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A Systemic Expansion of Dhaka City using Voronoi Diagram

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***Abstract*—Urbanization is the most important aspect of societal advancement, particularly in densely populated capitals like the city of Dhaka in Bangladesh. There have been numerous mega projects incorporated within the city, but there is still a lack of proper planning mechanisms for further expansion. As the city continues to evolve, efficient planning becomes imperative to sustain growth and enhance living standards. With the help of Voronoi diagrams, this research offers a systemic approach to expanding Dhaka's urban landscape, which, to our knowledge, is a unique approach to solving the problem of representing Dhaka city. Through a fusion of Voronoi tessellation and Delaunay triangulation, the key map zones of the city are mapped, identifying optimal expansion sites and the shortest destination points for future infrastructure project routes. By addressing Sustainable Development Goal 11 (Sustainable Cities and Communities), the methodology aims to foster sustainable urban growth, enhance livelihoods, and mitigate congestion. Through empirical analysis and spatial modeling, the findings in the research provide actionable insights for policymakers, urban planners, and stakeholders, facilitating informed decision-making for Dhaka's sustainable development trajectory.**

***Index Terms*—Voronoi Diagram, Delaunay Triangulation, Computational Geometry, Sustainable Cities and Communities, City Planning and Sustainable Development Goals**

I. Introduction

Urbanization is one of the most important factors in the economic and social development of a nation, and being a densely populated capital demands a simple yet efficient method of planning for further expansion. Dhaka is the capital and largest city of Bangladesh, with a population of over 10 million residents. As a result of such a huge population, it remains the most concentrated zone of urbanization in the whole world. Certain mega-projects like the Elevated Expressway and Metro Rail pose a greater need for further building up and planning for the future of the city. The 2030 Agenda for Sustainable Development was proposed by United Nations Member States [1] in 2015 to overcome constraints in people's day-to-day lives and maintain important factors that affect the well-being of people all over the world. Our research will focus on addressing one of the seventeen Sustainable Development Goals (SDG), to build sustainable cities, improve career opportunities, improve living conditions, and create an impact on society through future development projects. Being a mega-city, Dhaka does need to be considered for further development for better infrastructure and road mapping to foster future developments. The research will mainly focus on representing Dhaka city using a Voronoi diagram and Delaunay triangulation. The bionic design will further foster the architectural and urban planning of the city represented in a Euclidean plane. The discretization of the space representing hot zones of the city will be represented using spatial Voronoi cells to represent structures based on Voronoi tessellation and will serve as a blueprint for further construction of mega projects in the city.

In this research, we represent Dhaka City in 2D space using a Voronoi diagram to compute the shortest distances from key zones using the line sweep algorithm [2]. The study focuses on five major areas for successful urban planning: (1) advanced spatial analysis to identify patterns of urban growth in Dhaka, providing insights into urbanization dynamics and built-up area expansion. (2) Identification of crucial vertices for city expansion. (3) Actionable policy recommendations for sustainable urban development, focusing on infrastructure improvement, urban sprawl management, environmental conservation, and inclusive growth. (4) Contribution to urban planning knowledge by offering empirical insights into Dhaka's urbanization. (5) Demonstration of the utility of geospatial analysis in evidence-based decision-making to achieve the Sustainable Development Goal of a sustainable city.

II. Literature Review

Voronoi diagrams are instrumental in urban planning and architecture, providing efficient space division and innovative design solutions [3]. In urban projects like the redevelopment of Glorieta Juan Carlos I in Spain and the conceptual Aldgate Aerial Park in London, Voronoi algorithms design walkways and activity zones, incorporating features such as photovoltaic elements and fog systems. In architecture, they assist in creating structural forms and optimizing roofing designs, as seen in projects like WesterndGate public space in Frankfurt and the Melbourne Recital Centre, as well as Alibaba Headquarters in Hangzhou. Voronoi diagrams also inspire organic designs,

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