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Tackling Traffic Woes in Dhaka: A Cost-Effective Solution through the Overpass and Underpass Systems

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ABSTRACT

This study explores a cost-effective solution to address the severe traffic congestion in Dhaka city by proposing the implementation of short-span overpass and underpass systems at key intersections. These junctions, where vehicles frequently stop to allow cross-traffic, are primary contributors to gridlock. This study aims to identify Dhaka's most congested intersections and propose feasible, low-cost overpass and underpass systems by evaluating their design suitability, cost-effectiveness, and potential socio-economic and environmental impacts compared to existing traffic management approaches. Using a mixed-method approach that includes pilot design proposals, analysis of secondary traffic and mobility data, observational insights, and international case comparisons, this study identifies four high-impact intersections and presents a practical roadmap for phased implementation. By alleviating these bottlenecks, the conceptual model proposed in this paper offers a practical approach to alleviate traffic jams. Quantitative estimates suggest a potential reduction in congestion levels by up to 65 - 70 percent, a 40 - 50 percent improvement in average travel speed, and a 25 - 30 percent decline in vehicular emissions. The study provides policy-level recommendations, encouraging decision-makers to adopt this strategy in a pilot phase at four intersections - an overpass system at Science Lab-Nilkhet and Mirpur-1, and an underpass system at Farmgate and Shahbagh. If implemented, it has the potential to significantly improve traffic flow and enhance the quality of urban life. While the analysis is primarily based on conceptual designs and secondary data, future research incorporating real-time simulation or field trials is recommended. The findings contribute to urban transport planning literature and offer scalable solutions for developing megacities facing infrastructure bottlenecks. Overall, the study provides clear policy and planning insights for urban traffic management in South Asian contexts and lays a foundation for further empirical research.

INTRODUCTION

Background

Dhaka, the political and commercial hub of Bangladesh, ranks among the most traffic-congested cities globally (Akter & Khatun, 2017; Das *et al.*, 2019; Khan, 2007). The traffic gridlock, which has worsened over the years (Shamsher & Abdullah, 2015), is more than a typical urban jam - it represents a chaotic mismanagement of transportation (Haider, 2018; Sun & Lu, 2023). The severity of this issue has pushed daily commuters to the brink of tolerance, as decades of suffering have made navigating Dhaka's streets a daily nightmare (Al-Amin, 2022; Basher, 2015; Rahman & Hoque, 2018). The situation has now reached unprecedented levels (Al-Amin, 2022), demanding immediate and pragmatic solutions. An efficient transportation system is crucial for sustaining the socio-economic growth (Taleb & Majumder, 2012), yet Dhaka, with 650 intersections and only 60 traffic lights (Morshed, 2015), is ill-equipped to handle its traffic volume.

Extant studies discussed the remedies to get relief from traffic congestion, such as Al-Jabbar *et al.* (2011), Gao (2012), Levinson and Falcocchio (2012), and McNeil (1939)'s studies are conducted on traffic congestion. Despite numerous attempts by governments and authorities, no substantial progress has been made in reducing Dhaka's congestion. The continuous failure has left residents hoping for a miracle to ease their daily commutes. Addressing such urban issues is vital for the sustainable development of the country, and allowing this crisis to persist is untenable. Although several efforts have been initiated, success remains elusive. Recognizing the urgent need for effective intervention, this paper proposes a conceptual solution based on overpass and underpass systems, which have proven successful in other densely populated countries. Besides, recent projects in Bangladesh, such as the Dhaka-Bhanga expressway, have effectively used overpasses and underpasses to address traffic issues at intersections.

Identifying traffic hotspots presents opportunities for improvement (Hosseinlou & Sohrabi, 2009; Huang & Shang, 2023). Sustainable solutions can be found in the strategic use of underground spaces for future transport demands (Verma *et al.*, 2017). However, Dhaka lacks expressways and freeways with proper intersections or access control, and encroachments on major roads have further hindered the economy (Murshed *et al.*, 2020). Implementing a network of overpass and underpass systems could alleviate the city's chronic gridlock.

Four pedestrian underpasses have been built in Dhaka

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specifically for pedestrian use: the Sur Saptak underpass in Kurmitola, which is 42 meters long that cost approximately US$ 4.5 million and opened in 2022; the Gulistan underpass, measuring 135 meters and costing about US$ 2.8 million, completed in 1997; the Karwan bazar (Butterfly Cave) underpass, which is 66 meters long opened in 1997; and the Gabtoli underpass that is 40 meters long opened in 2017. Additionally, a 1.7 kilometers (KM) multimodal pedestrian underpass is planned for the Dhaka Airport area, estimated to cost around US$ 7 million and featuring nine entry and exit points (Saif, 2023; Sultana, 2022). However, there are currently no underpasses designated for vehicle traffic.

Despite extensive research on transportation systems, little has been known about how to address Dhaka's specific traffic issues. Existing literature lacks viable, cost-effective solutions tailored to Dhaka's traffic problems. Anne *et al.* (2023) studied the underlying causes of frequent road accidents along the Onitsha-Owerri expressway in Eastern Nigeria and devised context-specific engineering design solutions, emphasizing that inadequate road geometry and poor traffic management are major contributors to accident prevalence in developing urban corridors. Yazici *et al.* (2013) highlighted Istanbul's Metrobüs BRT, serving 600 thousands passengers daily, and Yang *et al.* (2020) and Zhang *et al.* (2022) mentioned how infrastructure transitions (bridge to tunnel) can impact traffic safety. Taleb and Majumder (2012) explored the effects of flyovers on local residents, and other studies examined the role of overpass and underpass systems in mitigating traffic in both developed and developing countries (Afifipour *et al.*, 2011; Antoniou *et al.*, 2017; Click *et al.*, 2010; Jiang *et al.*, 2022; Said *et al.*, 2017; Yasin *et al.*, 2017). These have largely focused on railway underpasses (Chasco *et al.*, 2010; Cushing & Lewis, 2012) or pedestrian and wildlife crossings (Alimardonov & Zardakov, 2018; Bond & Jones, 2008; Clevenger & Waltho, 2000; Rana, 2021), but none have assessed their potential in managing Dhaka's traffic. While studies by Ali *et al.* (2023) and Rahman and Hoque (2018) examined the factors and impacts of severe traffic congestion in Dhaka, they did not propose the systems approach suggested in this study. This study aims to bridge that gap by proposing a practical, low-cost solution to reduce traffic congestion in Dhaka.

Problem Statement

Dhaka, the capital of Bangladesh and the sixth most populous city in the world, frequently faces severe traffic congestion, trapping millions in seemingly endless jams (Ali *et al.*, 2023; Khan & Islam, 2013; Rosen, 2016; TBS, 2023) as seen in other cities in the USA, the UK, China, France, Russia, and others (Li, 2013). Home to over 10.3 million within the city corporation and 23.9 million in the metropolitan area (Akter & Khatun, 2017; Arefin, 2023), Dhaka's infrastructure struggles to support its growing population, which is projected to reach 27 million by 2030 (Haider, 2018; Imam, 2023). The city covers approximately 220 KM of roads within 340 square KM, with an average population density of 23,200 - 29,000 people per square kilometer (Imam, 2023; Opu, 2022; WPR, 2024; Wright, 2020). People from all walk of lives flock to Dhaka for its array of socio-economic opportunities, such as, business, education, technology, and training (Khan, 2007), though, job opportunities and infrastructure have not expanded proportionately (Ullah, 2013), creating a significant challenge.

As the population has grown and the upper-middle class expanded, the number of cars on the roads has skyrocketed (Al-Amin, 2022). Despite having approximately 3.1 million registered vehicles in the country, there are estimates that up to 5 million vehicles, including unregistered ones, crowd the roads in Dhaka, with 72 percent lacking proper fitness certification (Haider, 2018; Sanaullah, 2021). Every day, 55 new cars are added to the streets, exacerbating the demand for parking and road space (Haider, 2018). In consequences, traffic in Dhaka has become notorious for its stagnation, with average vehicle speeds dropping from 6.4 kilometers per hour (KMH) to just 4.8 KMH (Al-Amin, 2022), barely above walking speed, and projected to fall to 4 KMH by 2035 (Haider, 2018; Imam, 2023). The city has been dubbed the "traffic capital of the world" by international publications (Morshed, 2015).

Compounding this is the fact that public transportation is inadequate, pushing many residents to rely on private vehicles resulting in standstill traffic condition (Al-Amin, 2022). The revised strategic transport plan of 2016 indicates that Dhaka residents make 30 million trips daily, with buses accounting for 47 percent of trips, rickshaws for 32 percent, and private cars for 9 percent. Despite this, private cars, which serve only 6 percent of the population, occupy 76 percent of the city's roads (DT, 2020; Haider, 2018; Morshed, 2015). This imbalance worsens traffic conditions, as three private cars take up the same space as a bus, yet carry fewer passengers (DT, 2020).

