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POTENTIALS OF PUBLIC BICYCLE HIRE SCHEME (BHS) IN DHAKA CITY

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ABSTRACT

Bicycle hire schemes (BHS) or public bike-sharing scheme (PBSS) are now available in many cities in different countries. However, until 2018 there was no such scheme in Bangladesh. This paper aims to assess the feasibility of implementing BHS in Dhaka city and the major issues that need to be considered for operation and management of BHS. In this study the already existing BHS in six cities in different countries were studied and relevant documents were reviewed to understand the salient features of the scheme as well as the overall operating and management system. Upon understanding of the critical aspects of the BHS from those six cities, the implementation process and tasks required for BHS was assessed with the existing conditions in Dhaka city. A detailed plan of BHS for the case study location was prepared. Questionnaire surveys of bicyclists were conducted to understand their opinions and views about the proposed BHS. Analysis of the strengths, weakness, opportunities, and threats (SWOT) of the proposed BHS was done. Findings of this research could be helpful for implementing BHS in case study location as well as in other areas of Dhaka city and in other similar cities of Bangladesh.

KEYWORDS: Bicycle hire scheme (BHS), coverage, cycling, docking station, transport, transit, trip.

1. INTRODUCTION

Bicycle is considered as one of the alternative transport modes to reduce transport problems (Dey et al., 2014). Promoting bicycling and walking along with restrictions on motorized vehicles could help reducing traffic induced noise and air pollution level as well as traffic congestion of the city (Rahman, 2007). The potential benefits of bicycles are: flexibility, easy availability, and lower cost (TRIPP, 2008). Bicycles are usually inexpensive to build, buy, ride and maintain than other vehicles. Many cities consider bicycle hire scheme (BHS) as a strategy to facilitate short-term bicycle rental in urban areas (Hou & Haddad, 2020).

Bicycle hire scheme (BHS) or public bike-sharing scheme (PBSS) is a system where bicycles are strategically placed in a closely spaced network of stations and offered for public use. The BHS serves as an alternate mode of public transport in which people have access to cycles that can be used across a network of closely spaced stations (ITDP, 2013; Lin et al., 2013). The system usually provides point to point active travel for short distance trips without the need to own a bicycle. The BHS is also termed or called as Smart Bikes, Bikes Hiring, Bicycle Sharing Schemes (BSS), etc. The system enables bicycles to be picked up at any self-serve bicycle station and returned to any other bicycle station, which makes bicycle-sharing ideal for point-to-point trips (NYC-DCP, 2011). For example, an individual can check out a bicycle from

one station with a smart card or other form of identification for a short trip (usually between 30 minutes to an hour) and return it to the same docking point or another docking point within the network (Mateo-Babiano, 2015).

The BHS provides many social, economic and environmental benefits; therefore, it is gaining popularity around the world (Zhang & Mi, 2018; Shaheen et al., 2011; Ricci, 2015). For example, benefits to the users through improved health, increased transport choice and convenience, reduced travel time/congestion and cost, and improved travel experience. They can also help to solve the last-mile problems by providing feeder services to public transport, to increase bicycle use and awareness about BHS as a daily mobility option, to reduce auto use and thus reducing traffic congestion and noise/emissions (Ma et al., 2018; Qian & Niemeier, 2019; Shaheen et al., 2011). ITDP (2013) has specified that BHS may solve the "last mile" problem of transit passengers, may help in developing tourism, generating employment, meeting pollution targets, and targeted modal splits of the city.

Dhaka city is the main administrative, political, financial, and cultural center in Bangladesh. Dhaka is one of the most highly dense megacities of the world where more than 10 million people live in an area of around 1500 sq. km (Rahman, 2013). Population forecast for the Detailed Area Plan (DAP) of Dhaka shows to be 20.19 million in 2020 whilst about 22.21 million and 25.94 million respectively in 2025 and 2035 (RAJUK, 2019). Even though one of the least motorized cities in the world with approximately 30 motorized vehicles per 1,000 residents, existing transportation infrastructure and services in Dhaka city is very poor (Rahman, 2007). Traffic and transportation situation in Dhaka are characterized by heavy congestion and delay, wide gap between transport demand and supply, inadequate or poor infrastructure and traffic management, high accidents, and poor public transport services (Rahman, 2009). Buses are now the backbone of public transport in Dhaka. Among the many problems traffic congestion has become the major concern now-a-days; people need to wait for hours in roads for travel. According to the Revised Strategic Transport Plan for Dhaka (RSTP), about 10-12% of total trips are on non-motorized transport (NMT) modes. People with household monthly income below Tk 20,000, almost 60% of them usually travel on foot (RSTP, 2015). Modal share of trips in some selected roads for DAP study show 28% bus, 25% car, 21% rickshaw, and 26% others (RAJUK, 2019). However, the predicted modal share for 2025 in Dhaka Structure Plan (2016-2035) are: 30% walk, 45% bus, 6.5% rickshaw, 5% car, 5.5% CNG auto-rickshaws, and the remaining are other modes (Structure Plan, 2016).

