
- Using the action planning process to clarify and examine the implications of the existing situation for vulnerable communities.
- Bringing together stakeholders to engage and consider the priority issues.
- Exploring and selecting the range of different actions which can be mobilised to reduce vulnerability and adapt to climate risks.

Need for the action plan –
Madurai faces a range of climate hazards - particularly flooding – which already impacts its people and physical infrastructure. The areas which are particularly prone to flooding include parts of the city which lie within the natural floodplain of the river and drainage channels. The availability and management of water resources available to Madurai is one of the most significant issues facing the city due to underinvestment in water supply and storage infrastructure within the Vaigai catchment. Within the Vaigai catchment in which Madurai is situated there is a water balance deficit in surface water and groundwater sources which has caused excessive pressure on groundwater resources (Atkins, 2014). Given the severe water stress the city and wider region are already experiencing, the interconnectedness of Madurai’s blue infrastructure is an urgent system-wide priority for Madurai.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

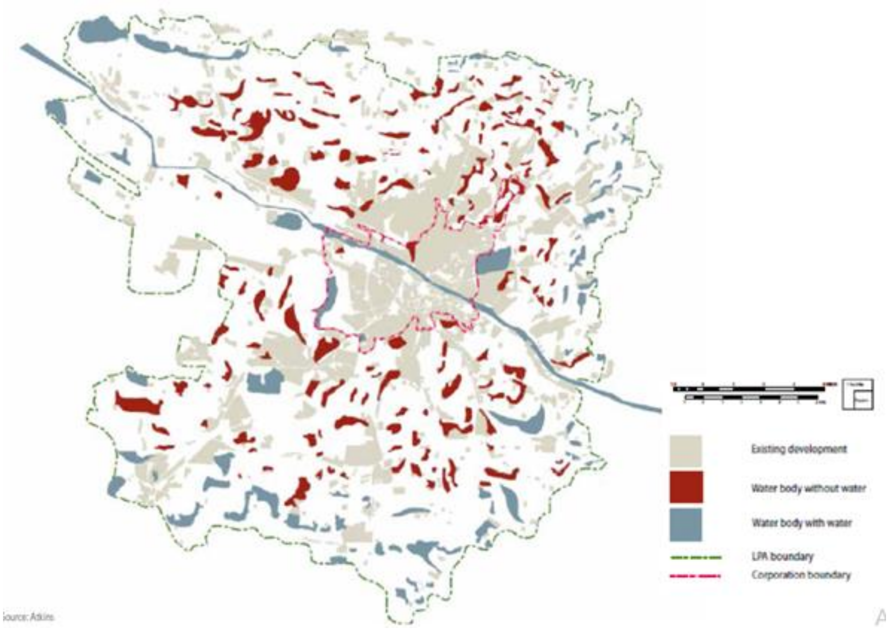

Fig-9: Distribution of water bodies in Madurai including those with and without water (Atkins, 2014)

Future-proofing Madurai for 2031 –
The strategy for future proofing the blue-green infrastructure for Madurai is to build up a programme of projects and actions which reduces vulnerability and address, climate and water security risks, while delivering multiple benefits to the community. 14 projects have been selected as parts of integrating Blue-green infrastructure in Madurai for making it future proof for the year 2031 and divided as short, medium and long term actions.

The major verticals in this project include:
- Social capital building and community led initiatives.
- Enabling actions for sanitation, sewer rehabilitation and solid waste management.
- Enabling actions for channel and tank restoration, flood risk mitigation and water resources management.
- Government and future proofing planning actions.
- Implementation of more capital intensive infrastructure improvements.

Delivery and implementation –
City Partnership Model: A Madurai city partnership would be formally established and provide a forum to coordinate and collectively agree on the urban development, infrastructure and environmental priorities. The partnership would include advisory bodies for channelling the comments and inputs from all stakeholders with interests in the planning and implementation of projects.

Madurai City Administrative Forum: The city partnership platform led by Madurai Municipal Corporation (MMC) and supported by individual departments and delivery bodies would enable Madurai to deliver more integrated projects and to coordinate the actions of individual agencies.