Traffic jam issue is prompted by the rising number of vehicles, which is disproportionate to the available road capacity (Mudiyono, 2024). There are 700 thousands motor vehicles including buses, microbuses, trucks, private cars, pick-ups, auto-rickshaws, motorbikes, which is parallel in number of non-motorized vehicles like rickshaws, vans, cycles, and pushcarts. Dhaka's road infrastructure occupies just 7 percent of its total land area, far below the recommended 25 percent (Imam, 2023). The number of vehicles, both motorized and non-motorized, has surged with the city's expansion (Banister, 2015), overwhelming the already limited road capacity. During the rainy season, many roads become flooded, exacerbating traffic issues (Khan, 2007; Morshed, 2015). Public transport occupies only 6-8 percent of the streets, while unauthorized vehicles, illegal constructions, and parking further reduce road efficiency (DT, 2020). If the incoming traffic flow remains constant, congestion will build up upstream of the bottleneck as the traffic demand surpasses the available capacity at that point (Ao *et al.*, 2016; Yu *et al.*, 2020).

It is usual that the mega cities throughout the world are suffering from traffic gridlock for a certain periods (Arnott & Small, 1994; Das *et al.*, 2019). Traffic congestion in Dhaka typically peaks from 9:00 am to 10:30 pm, with slight relief from 11:00 am to 3:00 pm, and becomes severe again between 6:00 pm and 8:00 pm (PA, 2020; Ullah, 2013), which is unusual. Commuters, including students, face hours of delays daily, significantly affecting productivity and class attendance (Al-Amin, 2022). Overcrowding on Dhaka's roads has led to long traffic standstills, even during off-peak hours (Khan & Hoque, 2013).

The most congested areas include junctions at Shahbagh, Farmgate, Mirpur, New Market, Mouchak, Malibagh, Maghbazar, Gabtoli, Aminbazar, Motijheel, Gulistan, and Jatrabari (Sanaullah, 2021; Ullah, 2013). Old Dhaka remains a persistent traffic hotspot (Sanaullah, 2021), with narrow roads and insufficient infrastructure to handle the traffic volume (Ullah, 2013). This rising congestion reflects broader challenges, such as resource constraints, sustainability, and inequality (Banister, 2015). Additionally, infrastructure development remains insufficient, as stakeholders seek cost-effective, reliable systems to manage the overwhelming demand (Nguyen & Brilakis, 2016).

Research Objectives

The main objective of this study is to propose a feasible, low-cost overpass and underpass systems at key intersections in Dhaka to alleviate traffic congestion. The secondary objectives surround the followings:

- To analyze the most congested intersections in Dhaka and identify key spots where these solutions would have the most impact.
- To evaluate the costs and benefits of implementing overpasses and underpasses compared to other traffic management systems.
- To propose design parameters for simple, cost-effective systems suitable for Dhaka's traffic patterns and road structures.
- To assess the social and economic impact of the proposed infrastructure projects.

Significance of the Study

Former US President John F. Kennedy remarked, "It is not wealth that built our roads but the roads that built the wealth," highlighting the vital role of road infrastructure in economic progress (Khan, 2007). This insight underscores the importance of addressing Dhaka's traffic jam through cost-effective infrastructure solutions. As Bangladesh transitions from least developed country status, Dhaka must be equipped to support the nation's economic growth (Haider, 2018). This study offers actionable insights for urban planners and policymakers, emphasizing infrastructure solutions tailored to a developing city context. By addressing this critical issue, it encourages policymakers to take traffic congestion more seriously and consider practical alternatives. The study outlines the consequences of an action, presents a forward-thinking conceptual solution, demonstrates use cases, presents cases, explains feasibility and impacts, and implementation steps, evaluates results with limitations, and suggests for further research directions, and concludes with recommendations for future action.

Structure of the Study

This study is organized into eight sections. The introduction presents the background, problem statement, objectives, significance, and structure of the paper. The literature review explores the causes and impacts of traffic congestion, solutions proposed for Dhaka's traffic jams, and propositions derived from existing research. The methodology outlines the research approach, including sampling strategy, observations, data protocol, data collection, conceptual design, and case studies. The conceptual model proposes overpass and underpass systems with implementation recommendations, which is discussed in results and conceptual model section. The pilot use cases detail specific implementations at key intersections. The case studies section draws insights from traffic solutions in Dhaka, Singapore, Tokyo, Delhi, Cairo, Bangkok, Mumbai, Manila, Hong Kong, and Jakarta. Lastly, the discussion part evaluates the project's feasibility, implications, limitations, and future research directions, followed by the conclusion.

LITERATURE REVIEW

Causes of Traffic Congestion

Dhaka's roads, originally designed for far fewer vehicles, now struggle to accommodate the overwhelming traffic volume (Al-Amin, 2022). Before exploring potential solutions, it is essential to understand the causes of Dhaka's traffic congestion, which is a product of rapid urbanization and inadequate planning.

Key causes of traffic congestion in Dhaka include unfit vehicles, inexperienced drivers, poor road conditions, and an inadequate traffic management system (Ullah, 2013). The city faces challenges from faulty urban planning, an over-reliance on private cars (Al-Amin, 2022; DT, 2020; Sun & Lu, 2023), overpopulation, insufficient and damaged footpaths (Banister, 2015; Imam, 2023), frequent violations of traffic rules (Haider, 2018), and chaotic pedestrian movement (Efroymson, 2022). The lack of parking space (Haider, 2018), narrow roads, and the absence of designated lanes further contribute to the issue. Rickshaws, while essential for many lower-middle-class residents, exacerbate traffic problems due to their large numbers and the limited availability of public buses (Khan, 2007). Additionally, bus stops are poorly regulated, leading to frequent stops that disrupt traffic flow (Ullah, 2013).

Private vehicles occupy a disproportionate amount of road space relative to the number of passengers they carry. While buses could serve 36 - 40 people, three private cars carrying a total of 12 passengers occupy the same space (DT, 2020). Despite this, there are 33 times more private cars than buses in Dhaka, contributing to chronic congestion (Al-Amin, 2022). Manual vehicles sharing the road with high-powered vehicles further complicates the situation, and the limited number of traffic police makes it difficult to manage the city's mixed traffic efficiently (Ullah, 2013). At key intersections, even after having traffic signal lights and police officers, congestions persist (Haider, 2018). Dhaka's lack of direct public transport options exacerbates these problems, a rarity among major cities worldwide (Al-Amin, 2022).

Dhaka has expanded significantly over the years, but the increase in shopping malls, residential apartments, and the rapid proliferation of schools, colleges, private universities, and clinics along both sides of the roads has greatly worsened the situation (Khan, 2007). The influx of rickshaws, unregistered vehicles, and uncoordinated development projects further strain the city's infrastructure (Sanaullah, 2021; Shamsher & Abdullah, 2015). For instance, ongoing construction by various agencies such as Dhaka Water Supply and Sewerage Authority, Dhaka Electricity Supply Authority, and RAJUK often disrupts roads without coordination, adding to the traffic chaos. Additionally, frequent pipe and cable-laying projects hinder road conditions, with little collaboration among the relevant authorities (Khan, 2007).

Cultural and structural factors also play a significant role in Dhaka's traffic congestion. The lack of proper infrastructure, insufficient monitoring systems, the proliferation of unregistered and unfit vehicles, inadequate transport planning, and various fairs and concerts are major contributors to the gridlock (Khan & Hoque, 2013; Morshed, 2015). Poorly enforced traffic regulations, an under-resourced traffic management team, and unauthorized encroachments on roads and sidewalks compound the issue (Mahmud *et al.*, 2012). Faulty traffic signals, drivers' overtaking tendencies, and the issuance of driving licenses and vehicle fitness certificates without proper oversight further worsen the situation (Barnamala *et al.*, 2015; Sanaullah, 2021). Zulkarnaen *et al.* (2024) found that congestion at intersections near Kapuas Bridge II in Indonesia requires coordinated solutions, highlighting that poorly managed intersections are critical contributors to urban traffic delays.

In summary, the causes of traffic congestion in Dhaka are multifaceted, ranging from infrastructural inadequacies and poor planning to cultural behaviors and weak enforcement of regulations. Addressing these root causes is essential to alleviating the city's ongoing traffic crisis.

Consequences of Traffic Congestion

The traffic jam issue negatively impacts both the economy and society on multiple levels (Arnott & Small, 1994; Banister, 2015; Barnamala *et al.*, 2015; Hosseinlou & Sohrabi, 2009; Huang & Shang, 2023; Khan & Islam, 2013; Taleb & Majumder, 2012). Traffic congestion in Dhaka has profound consequences on the economy, environment, public health, and the quality of life for its residents (Morshed, 2015). The worsening traffic conditions lead to significant economic losses, with an estimated 8.2 million working hours lost per day due to delayed commutes (Ali *et al.*, 2023; BSS, 2024; Imam, 2023). Financially, the costs are staggering. The Accident Research Institute at Bangladesh University of Engineering and Technology estimated that Dhaka's traffic congestion costs the economy approximately US$ 6.5 billion annually, though other sources such as Haider (2018) and Imam (2023) found even higher figures - US$ 11.4 billion and US$ 18 billion, respectively. These losses come from decreased productivity, fuel wastage, and health-related expenses, contributing to a reduction in Bangladesh's GDP by 6-10 percent annually (Liaquat, 2022).

The chronic congestion has earned Dhaka the notorious distinction of being the world's slowest city, ranked 168th out of 173 cities globally - preceded only by cities like Karachi, Lagos, and war-torn Damascus (EIU, 2024; Imam, 2023). Traffic jams are not just a nuisance but a critical issue demanding immediate attention. Khan and Islam (2013) highlighted that traffic congestion directly increases travel time costs and vehicle operating costs, with indirect consequences such as travel time variability and deadweight loss - the social costs of congestion that could be avoided. These delays also impose external costs on others and contribute significantly to environmental degradation.

Traffic jams also lead to a range of other societal and infrastructural issues, including road accidents, parking shortages, pedestrian hazards, and excessive fuel demand (Alam, 2024; Alam & Habib, 2003; Banister, 2015). According to the Passengers Welfare Association, approximately 90 percent of motor vehicles, including buses, minibuses, and auto-rickshaws, routinely violate traffic laws (Haider, 2018; Sanaullah, 2021). As a result, the country sees an average of 64 traffic-related deaths per day, with an additional 150 individuals suffering injuries (Haider, 2018). The constant delays and gridlock leave commuters feeling mentally fatigued, which reduces overall productivity and contributes to a sense of frustration and helplessness (Khan, 2007).

The environmental impact of Dhaka's traffic is equally alarming. Constant congestion leads to increased air and noise pollution, posing serious threats to public health (Mahmud *et al.*, 2012). The buildup of vehicles in standstill traffic contributes to high levels of carbon emissions, exacerbating air pollution and making the city's air quality among the worst in the world. Noise pollution from incessant honking and engine sounds also adds to the negative environmental footprint. For example, Haruna and Fasakin (2023) evaluated road traffic noise variations across different land uses in Jos, Nigeria, highlighting the varied impacts of traffic jam on urban environments, and their findings disclosed significantly higher noise levels in commercial and roadside residential areas compared to institutional zones, underscoring the urgent need for effective traffic and urban planning interventions.

The health consequences of Dhaka's traffic congestion extend beyond just physical injuries. The stress and frustration of being stuck in traffic for hours affect mental well-being, while the physical health of residents is endangered by long-term exposure to air pollutants. Prolonged idling of vehicles releases harmful emissions, further deteriorating air quality. Meanwhile, frustrated drivers are more prone to making risky decisions, leading to increased traffic accidents. Addressing these issues is crucial to the city's future development and the well-being of its residents.

Solution Recommendations

Numerous scholars worked on introducing systems to reduce Dhaka's traffic congestion and thus, they suggested how to tackle this problem. This part accumulates them in one place.

The public-private partnership (PPP) projects, such as light rapid transit (LRT), mass rapid transit (MRT), bus rapid transit (BRT), elevated expressways (EEs) were suggested along with comprehensive strategy including expanding road capacity, introducing subway system, initiating trams system, expanding waterway, increasing bypass roads, improving public transport, banning non-motorized vehicles like rickshaws, reducing small transports, bringing buses under the franchise system, restoring disciplines in the transport sector, initiating charge for congestion and road pricing, recovering sidewalk, investing public money, developing communication infrastructure, enhancing public awareness, providing logistic support, exaggerating alternative public transport, and enhancing traffic management system to reduce traffic congestion (Al-Amin, 2022; Ali *et al.*, 2023; Imam, 2023; Khan, 2007; Mahmud *et al.*, 2012; PA, 2020; Rahman & Hoque, 2018; Taleb & Majumder, 2012). Khan (2007) argued for subway construction beneath the current roads as the most effective solution. On the other hand, Al-Amin (2022) emphasized on coordinated urban strategies, sustainable funding sources that are more effective and lucrative, and improved public transportation services that provide superior mobility choices.

Moreover, effective traffic management and enforcement of regulations are essential, as well as doubling public transport capacity with larger buses (Sanaullah, 2021; Ullah, 2013). Shamsher and Abdullah (2015) suggested expanding road infrastructure, imposing penalties on violators, and constructing more flyovers and metro rails, while Imam (2023) added reducing population density. Morshed (2015) noted that increasing public transport access can decrease private car ownership. Ullah (2013) called for regulating illegal vehicles, relocating factories, enforcing traffic rules, preventing untrained drivers, regulating driving licenses, banning passenger pickups at busy intersections, addressing illegal road use, repairing roads promptly, and preventing bribery of traffic officials, and involving NGOs in solving traffic problems. Other proposals include improving driving practices and decentralizing city areas (Haider, 2018; Sanaullah, 2021).

Other solutions include enhancing ethical driving and road crossing, and improving transport connectivity (Taleb & Majumder, 2012), stopping issuance of driving license without strict scrutiny, introducing surveillance at city entry points, relocating garment factories, and curbing illegal road occupants, implementing entry taxes for peak hours, creating dedicated lanes, widening roads, reducing car import incentives, and modernizing bus systems are also crucial (DT, 2020; Sanaullah, 2021). Furthermore, constructing additional roads, repairing traffic signals, imposing penalties on pedestrians who do not use foot over bridges (Efroymson, 2022), implementing U-loops (Murshed *et al.*, 2020), banning autos from major roads, managing bottlenecks, introducing rail transit system (Alam & Habib, 2003), proper utilizing zebra crossing (Morshed, 2015), controlling rural-urban migration (Ullah, 2013). Additionally, integrating smart technologies, like IoT-based traffic control solutions, could further enhance monitoring and efficiency in managing urban flow (Shahid *et al.*, 2017).

Flyovers like the Kuril interchange have improved traffic flow (Rahman *et al.*, 2020), but poor designs, such as the Moghbazar-Mouchak flyover, have worsened congestion (Das *et al.*, 2019). Successful projects like the Banani Overpass (Islam, 2018) and Jillur Rahman Flyover (Akter & Khatun, 2017) have reduced travel time but have led to some negative effects, such as increased accidents. Nonetheless, Mayor Hanif Flyover along with Khilgaon flyover is the worst performing flyovers while other studied flyovers have performed poorly (Islam, 2018). Sanaullah (2021) proposed introducing 60-seat double-decker buses could reduce at least 25 rickshaws or smoke-spewing auto rickshaws per bus, while Hausknecht *et al.* (2011) recommended contraflow lane reversals to increase road capacity by up to 72 percent. Yu *et al.* (2020) suggested freeway flow regulation to manage congestion, which maximizes outgoing flow and alleviates congestion upstream of the bottleneck.

Propositions Development

Implementing public services, especially in urban transportation demands substantial investment. Even with detailed planning, governments often face financial constraints. A promising approach to address these funding gaps is through PPP as stated by Al-Amin (2022), which can provide a practical solution to secure the necessary financial resources (see Figure 1). For successful implementation, it is crucial that public authorities take the lead in initiating these projects (Al-Amin, 2022).

To alleviate traffic congestion, the government has initiated several long-term projects, including three ring roads to divert traffic from the city center, five metro rail lines, two rapid bus routes, and 1,200 KM of new roads. Many of these projects are already in progress at various stages (Haider, 2018). However, building more roads may not resolve the issue, as they tend to become congested quickly (Morshed, 2015). Recent infrastructural projects like road widening, footpath expansion, flyovers, EEs, and U-loops have yet to significantly improve the traffic situation (Efroymson, 2022; Haider, 2018; Morshed, 2015; Sanaullah, 2021; Shamsher & Abdullah, 2015). Despite promises that flyovers, metro rails, and expressways

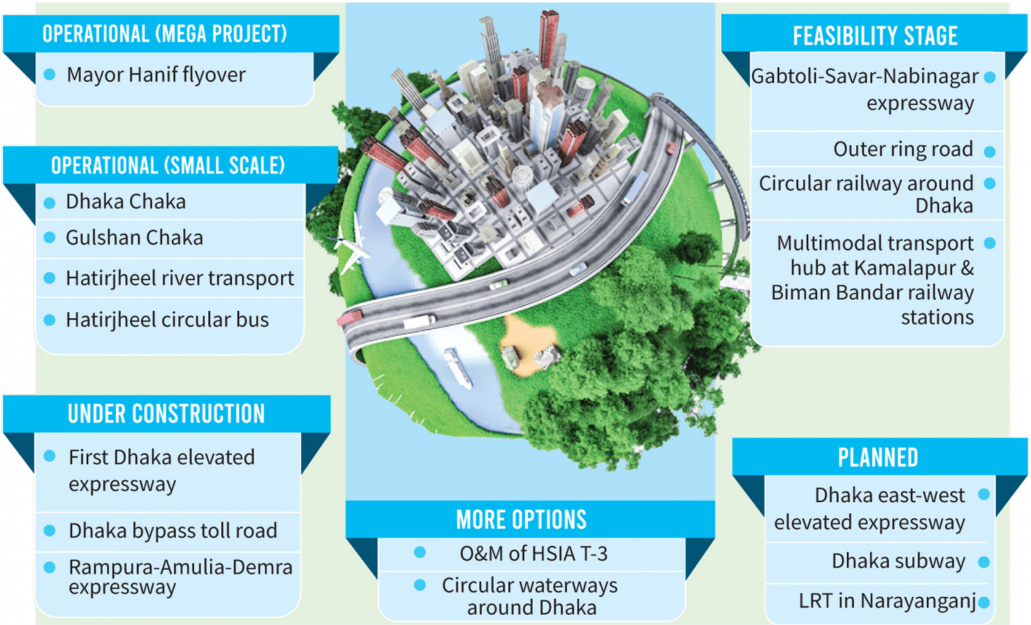


Figure 1: Public Transport in Dhaka under the PPP Scheme
Source: *Al-Amin (2022)*

would ease congestion, the situation appears unchanged even after some projects have been completed (Ao *et al.*, 2016; Imam, 2023). Additionally, Dhaka's metro system costs over US$ 140 million per KM, with an estimated 45-year recovery period for construction costs, making it an unaffordable solution to gridlock (Alam & Habib, 2003; Banister, 2015; Shah, 2024). Thus, looking out alternative solutions are necessary (Alam, 2024; Al-Amin, 2022).