Tamil Nadu State Forum: The State forum would include nodal representatives of state level authorities in order to strengthen communications across State level bodies at project and programme level Plans and projects.
Community forum: The community stakeholders would serve in an advisory capacity as well as facilitating platforms for wider community engagement around projects and proposals (Atkins, 2014).

3.2. The All London Green Grid (2012)

Organisation – Greater London Authority

Aim –
To create a well designed green infrastructure network of interlinked, multi-purpose open and green spaces with good connections to the places where people live and work, public transport, the Green Belt and the Blue Ribbon Network, especially the Thames. This will provide a richly varied landscape that will benefit both people and wildlife providing diverse uses to appeal to, and be accessible by, all (Authority, 2012).
Inherent functions of green infrastructure in the London Plan –
- Protection and enhancement of biodiversity, including mitigation of new development.
- Making a positive contribution to tackling climate change by adapting to and mitigating its impact.
- Improving the management of water resources, flood mitigation and reduced flood risk through sustainable urban drainage systems.
- Increasing recreational opportunities, access to and enjoyment of open space and the Blue Ribbon Network to promote healthy living.
- Creating a sense of place and opportunities for greater appreciation of the landscape, cultural heritage and geo-diversity.

Flood risk management –
The predicted rise of sea levels, wetter winters and increased incidences of heavy rainstorms, will increase the likelihood of flooding from tidal, fluvial, surface and sewer sources. Currently, 83,200 properties in London are at 'moderate' or 'significant' risk of flooding from rivers. 680,000 properties are at risk of flooding from heavy rainfall following a 1 in 200 year event. An expanded and reshaped network of green infrastructure could significantly absorb and temporarily retain rainwater, reducing both strategic and local flood risk.

Overheating management –
London is vulnerable to 'overheating' in hot weather. Climate Change Adaptation Strategy strongly promotes increasing urban green cover in London to help tackle overheating by reducing how the urban heat island effect intensifies the heat in hot weather (Authority, 2012). Research by the LUCID project recommends that a 'mosaic' of green spaces within the urban realm can help off set the urban heat island effect.

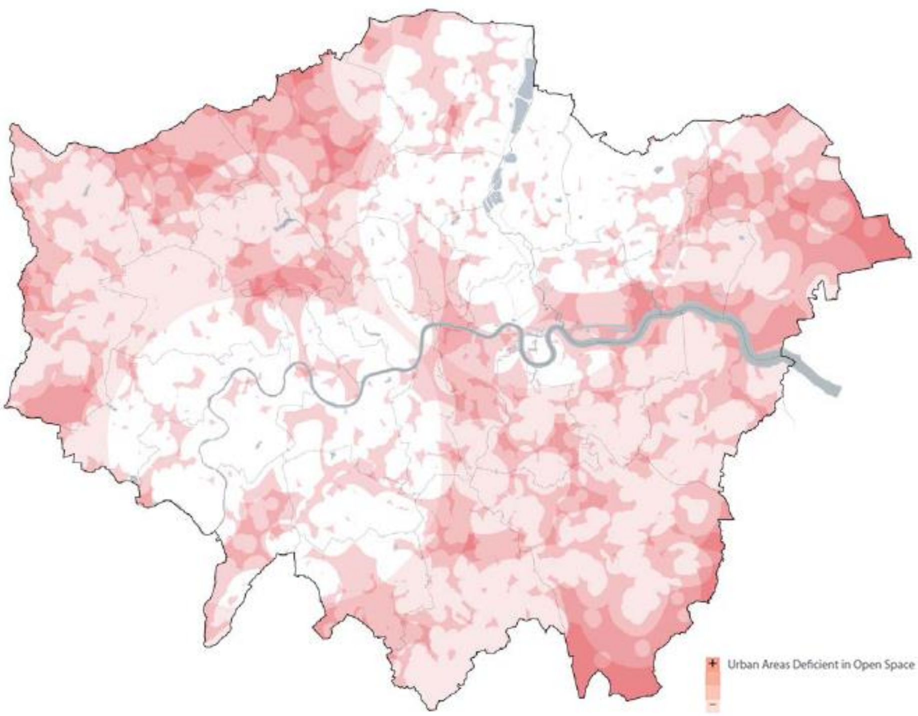

Fig-10: Regional, Metropolitan, District and Local composite open space deficiency plan (Authority, 2012)

Availability of open spaces –
The various scales of open spaces present in the London urban area have been mapped and the grey spots with regions of inaccessible open spaces are marked to propose a connected green grid for making public open spaces more accessible to the residents.