Likewise, though having some positive aspects in reducing traffic jam to some extent, flyover construction that requires significant investment, introduces new problems (Taleb & Majumder, 2012). During flyover construction, the city experiences unprecedented disruptions, resulting in severe traffic congestion (Samad, 2023), and many projects have failed to meet their objectives due to the absence of bypass roads for excess traffic (Taleb & Majumder, 2012). Flyover construction has also led to land loss, displacement, disrupted economic activities, job losses, infrastructure damage, and increased noise, air pollution, accidents, and congestion (Haruna & Fasakin, 2023; Taleb & Majumder, 2012). Urban experts warned that flyovers cause "irreparable damage" and recommended practical solutions, as the situation remains unchanged even with metro rail projects (PA, 2020). Despite this, flyovers continue to be built, but they often fail to resolve congestion effectively, merely creating "roads over roads" that rarely enhance road space (Islam, 2018).

Globally, flyover-centric treatment of traffic congestion is not effective in urban areas (PA, 2020), rather they have also made road crossing more dangerous for pedestrians in some areas (Samad, 2023). Recently, it has been observed that flyovers are contributing to congestion rather than alleviating it (Das *et al.*, 2019). Till the date, eight flyovers are developed in the last two ages for the purpose of showcasing of eye catching infrastructure not for solving traffic congestion (Islam, 2018). Actually, flyovers or 'road over road' are not but a 'road occupied by road' that rarely enhances road space, meaning that the space relieved after constructing flyovers do not outweigh the costs.

Given the ineffectiveness of these current solutions, policymakers have the opportunity to reconsider the purpose and effectiveness of flyovers in addressing Dhaka's transportation challenges (Das *et al.*, 2019). Hence, a new approach is urgently needed. One promising alternative is the use of overpasses and underpasses to improve traffic flow at key intersections (Headrick & Uddin, 2014; Zhai & Ardian, 2020). Taleb and Majumder (2012) stated that effective traffic discipline and simple planning could address traffic issues more efficiently. Mudiyono (2024) suggested enhancing junction efficiency with overpass and underpass structures or a combination of both, while Afifipour *et al.* (2011) argued for underground infrastructure like tunnels in densely populated cities. Bridge-tunnel connections are also becoming more common in high-speed railway networks (Yang *et al.*, 2020). When traffic congestion is creating huge obstacles and throwing many challenges towards city dwellers, in response to Dhaka's traffic challenges, this paper proposes two key solutions:

P1: Overpass systems are feasible in road intersection to assuage traffic gridlock where metro rail or flyover is not already constructed.

P2: Underpass systems work best in tackling traffic congestion in junctions where metro rails or flyovers have already been constructed.

MATERIALS AND METHODS

In order to meet the study objectives, this study employs a mixed-methods approach combining qualitative observations, secondary data analysis, and conceptual design modeling. It incorporates four use cases and nine case studies to demonstrate the practical application of overpass and underpass systems at key intersections in Dhaka.

Sampling Strategy

The intersections were purposively selected based on qualitative observations over 15 years. Four high-impact intersections - Farmgate, Shahbagh, Science Lab-Nilkhet, and Mirpur-1 - were chosen for analysis as use cases. The selection was based on qualitative criteria such as traffic pattern intensity, recurring delays, spatial configuration challenges, and their strategic importance in connecting major urban arteries. This purposive sampling ensures relevance to the study's goals and high congestion impact.

Qualitative Observations

The qualitative aspect of this study follows a systematic approach to develop a novel concept for addressing Dhaka's traffic issues. Drawing on personal experience living in Dhaka, the author observed chronic congestion at key intersections, especially during working days' peak hours. Daily observations were recorded during morning and evening peak hours (7:30 - 10:30 AM and 5:00 - 7:30 PM). These observations focus on the most heavily trafficked intersections, which cause significant social, economic, and environmental challenges. Observation metrics included vehicle queue length, waiting time per signal cycle, pedestrian volume, and average traffic standstill durations. Based on these insights, the author identified intersections where overpasses and underpasses could significantly reduce traffic jams. Through daily observations as a resident, the author gained a deep understanding of the city's traffic problems, which fueled me drive to find a solution. Therefore, data were collected from the observational counts and observations were triangulated with digital data to ensure reliability.

Google Maps Data Protocol

Traffic pattern analysis was conducted using Google maps real-time data. Real-time traffic density and delay times were recorded using Google maps at 15-minute intervals over seven consecutive weekdays for each site. These data points were analyzed for average congestion trends, recurring delay times, and bottleneck causes. Feasibility factors such as road width, land acquisition requirements, and availability of alternate routes were considered viewing from Google maps before designing solution recommendation.

Secondary Data Collection

The study employs existing literature and database searches to identify relevant research, primarily from reputable journals and indexed databases like Web of Science and Scopus. However, the paucity of research in these databases necessitates collecting papers from Google Scholar and Research Gate platforms. Additionally, newspaper articles and online sources are considered to provide a broader perspective on potential solutions, which are summarized at the end of the paper. Thus, secondary data were collected from sources such as journal articles, book chapters, conference papers, traffic reports, government publications, urban planning research, and the daily newspapers. These sources provided valuable data on traffic volumes, congestion periods, and infrastructure challenges at key intersections. The study uses the key search string: "overpass", "underpass", "traffic congestion", "Dhaka", "traffic jam", "flyover", "grade separation", "flyover effectiveness". No time period restriction is applied; thus, the publication years do not specify inclusion criteria since studies on transportation system in Dhaka are not so old recognizing very few studies are in the literature. Additionally, traffic volume data, accident statistics, and intersection-specific performance metrics were gathered from government reports (Dhaka transport coordination authority and Bangladesh road transport authority) and newspapers (e.g., The Daily Star, The Prothom Alo). Reliability of statistical data was cross-validated through alternative independent sources.

Conceptual Design and Visual Modeling

The study proposes a conceptual model tailored for Dhaka, with solutions that focus on the societal and economic impacts following the model as illustrated in Alam *et al.* (2022). This design methodology adapts principles from Dehnert and Prevedouros (2004) to design feasible and replicable interventions, focusing on low-clearance, short-span, cost-effective solutions for dense urban intersections. The key design considerations include cost-effectiveness, road width and space availability, clearance height, utility line positioning, construction footprint, and traffic flow optimization to provide practical and scalable solutions for Dhaka. The designs also emphasize ease of construction and minimal disruption to daily traffic.

Generative AI (ChatGPT with DALL·E integration) was used to produce visual blueprints of proposed structures, serving as proof-of-concept illustrations. This conceptual model is designed for low-cost, simple overpass and underpass systems aimed at addressing Dhaka's traffic issues, which remedies are also advocated in many previous studies. These designs are supported by visual representations, including diagrams and models, showing how the proposed infrastructure would integrate into the city's existing road network.

Use Cases and Comparative Case Studies

The research examines four major intersections in Dhaka as pilot sites for implementing the overpass and underpass solutions in intersections: Farmgate, Shahbagh, Science Lab-Nilkhet, and Mirpur-1. These solution recommendations serve as the primary use cases. They were selected based on their high traffic volumes, complex road layouts, and the potential for significant social and environmental improvements. Each site has been analyzed to propose specific design solutions that address the local context, including anticipated economic and social impacts during and after construction. For each intersection, an overpass or underpass design has been suggested to address traffic flow challenges. These pilot sites serve as models for wider implementation across Dhaka, offering a practical demonstration of the concept.

Additionally, ten case studies from cities – Rampura-Dhaka, Singapore, Tokyo, Delhi, Cairo, Bangkok, Mumbai, Manila, Hong Kong, and Jakarta - provide comparative insights. These cases highlight the effectiveness of overpass and underpass systems as cost-efficient solutions and offer lessons on design, construction methods, benchmark cost, traffic relief estimates, and their socioeconomic impacts, reinforcing the potential for similar success in Dhaka.

RESULTS AND DISCUSSION

Results and Conceptual Model

Overpass system is a significant addition to roadway capacity expansion in developing countries. They are a crucial system of transport infrastructure, typically constructed at busy intersections or along highways to reduce urban traffic congestion (Akter & Khatun, 2017; Das *et al.*, 2019; Liu *et al.*, 2007; Rahman, 2017). By focusing on short, targeted overpasses and underpasses, the city can create a more efficient road network that reduces traffic congestion at its source. Grade-separated infrastructure, such as overpasses and underpasses, not only alleviates congestion but also enhances road safety by minimizing collision points and organizing vehicular flow more efficiently (Anene *et al.*, 2023). These systems are a practical, cost-effective solution that can be adapted to Dhaka's unique urban challenges, offering a path forward to a more streamlined and functional transportation infrastructure.

Conceptual Model Development

The solution to Dhaka's entrenched traffic congestion lies in a simple yet innovative idea: constructing cost-effective overpasses and underpasses at major intersections. These intersections are the primary cause of traffic jams, especially during peak hours when vehicles from multiple directions converge, creating long queues and delays. By implementing overpasses or underpasses at key junctions, traffic flow could be dramatically improved, reducing the gridlock that plagues the city.

To validate the applicability and design of this proposed model, four critical intersections in Dhaka city - Farmgate, Shahbagh, Science Lab-Nilkhet, and Mirpur-1 are selected, which are among the most congestion-prone zones in the city. Farmgate and Shahbagh are known for their administrative and commercial traffic loads, Science Lab-Nilkhet is a key academic and transit hub, while Mirpur-1 serves a densely populated residential area with chaotic vehicular influx. This selection ensures that the model addresses a diverse range of intersection challenges, allowing for scalable and context-sensitive design considerations.

Overpass System

Overpasses are a significant addition to urban transportation systems in developing countries. Constructed at busy intersections, they are designed to relieve urban traffic congestion (see Figure 2). The overpass system proposed here is small-scale, with a structure that spans the intersection - typically around 60 to 80 meters for small urban crossings, with additional ramps extending the total length to around 250 to 400 meters. This allows for smooth traffic flow, ensuring vehicles can move through the intersection without delays. In some cases, compact designs, such as "flyover junctions" or "grade-separated interchanges," could reduce the total length of around 150 to 300 meters, making them suitable for dense urban areas.

For example, in Singapore, flyovers at urban intersections are as short as 200 meters, allowing for continuous traffic flow while minimizing land use. Similarly, in Tokyo, overpasses designed to cross intersections are built with a length of around 250 to 350 meters. The goal is to create a streamlined traffic system, enabling the free movement of vehicles while

Figure 2: 3D Design of the Overpass System
Source: Cadac Group

maintaining a minimal infrastructure footprint.

Underpass System

Underpasses (see Figure 3) offer an alternative solution for intersections where overhead construction is not feasible. These structures also span the width of the intersection - typically 60 to 80 meters, with additional ramp lengths bringing the total length to around 250 to 400 meters. The construction of underpasses involves more complexity and cost, particularly concerning ventilation and utilities, but they allow vehicles to pass under the intersection without interruption.

To avoid issues with clearance height, it is essential that the underpass system is designed to accommodate all types of vehicles safely. Examples of successful underpasses include the all India institute of medical sciences (AIIMS) intersection in Delhi, India, which spans approximately 300 meters, and the Rama IX intersection in Bangkok, Thailand, which spans about 250 meters. In Cairo, underpass systems designed to reduce congestion are built with lengths between 250 and 350 meters, showing that effective underpass solutions can be applied even in densely populated areas.

Implementation Considerations

It needs to specify for lucidity that the author is not proposing large, expensive flyovers in the name of overpasses. In contrary, underpasses do not underline the concept of subways. Rather, his main concept encapsulates the short cost-effective overpass and underpass systems, designed specifically to allow motor vehicles to pass over or under the intersection instantly, bypassing the traffic without the need to stop. In this case, the previous entry-exit points of the newly constructed segment must be closed to enable smoother flow on the alternate sides of the intersection, while vehicles use the overpass or underpass to proceed without resistance. This conceptual model illustrates the intended traffic flow patterns and infrastructure configurations. It is important to note that the proposed model serves as a conceptual blueprint rather than an exact design, offering a likely configuration that can be adapted and refined through detailed site-specific engineering analyses and stakeholder input.

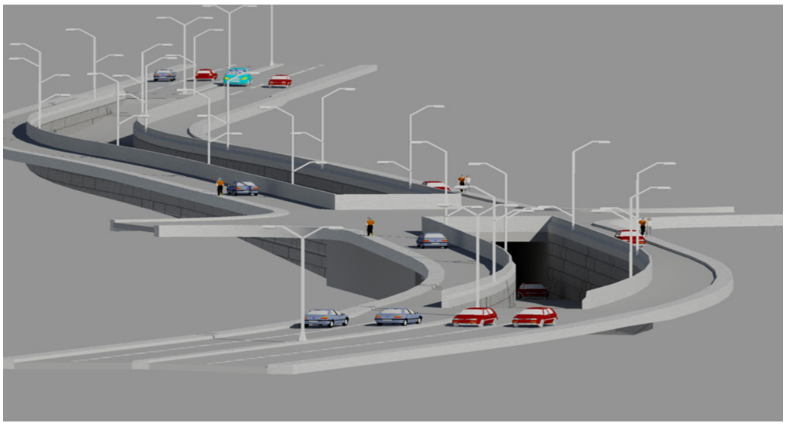


Figure 3: 3D Design of the Underpass System
Source: Phuentsholing Thromde

The proposed overpass and underpass systems must be cost-effective and designed for short spans to reduce construction costs while maximizing efficiency. By focusing on low-cost solutions that meet the basic requirements for vehicle transit, these systems can be implemented quickly and affordably. 'Simplicity is the key' should be taken into account. These structures should be financed through a combination of PPP to avoid reliance on foreign loans, allowing for greater local control over the project.

The key considerations for underpass construction include maintaining sufficient clearance for vehicle safety and ensuring that the height of the structure does not interfere with traffic. Nguyen and Brilakis (2016) highlighted the risks associated with low-clearance underpasses, such as accidents and derailments, which must be carefully managed during planning. Additionally, challenges related to soil conditions, ventilation, and utility management must be addressed to ensure smooth implementation. In Tennøy and Hagen (2021)'s study, it is found that while congestion grew in the tunnel and on nearby road links, road users adjusted their behavior, leading to a notable decrease in traffic through the tunnel. Qihu (2016) identified five key issues in the utilization of underground space in China, including uncoordinated solutions, a fragmented management system, incomplete regulations, inadequate planning, and unclear policies. These issues must be addressed before planning and implementing the underpass system in the selected intersections.

Expected Systems Payoffs

A reliable and efficient transportation system is crucial for sustainable development (Taleb & Majumder, 2012). Certain intersections in Dhaka are so congested that at-grade traffic management solutions are no longer sufficient (Dehnert & Prevedouros, 2004). Grade separation techniques, like underpasses or overpasses, offer several benefits, including uninterrupted traffic flow, increased capacity for current and future demands, and reduced delays and accidents. Although Dehnert and Prevedouros (2004) found that low-clearance underpasses can be more affordable and effective in alleviating congestion than standard underpasses, it is recommended to build standard underpasses where possible for allowing smooth traffic of all kinds of motor vehicles.

When the proposed overpass or underpass system is successfully implemented, the changes could be transformative. The most immediate benefit would be a significant reduction in traffic congestion, allowing for an uninterrupted flow of vehicles, particularly at intersections notorious for causing delays. By eliminating the need for frequent stops, traffic would flow more smoothly through the city, substantially reducing overall travel times.

This system would also reduce the need for constant traffic management by police officers. Currently, a large workforce of traffic police is deployed for hours each day to manage Dhaka's traffic jams. The new system would ease this burden, allowing the police to focus on other aspects of city management and reducing the overall demand for their presence at intersections.

Another crucial benefit is the time saved by commuters, including students, who would be able to reach their destinations faster. This would boost productivity across the city and reduce the frustration and stress that accompany daily travel. Additionally, smoother traffic flow would lead to less fuel consumption, as vehicles would no longer need to frequently stop and start. This could result in significant savings for commuters while also reducing carbon emissions, contributing to improved air quality and public health.

There would also likely be a reduction in traffic accidents. Congested areas, particularly busy intersections, are often hotspots for collisions. By eliminating the need for vehicles to stop and navigate through complex intersections, the potential for accidents would be reduced.

Challenges and Solution Recommendations

Despite the clear benefits, the implementation of overpasses and underpasses across Dhaka is not without challenges. Despite the model aims at low-cost constructions, the most immediate hurdle would be the high initial cost of construction. Although the implementation cost is comparatively lower than flyover and other mega projects, total cost is massive since Dhaka possesses a number of junctions, which need to be addressed to mitigate the problem. Moreover, during the building phase, traffic conditions could worsen temporarily due to road closures and detours. However, these short-term disruptions would be outweighed by the long-term improvements in traffic flow and quality of life.

Careful planning would be essential to minimize these issues. The government needs to prioritize intersections with the highest traffic volumes, such as those at Shahbagh, Farmgate, Motijheel, and Mirpur-10, where underpasses might provide the greatest relief (see Figure 4). Similarly, overpasses could be implemented at intersections like Science Lab, Nilkhet, Mirpur-1, Bijoy Sarani, and Nayabazar intersection, where space and road layouts are more conducive to elevated solutions. By starting with four of these critical intersections as pilot projects, the government could evaluate the success of the system before expanding it to other areas. Once the benefits become apparent, additional intersections could be targeted, gradually easing the traffic congestion throughout the city.

Pilot Based Use Cases

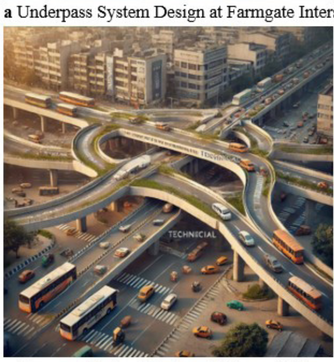
To demonstrate the practical application of the proposed conceptual model, this section presents pilot-based use cases for four critical intersections in Dhaka as outlined in Figure 4.