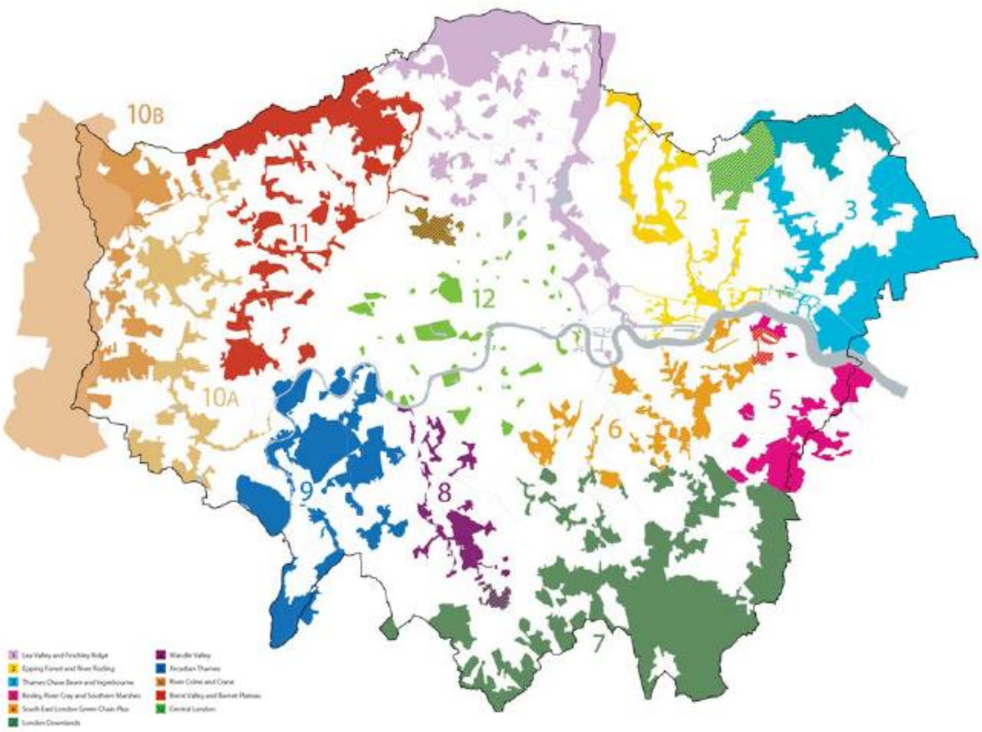

Fig-11: The complete All London Green Grid (Authority, 2012)

The demarcation of the Green Grid areas –
The twelve Green Grid Areas (GGAs) provide the basic framework from which policies and projects can be developed and delivered. It highlights and suggests enhancements to the existing open space network of landscape corridors, the east west links in-between and the urban areas it serves. It also identifies the key open space opportunities that should be used to inform the development and delivery of the network and the implementation of the Green Grid (Authority, 2012).

4. CONCLUSION

The studies enabled me to gain a significant understanding of the various approaches for implementation of blue green infrastructure and how the planning and execution of the projects have been envisaged to bring about a positive change in the community.

Integration with the social fabric –
The inclusion and consideration of existing public spaces on the neighbourhood, local and city level. The proposed intervention should be interconnected with the transportation corridors and the routes of commute to make the place accessible and part of the urban social fabric.

Land suitability analysis –
Identification of core patches for possible blue green infrastructure implementation analysing parameters like hydrologic soil group and permeability, slope, drainage density of the site. Use of geospatial tools to demarcate areas based on geospatial analysis for final implementation.