Underpass System at Farmgate Intersection

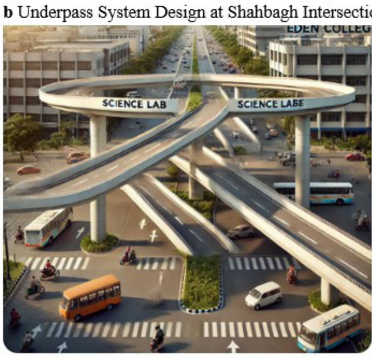
The proposed underpass system at the Farmgate

a Underpass System Design at Farmgate Intersection

b Underpass System Design at Shahbagh Intersection



c Overpass System Design at Mirpur-1 Intersection



d Overpass System Design at Science Lab-Nilkhet Intersection

Figure 4: A Sample Design for Modern Overpass and Underpass Systems at Four Intersections in Dhaka City

Source: Designed with the Assistance of ChatGPT Tool intersection, one of Dhaka's busiest junctions, will facilitate the smooth, unrestricted movement of vehicles from both directions. By utilizing an underpass, traffic coming from Shahbagh will flow seamlessly through the intersection (Figure 4a). The system will feature two routes diverging at the center of the intersection - one route leading towards the Parliament area and the other continuing straight towards the Prime Minister's Office. Meanwhile, vehicles traveling from the parliament area and the prime minister's office will utilize the existing at-grade roadway network. Together, the combination of the underpass, regular road, and metro rail system will efficiently handle all traffic, eliminating any queues or delays at the intersection.

Underpass System at Shahbagh Intersection

The proposed underpass system at the Shahbagh intersection, another busiest junction at Dhaka, will enable the smooth, unrestricted movement of traffic from both directions (Figure 4b). With the underpass in place, vehicles coming from the Ministry of Foreign Affairs will flow seamlessly through the intersection. Two routes will branch out from the center - one leading towards the Farmgate area and the other continuing straight towards Science Laboratory. Meanwhile, vehicles arriving from Farmgate and Dhaka University will continue to use the regular road. The integration of the underpass, regular road, and metro rail will ensure efficient traffic management, eliminating the need for vehicles to queue at the intersection.

Overpass System at Mirpur-1 Intersection

The proposed overpass system at the Mirpur-1 intersection will ensure the smooth, unrestricted flow of vehicles from both directions (Figure 4c). With the overpass, traffic from Mirpur-10 and Mirpur-2 will move efficiently across the junction. Two routes will branch out from the center of the intersection - one towards the Technical area and the other straight towards Mazar Road. Meanwhile, vehicles traveling between Zoo Road and Technical will use the regular road. The combination of the overpass and regular road will effectively manage the traffic, eliminating the need for any waiting lines at the intersection.

Overpass System at Science Lab-Nilkhet Intersection

The proposed overpass system at the Science Lab and Nilkhet intersections will facilitate the smooth, unrestricted flow of vehicles from both directions (Figure 4d). Traffic along Mirpur road and Azimpur will move seamlessly via the overpass. At the Science Lab intersection, four routes will branch out from the center - one leading towards Shahbagh and two towards Zigatola. At the Nilkhet intersection, three routes will lead towards Dhaka University, and two towards the border guard Bangladesh (BGB) Gate. Meanwhile, vehicles traveling between Shahbagh, Mirpur road, and Zigatola, as well as those between Dhaka university and the BGB Gate, will use the regular road. The combination of overpass and regular road will effectively manage the traffic, ensuring a smooth flow without any waiting lines at the intersections. The proposed overpass and underpass systems have already been successfully implemented in cities around the world, many of which faced traffic congestion issues similar to Dhaka's current situation. When the author traveled to Madrid for pursuing his higher studies, he observed how effectively these systems, combined with active traffic signaling, alleviated the city's traffic congestion. Vehicles transitioned smoothly along the roads, without frequent stops at intersections, thanks to well-designed overpasses and underpasses. Similar applications can also be found in developing countries like Sri Lanka (Bandara & Hewawasam, 2020), India (Jha, 2020), China (Liao *et al.*, 2018), Brazil (Bull & Cooperation, 2003), Mexico (USTDA, 2014), and Indonesia (JICA, 2004). In these cities, the construction of overpasses and underpasses has transformed traffic management, allowing vehicles to flow continuously through high-traffic areas. In these examples, the elimination of constant stopping and starting at intersections has led to a significant improvement in traffic conditions. Traffic flow has become smoother, travel times have been reduced, and congestion has been alleviated. These systems are practical and cost-effective, offering a tested solution for cities like Dhaka, which are grappling with similar congestion challenges.

Case Studies

To validate the feasibility and contextual relevance of the proposed system, this section presents case studies from cities that have successfully implemented similar overpass and underpass infrastructures.

Dhaka's First U-loop: A Local Success Story

Dhaka's first U-loop, constructed near Rampura TV Station, offers a promising local example of a low-cost traffic solution (Figure 5). Built and opened to public in June 2016 at a cost of nearly US$ 4 million, the U-loop allows traffic from the Banasree area to travel to key destinations like Badda, Tejgaon, Karwan Bazar, or Moghbazar without being delayed by gridlock. The success of this project highlights the potential of cost-effective infrastructure solutions to reduce traffic congestion in Dhaka. Ergo, experts have called on the government to replicate these solutions across other major intersections in the capital (Azad, 2018).

The Rampura U-loop has shown tangible results. After its implementation, average vehicle speeds increased by 86.9 percent, average delays per vehicle were reduced by 62 percent, and total stopped delays fell by 73 percent. These improvements illustrate that the simple infrastructure changes can have a greater impact on traffic flow. Moreover, the U-loop bridges can be fully designed and constructed using local resources, minimizing the need for external funding and expertise (Murshed *et al.*, 2020). This successful pilot case in Dhaka demonstrates that

Figure 5: U-loop near Rampura TV Station
Source: Flickr

implementing overpass and underpass systems at other high-traffic intersections can offer similar benefits, providing a practical roadmap for alleviating traffic congestion across the city.

Overpass System in Singapore

Singapore's limited land area has necessitated the development of compact overpass systems to address traffic congestion. These flyovers, typically 200 to 300 meters long, help alleviate traffic bottlenecks while minimizing land use. Singapore's land transport authority (LTA) has consistently invested in transport infrastructure, allocating over US$ 3 billion in the early 2000s for road and flyover construction. Flyovers in Singapore enable uninterrupted traffic flow, reducing waiting times at intersections and improving overall road capacity. The cost of these overpass systems typically ranges between US$ 20 - 40 million per kilometer, including construction and land acquisition costs (LTA, 2002).

Overpass System in Tokyo

Tokyo, Japan, utilizes overpass systems in its dense urban areas to mitigate traffic congestion. These grade-separated junctions, typically 250 to 350 meters long, connect key intersections in central districts without requiring large detours or underground tunneling. Tokyo's overpasses are a critical part of the city's broader road infrastructure, which includes EEs and tunnels. Building overpasses in Tokyo is costly due to land acquisition challenges and the need for earthquake-resistant designs. The cost per KM of elevated infrastructure ranges from approx. US$ 70-100 million. These overpasses help reduce traffic jams and improve travel times while maintaining safety in a seismically active region (MLIT, 2014).

Underpass System in Delhi

Delhi, India, has constructed several underpasses to alleviate congestion at busy intersections. A key example is the AIIMS underpass, which spans approximately 300 meters and connects high-traffic areas. Completed as part of the 2010 commonwealth games infrastructure upgrades, the AIIMS underpass cost around US$ 18 million. Other underpasses in Delhi have costs ranging between US$ 10-20 million, depending on site complexity and land acquisition challenges. The underpasses in Delhi have significantly reduced waiting times at traffic signals, improved connectivity, and lowered vehicular emissions. These benefits have contributed to improved air quality and reduced traffic accidents (PWD, 2023).

Underpass System in Cairo

Cairo, Egypt, has constructed underpasses to ease congestion at critical intersections in the city. The Haram street underpass, spanning 250 to 350 meters, connects key districts in Giza and central Cairo. These projects cost between US$ 30-60 million per underpass, depending on location and complexity. These underpasses have reduced traffic jams and improved connectivity between business districts. By decreasing vehicle idling, they have also contributed to reducing pollution levels in Cairo, improving air quality and promoting urban mobility (Morsy, 2021).

Underpass System in Bangkok

Bangkok, Thailand, has invested heavily in underpasses to manage traffic congestion in its central business district. The Rama IX intersection underpass, approximately 250 meters long, allows vehicles to bypass a major choke point. This project was part of a larger urban transport initiative costing US$ 70 million. Designed with flood control measures, the underpass has improved traffic flow and reduced congestion-related emissions in Bangkok (Chakraborty, 2024).

Overpass and Underpass Systems at Mumbai

Mumbai, India, has long struggled with traffic congestion due to its dense population and limited road space. In response, the city implemented multiple flyovers and overpasses under the Mumbai Urban Infrastructure Project. A key example is the eastern freeway (EF), completed in 2013, which significantly reduced travel times between South Mumbai and the suburbs. Other vital overpasses, such as the Sion-Panvel Highway flyover, also helped alleviate congestion in key areas. However, Mumbai still faces challenges due to limited space for expanding road networks and high traffic volumes. The city is exploring underground road projects and EEs as potential solutions. The total cost of the EF was estimated at US$ 170 million, while an extension of 14 KM is projected to cost approximately US$ 380 million (Mehta, 2014).

Overpass and Underpass Systems at Manila

Manila, the capital of the Philippines, has implemented multiple overpass and underpass systems to combat traffic congestion. The metro Manila bridges project, partially financed by the Asian development bank, introduced overpasses and pedestrian bridges, such as the runway Manila footbridge, which connects ninoy aquino international airport to newport city. The runway Manila project cost US$ 33.2 million and has the capacity to handle up to 216 thousand individuals daily (Desiderio, 2017; Manglinong, 2018).

Another key project is the Ortigas overpasses, which provide relief to commuters in one of Manila's busiest business districts. Despite these improvements, Manila continues to face challenges such as population density and poorly maintained infrastructure. The metro Manila skyway stage 1 and 2 project cost approximately US$ 630 million, while the skyway stage 3 cost US$ 650 million (Armengol, n.d.; PPP, n.d.).

Overpass and Underpass Systems at Hong Kong

Hong Kong (HK), the densely overpopulated and relatively land-scarce territory, has coped with traffic congestion for years through a highly sophisticated web of flyovers, overpasses, and tunnels complementing its public transit system. Good examples are the Cross-Harbour Tunnel and the numerous elevated roads within Central and Wan Chai that act to divert through-traffic from overloaded surface roads.

The Central-Wan Chai Bypass (CWCB), which was finished in 2019, is a major infrastructure project that features tunnels, flyovers, and underpasses to reduce travel time along HK Island's northern corridor (CPA, 2019). Just the bypass has reduced peak-hour travel time by up to 70% and significantly eased congestion in the city's commercial areas (Siu, 2013). Despite all these advances, KH continues to grapple with having too many cars on the roads and not sufficient space for the introduction of new surface roads, resulting in ongoing investment in road tunnels underground and smart traffic systems. The construction of the CWCB cost almost US$4.6 billion due to design modifications and the complexities of construction (HD, 2020; Siu, 2013).

Overpass and Underpass Systems at Jakarta

Jakarta, Indonesia, has implemented overpass and underpass systems to address its severe traffic congestion, incorporating them as part of an integrated transport network that includes BRT, MRT, and LRT systems. One notable strategy is the integration of the TransJakarta BRT with the MRT and LRT systems. Overpasses and underpasses enable seamless transitions between these different modes of public transport, facilitating efficient travel across the city without surface-level congestion (ITDP, 2021).

For example, at the CSW intermodal transit hub, elevated structures and underpasses connect different transport corridors, serving over 200 thousands passengers daily (Adriana, 2018; ITDP, 2021). While these systems have improved traffic flow at key intersections, challenges such as limited public transport coverage, urban sprawl, and high infrastructure costs persist (Zhai & Ardian, 2020). The total cost of integrating the MRT, LRT, and BRT systems was between US$ 10.72 billion and US$ 15.82 billion (Adriana, 2018).

Discussion

Empirical Relevance and Modeled Projections

Drawing insights from comparable global intersections, a modeled estimation was conducted for the proposed Dhaka pilot cases. Based on traffic simulations using estimated volumes and configurations from similar urban nodes, the implementation of overpasses and underpasses is expected to reduce peak-hour delays by 65-75 percent, lower vehicle idling time by 40 - 50 percent, and improve average speed from 4.8 km/hour to approximately 9.5 km/hour as well as decline 25 - 30 percent in vehicular emissions. For example, post-U-loop implementation in Rampura saw an 86.9 percent speed increase, which supports the feasibility of similar interventions elsewhere in Dhaka. These projections, while conceptual, offer early validation of the model's potential efficacy in Dhaka.

Cost Comparison and Feasibility Analysis

Cost estimation covers construction materials, labor, land acquisition, and long-term maintenance as well as social costs. The cost-benefit analysis also includes economic benefits from reduced environmental degradation, such as lower healthcare costs due to decreased pollution and potential energy savings (Mao *et al.*, 2012). A key component of this study is the cost estimation for the proposed overpass and underpass systems, which includes:

Material Costs

A detailed breakdown of materials required for construction (e.g., concrete, steel, asphalt). Locally sourced and low-cost materials are prioritized to minimize overall expenses.

Labor and Machinery Costs

Estimates for required labor, including engineers, construction workers, and machinery operators, are based on current market rates in Bangladesh for similar infrastructure projects.

Land Use and Acquisition Costs

In areas where additional land is needed, costs are estimated for land acquisition or compensating businesses affected by the construction. Special consideration is given to minimizing land acquisition costs by optimizing the use of existing road space, especially in densely populated areas.

Maintenance Costs

Long-term costs for maintaining the infrastructure, including regular inspections, repairs, and possible upgrades, are included in the cost analysis.

Dhaka currently has eight flyovers under the jurisdiction of Dhaka North and South City Corporations. The three major flyovers are the Mayor Hanif, Moghbazar-Mouchak, and Kuril flyovers. The others are medium to small in scale (Rita, 2024; TBS, 2023). The construction and maintenance costs of these projects are significant, with a notable portion financed through foreign loans. Table 1 illustrates the details of various flyovers and two major infrastructure projects aimed at reducing traffic congestion in Dhaka (Suman, 2023).

Based on past projects in Dhaka and similar cities, the construction cost of a small-scale overpass is estimated between US$ 2 and 5 million, depending on location, materials, and length. Underpass construction is generally more expensive due to excavation and drainage requirements, with an estimated cost of US$ 4 to 8 million for a basic underpass.

Table 1: Details of Dhaka's Traffic Congestion Projects Including Their Associated Costs

Sl. No.	Project Name	Year Completed	Length (KM)	Establishing Body	Funding Body	Costs Incurred (approx. US$ in million)	Source
1	Mohakhali Flyover	2004	1.12	DTCA	GoB and WB	10	Khan (2021); TBS (2023)
2	Khilgaon Flyover	2005	1.9	LGED	GoB	7	Khan (2021); TBS (2023)
3	Bijoy Sarani-Tejgaon Link Road Flyover	2010	1.1	DNCC, LGED, and RHD	GoB	4	Khan (2021); TBS (2023)
4	Kuril Flyover	2013	3.1	RAJUK	GoB and WB	25.5	Khan (2021); TBS (2023)
5	Banani Zillur Rahman Flyover	2013	1.8	DSCC and LGED	GoB	17	Khan (2021); TBS (2023)
6	Mayor Mohammad Hanif Flyover	2013	10	PPP	GoB, SB, RB, JB, AB, SIB, ICB and Orion Group	190	Khan (2021); TBS (2023)
7	Moghbazar-Mouchak Flyover	2016	8.7	LGED	GoB, SFD, OFID	102	Khan (2021); RAJUK (2022); TBS (2023)
8	Kalshi Flyover	2023	2.3	DNCC and Bangladesh Army	GoB	85	TBS (2023)
9	Dhaka Metro Rail MRT Line-6	2022	21.26	DMTCL	GoB, JICA (75 percent)	2,820	Saif (2021); Shah (2024)
10	Dhaka Elevated Expressway	2023	23	PPP	GoB, (27 percent as VGF), Ital-Thai (51 percent), CSI (35 percent), Sinohydro (14 percent)	1,130	PPP (2024); RAJUK (2022); WB (2020)

Note: DMTCL - Dhaka Mass Transit Company Limited, PPP - Public Private Partnership, DNCC - Dhaka North City Corporation, LGED - Local Government and Engineering Department, RAJUK - Rajdhani Unnayan Kartripakkha or Capital Development Authority, IMED - Implementation Monitoring and Evaluation Division, DSCC - Dhaka South City Corporation, RHD - Roads and Highways Department, DTCA - Dhaka Transport Coordination Authority, GoB – Government of Bangladesh, WB – World Bank, SFD - Saudi Fund for Development, OFID - OPEC Fund for International Development, VGF - Viability Gap Funding, ItalThai - Italian-Thai Development Public Company, CSI - China Shandong International Economic & Technical Co-operation Group, ADB - Asian Development Bank, JICA - Japan International Cooperation Agency, SB – Sonali Bank PLC, RB – Rupali Bank PLC, JB – Janata Bank PLC, AB – Agrani Bank PLC, SIB – Social Islami Bank PLC, ICB - Investment Corporation of Bangladesh

Implications

Economic Impact

The cost-benefit analysis evaluates the projected capital and operational expenses against the expected benefits, including reductions in fuel consumption, travel time, and environmental damage. The analysis demonstrates potential long-term savings for both the city and its residents by implementing these solutions. Reduced traffic jams could lead to substantial productivity gains for the city. Through saving commuters' valuable time, improving mental health, and enhancing productivity might be crucial antecedents to economic upgrading.

The Padma Multipurpose Bridge, inaugurated in 2023, is the first major infrastructure project of the GoB. Spanning 6.15 KM, currently the 122nd longest in the world and the largest in South Asia, it connects over 35 million people in the Southwestern region with Dhaka, stimulating economic growth, employment, and reducing poverty. The bridge has boosted GDP by over one percent by improving transportation and facilitating trade. Despite its significant impact, the project, costing US$ 3.6 billion, is expected to take around 35 years to recover the investment (BSS, 2022; Rahman & Khondker, 2016; Zaman, 2023). The country's first 3.32 KM tunnel under Karnaphuli river connecting Chattogram port city and Anwara upazila represents the second major "dream scheme" in the road transport sector, following the Padma Bridge, which was completed in 2023 at a cost of US$ 1.56 billion. This project highlights the significant economic impact on the country. According to the project director, the tunnel is expected to boost the nation's GDP by 0.166 percent (Suman, 2023). However, Chowdhury (2024) stated that the costs associated with the construction of the project exceed its potential benefits. The government has launched a 50-year plan to develop a 258 KM underground railway in Dhaka, which will be executed in four phases. The initial phase involves a 29.35 KM route, stretching from the Jhilmil Project area in Keraniganj to Tongi projected cost of approximately US$ 8 billion (TDS, 2021).