On-ground implementation strategies –
Identification of relevant stakeholders and strategies to make the interventions feasible aligning them with the present management plans by non-governmental organisations, central/state/local government bodies.

5. RECOMMENDATIONS AND SCOPE OF IMPLEMENTATION INTO FURTHER RESEARCH

The knowledge and insights gathered from the research can be used to implement nature based solutions and building resilient communities in the vulnerably urbanized regions around ecologically endangered areas like the East Kolkata Wetlands. The East Kolkata Wetlands (EKW), located on the eastern fringes of Kolkata city, sustain one of the world's largest integrated resource recovery systems based on a combination of aquaculture, agriculture and horticulture (S.A., 2012). The Government of India designated EKW as Wetland of International Importance under Criteria I of the Ramsar Convention in 2002 (as an example of wetland wise-use).

EKW is a critical natural infrastructure for Kolkata City. The wetland treats over 900 million litres of sewage generated by Kolkata Municipal Corporation every day (approximately 65% of total sewage generated in the metropolitan area) saving the city nearly Rs. 4,680 million annually in terms of treatment costs saved, as well as providing a much-needed flood buffer on the peri-urban interface. A long term change assessment based on remote sensing images of 1973, 1989 and 2010 had indicated a continuous decline in fish farm area (1890 ha during 1973-1989 and an additional 1959 ha during 1989 – 2010). Similarly, a change assessment for 1990 – 2011 period had indicated a loss of 1,476 ha of area under wetlands (fish farms) to cropland and expansion of settlements.

The suburbs like Anandapur, Mukundapur, Garia in Kolkata, Saltlake and the emerging township of Newtown are getting rapidly urbanized owing to the infrastructure and economic boom (LTD., 2023). Several issues like high land surface temperatures, low evapo-transpiration rates, changed rainfall patterns, low piezometric levels showing disbalance in urban hydrodynamics, high relative humidity, high levels in Air Quality Index and condition of the canal system in the region have pointed out the need for solutions to prevent the region from become ecologically unstable in the near future (Mitra, 2020). Proper analysis and planning should be undertaken to find a solution for integrating the blue and green infrastructure in the region and creating a holistic interconnection with the East Kolkata Wetlands such that the region as a whole with its canals, waterbodies and green spaces function effectively for a more resilient tomorrow.

ACKNOWLEDGEMENT

I would like to express my gratitude to my guide who helped me in writing this research paper.

REFERENCES

Arup. (n.d.). *Blue Green Infrastructure and Nature-based Solutions Framework.* Interreg: Arup.

Atkins. (2014). *Future proofing Indian cities.* Atkins.

Authority, G. L. (2012). *The All London Green Grid.* London: Mayor of London.

Driver, S. U.-M. (2021). *Blue-Green Infrastructure: An Opportunity for Indian Cities.* Observer Research Foundation.

LTD., W. (2023). *The Journey of New Town, Kolkata.* Retrieved from www.wbhidcoltd.com: https://www.wbhidcoltd.com/about-new-town

Marcus Mayri, C. A. (2017). Blue-green network planning as a spatial development and climate-resilient strategy - the case of. *Caribbean Urban Forum 2017.* UN-Habitat, Climate Change Planning Unit.

Mitra, D. (2020). Urban hydrodynamics in the planned township of New Town, West Bengal.

Ravnish Kaur, K. G. (2022). Blue-Green Infrastructure (BGI) network in urban areas for sustainable. *City and Environment Interactions*.

S.A. (2012). *The evolving urban form: Kolkata: 50 mile city.* Retrieved from www.newgeography.com: https://www.newgeography.com/content/002620-the-evolving-urban-form-kolkata-50-mile-city

SAHANA GOSWAMI, S. B. (2023). *URBAN BLUE-GREEN CONUNDRUM: A 10-CITY STUDY ON THE IMPACTS OF URBANIZATION ON NATURALINFRASTRUCTURE IN INDIA.* World Resources Institute.

Wu, C. Z. (2020). A Planning Support Tool for Layout Integral Optimization of Urban Blue–Green Infrastructure. *MDPI*.