Despite the large investments behind mega projects like the Padma Multipurpose Bridge and Bangabandhu Tunnel, the results have not been as proportionally impactful. Similarly, the proposed underground railway project is unlikely to significantly reduce traffic congestion in Dhaka. In contrast, it is expected that implementing overpass and underpass systems, which require comparatively lower investment, could deliver surprisingly effective results in alleviating the city's traffic jams, providing massive economic gains adding to the country economy.

Social and Environmental Impact

A significant aspect of this study is the social and environmental analysis of the proposed overpass and underpass systems. The analysis examines two phases: construction and post-construction.

Construction Phase Impact

Air Pollution

Construction activities might temporarily increase dust and emissions that are adversarial to human health and environment. Measures such as dust suppression and the use of cleaner technologies might be employed to minimize the issue.

Noise Pollution

Construction noise, especially during peak hours, could increase causing human disruption and environmental degradation. Mitigation strategies, such as noise barriers and off-peak work schedules, might be implemented.

Waste Generation

The project might produce waste and garbage at the work station. Steps would aim to minimize construction waste and ensure proper disposal, following environmentally responsible practices.

Greenery and Beautification Destruction

The construction efforts might require cutting trees and destroying beautification. To mitigate this problem, efforts would be made to protect existing trees and beautification, with plans to restore or relocate green spaces if possible.

Policy Recommendation

The study findings suggest policy adjustment as outlined in RAJUK (2022) that shows 2016 till 2035 and other relevant governing authorities who are responsible for eradicating traffic gridlock problem.

Post-Construction Impacts

The reduction in idle time for vehicles could lead to social and environmental benefits in the following ways:

Reduction in Travel Time

It is expected that the overpass and underpass systems might reduce congestion and improve travel time for commuters passing through these intersections by at least 80-90 percent at each pilot site.

Reduction in Traffic Volume

By diverting a significant portion of traffic from surface-level intersections, the overpasses and underpasses are expected to reduce congestion by at least 80-90 percent at peak times.

Reduction in Traffic Emissions

The proposed systems would decrease vehicle idling times, leading to lower emissions and improved air quality by reducing pollutants such as carbon monoxide, nitrogen oxides, and particulate matter, thus, contributing to environmental sustainability.

Improvement in Air Quality

Estimates suggest a 15-20 percent reduction in harmful emissions in the immediate areas surrounding the selected intersections.

Noise Reduction

With traffic flowing more smoothly and reduced congestion at surface level, overall noise pollution in the area is expected to decrease, particularly near residential and commercial zones. Honking and engine idling noise levels are expected to drop by 10-15 decibels, enhancing the quality of life for nearby residents.

Energy Efficiency

By optimizing traffic flow, the reduction in stop-and-go traffic could contribute to lower fuel consumption. This leads to energy savings, both for private vehicles and public transport, indirectly reducing the carbon footprint.

Policy Recommendation

Although Dhaka's traffic challenges are significant, overpasses and underpasses at key intersections can make a meaningful impact. Strategic infrastructure development would ensure Dhaka moves toward becoming a more efficient, sustainable, and livable city, prompting policymakers to act swiftly. Hence, findings of this study suggest policy adjustments, aligned with RAJUK's 2016–2035 guidelines, to tackle traffic congestion effectively. Enhanced public transportation, as seen in the Dhaka Metro, remains crucial, and supplementary measures like ride-sharing and stricter law enforcement on traffic violations are essential.

Theoretical Contribution

In addition to practical applications, this study contributes significantly to the existing body of literature on urban traffic management. It provides valuable insights for future researchers, suggesting potential research directions and offering a framework for further studies in this field.

Limitations

While this study offers a comprehensive proposal for alleviating traffic congestion in Dhaka through the development of overpass and underpass systems, several limitations should be acknowledged.

First, the research relies heavily on secondary sources, including previous studies, government reports, and urban planning documents. The accuracy of the analysis is dependent on the validity and completeness of these external datasets, which may not always reflect the most current traffic and infrastructure conditions. Additionally, input from key stakeholders, such as city planners, traffic engineers, local government officials, and community members, is not included. Their perspectives and expertise could provide valuable insights, particularly in evaluating the practicality and social impact of the proposed solutions.

Although four intersections have been selected for the pilot phase, the scope of the study remains narrow and does not capture the full complexity of Dhaka's traffic network. As a result, the conclusions drawn from these cases may not be applicable to the entire city. Furthermore, the cost estimates provided in this study are based on previous projects and generalized assumptions. Actual construction costs may vary due to unforeseen factors, such as market fluctuations in material and labor costs or unexpected technical challenges during implementation. Again, the bottlenecks causing due to near intersections without overpass or underpass might be detrimental to reap the actual benefits of these pilot phases.

While the study includes an environmental impact analysis, the projected benefits are theoretical rather than empirically measured. Without real-world implementation, it is difficult to fully assess the long-term environmental impacts of the proposed systems. Finally, the study does not fully address potential technological or regulatory challenges in implementing the proposed infrastructure. Issues such as integrating smart traffic management technologies or navigating local legal frameworks related to land use and construction permits are not thoroughly explored.

Future Study Directions

The limitations of this study open up several avenues for future research:

Real-Time Primary Data Integration

Similar study might be conducted empirically collecting primary data from key stakeholders like commuters and policy makers and evaluating those data statistically using tools like SmartPLS to show the real feasibility and recommend further suggestions. Future studies should incorporate real-time traffic data from advanced monitoring technologies (such as GPS tracking, CCTV, or sensors) to provide more accurate and dynamic assessments of congestion patterns. This data could enable more precise planning and optimization of overpass and underpass systems.

Stakeholder and Community Engagement

Engaging key stakeholders in future studies will be essential. Urban planners, engineers, local residents, and policymakers should be consulted to ensure the proposed solutions are both technically viable and socially and politically feasible. Public opinion and community feedback can refine designs and address potential social or economic disruptions.

Cost-Benefit Analysis Over Time

Future research could conduct a more detailed long-term cost-benefit analysis, considering life cycle costs (construction, maintenance, and potential replacement) and broader economic benefits such as improved productivity, reduced fuel consumption, and healthcare savings due to decreased pollution.

Technological Integration

Future research should investigate how smart traffic management technologies can be integrated with the overpass and underpass systems. This could include automated traffic lights, vehicle flow optimization systems, and data-driven traffic predictions, which could further enhance the effectiveness of the infrastructure.

Regulatory and Policy Framework Studies
Additional research could examine the legal and regulatory frameworks necessary for implementing large-scale infrastructure projects in Dhaka. This would involve studying land acquisition laws, construction permits, and compliance with environmental regulations.

Citywide Implementation Studies
While this paper focuses on a small number of pilot cases, further research should explore the scalability of the proposed solutions. Studies could be conducted to assess how similar overpass and underpass systems can be applied to a broader range of intersections across Dhaka, or even in other cities facing similar congestion challenges.

Socio-Economic Impact Assessment
Future studies should delve deeper into the socio-economic impacts of these infrastructure projects. This includes analyzing how changes in traffic flow affect businesses, local communities, and overall quality of life. Research could also focus on how the infrastructure solutions impact access to local businesses, property values, and potential displacement of residents or businesses.

Environmental Monitoring Post-Implementation
Post-implementation studies should monitor environmental impacts to validate the projected benefits related to air quality, noise pollution, and fuel consumption. This could involve setting up air quality sensors, noise monitoring devices, and fuel consumption trackers in areas where the overpass and underpass systems are installed.

CONCLUSION

This study presents and recommends a conceptual model for mitigating traffic congestion in Dhaka through the development of cost-effective overpass and underpass systems at four critical intersections: Shahbagh, Farmgate, Mirpur-1, and Science Lab-Nilkhet. The proposed model provides a promising direction in tackling Dhaka's unstoppable traffic congestion. Additionally, the discussion highlights key socio-economic factors - such as travel time reduction, emission control, business continuity, and commuter cost savings. These factors are essential to evaluating the broader societal value of the proposed system and must be systematically integrated through traffic flow simulation tools (e.g., Vissim or Aimsun) and environmental impact assessments in subsequent phases. To move from concept to implementation, a phased roadmap is proposed:

Phase 1 (1 - 2 years)
Conduct detailed feasibility studies and traffic simulations at the four pilot intersections, integrating GIS-based road geometry analysis, stakeholder consultations, and environmental clearances.

Phase 2 (3 - 5 years)
Initiate construction at pilot sites through PPP models, alongside real-time data collection on congestion, emission, and travel pattern.

Phase 3 (5 - 10 years)
Expand to 10 - 15 additional intersections based on impact evaluation and stakeholder feedback, with continuous monitoring to refine design and operational strategies.
The overpass and underpass systems, if successfully implemented, the anticipated benefits might be 65 - 70 percent reduction in intersection congestion, 25 - 30 percent improvement in air quality, and 40 - 50 percent travel time savings. Before adoption, a holistic approach through interdisciplinary collaboration, data-driven simulations, and ground-level testing are suggested to perform in transforming this conceptual model into a viable infrastructure and context-sensitive solution tailored to Dhaka's complex urban dynamics.

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