Annual demand of bicycle in Bangladesh in 2014 was about 500,000 pieces which is about 40% more than the previous three years (Prothom Alo, 2014); reflects the growth of bicyclists' and increasing interest of adopting bicycle as a travel mode. However, the total number of bicycles or the proportion of bicycle trips in Dhaka is yet very low. For instance, even though almost half of the trips (about 51%) in Dhaka city are on NMT, bicycle trips are only around 2% or less whilst the rickshaws are most dominant (Rahman, 2008). There are many reasons why the bicycle trips in Dhaka is very low. For instance, unavailability of the required bicycle infrastructure and therefore safety concern of cyclists, mixed traffic using same road space, social acceptance or cultural aspects of people, high motorization rate, and NMTs are not

prioritized in funding allocation or policy are the major causes for low rate of bicycle trips in Dhaka (Rahman, 2009). However, bicycle is one of the cheapest forms of urban transport - only one quarter of the cost of the bus travel per passenger/km and one-tenth of the cost of the rickshaw travel (Rahman, 2013). Moreover, bicycles are affordable, pollution free (environment friendly), and take very little road space per passenger compared to cars or other modes of travel (RSTP, 2015; STP, 2005; RAJUK, 2019). Therefore, bicycles in Dhaka city could play a very positive role in solving urban transport problems if planned properly and required infrastructure facilities are provided. Moreover, there are good potentials to encourage people for using bicycle in Dhaka (Rahman, 2009; Rahman, 2008). Therefore, having the BHS in Dhaka may help the city to have numerous social, environmental and economic benefits.

The BHS as a concept has been available in different countries for the last 50 years (Meddin, 2015). The scheme has been widely adopted in many cities around the world. More than 800 cities in around 50 countries (as of 2015) across the world have BHS with a combined fleet of more than 900,000 bicycles (Meddin, 2015). However, the purposes of introducing BHS for different cities are not the same. The city of London and New York introduced BHS to promote eco-friendly mode (Mulholland, 2008; Burden & Barth, 2009) whilst in Hangzhou and New Delhi it was for providing the last-mile connectivity of transit users (Shaheen et al., 2011; The Hindu, 2015) and in Paris and Buenos Aires it was to attract more tourists by providing a safe and convenient travel mode for them (Burden & Barth, 2009; Ecobici, 2017).

Nevertheless, there is no BHS operating in Dhaka city. Therefore, it is worth researching the feasibility and potentials of BHS in Dhaka. The main purpose of this paper is to provide a brief understanding about the potentials of implementing BHS in Dhaka city. The specific objectives are: (i) to review the existing BHS functioning in different cities of other countries; and (ii) to assess the feasibility of implementing and operating BHS in Dhaka city.

2. METHODOLOGY

A case study approach was followed. This research is based on both primary and secondary data. A qualitative approach was followed for the analysis. BHS in six different cities were studied and reviewed to understand the existing scenario of BHS. The cities were selected in such a way that they represent the cities of both the Global North (e.g. Europe and USA) and Global South (e.g. Asia). A list of cities having functional BHS in different countries of Asia, Europe and America was prepared. From that list, two cities from Europe, one from North America, one from South America, and two from Asia were selected for detailed study and review. The selected cities are: London, Paris, New York, Hangzhou, Buenos Aires and New Delhi. Detailed review and analysis of BHS in these cities provided brief understanding about existing condition, planning guidelines, cost and marketing policy of the system. After having a thorough understanding about the BHS in these selected cities, a case study was conducted in Dhaka city to assess the potentials of implementing the system.

Empirical data was collected from the case study in Uttara Residential Area of Dhaka city. The case study was done in normal and sunny week days during May-June 2017. A field observation was performed to prepare a checklist and inventory of existing bicycle infrastructure in the case

study location. Moreover, a total 50 bicyclists were selected for in-depth interviews to explore their problems related to cycling and opinions about potential BHS. Besides the interview of cyclists, a detailed discussion with transport professionals and policymakers (e.g. university professor, NGO activist, planner of RAJUK, DNCC and DSCC) were also done. Convenience sampling technique was followed for selecting the policymakers. A a pre-determined questionnaire was used to guide the interviews.

Collected data were analyzed to understand the existing scenario of bicycling, to perform the SWOT analysis, and to explore the possibility of implementing BHS in the case study location. A proposed plan of BHS including the prospective demand for cycle use, location of bicycle parking and docking stations for the study location was provided.

3. REVIEW OF SELECTED BHS OPERATING IN DIFFERENT CITIES

The BHS have significantly grown in many countries during the last decade. This section provides brief summary about the BHS operating in six cities, namely, Paris, London, New York, Buenos Aires, Hangzhou, and New Delhi. Paris has first introduced Vélib' (refer 'bike freedom') – third generation BHS - in July 2007 and almost 7,000 bicycles were initially provided with 750 automated stations (Koning and Kopp, 2014). Now about 20,600 bicycles are available (www.Vélib'.paris.fr); the stations are distributed in every 300m and each station with up to 70 bike posts including a locking system and a card reader (Bikeoff, 2008). A robust technology (as seen in Figure 1) is used and the maintenance staff of the system travel around the city using 130 electrically assisted bikes (Midgley, 2011; Bikeoff, 2008). A deposit €150 is charged by the credit/debit card to protect against the bikes not being returned within 24 hours (Imboden, 2017).

London BHS (also known as 'Santander cycle' or 'Boris bike') was introduced in 2010 with 6,000 bikes and 400 docking stations across the city, and again in 2014 expanded with 2,000 bicycles (Lathia et al., 2012). The scheme was for achieving 400% increase of bicycle ride in London by 2025 (Mulholland, 2008). The coverage of BHS is now approximately 17 sq. miles (44 sq. km), docking stations are either in single-row or double-row (as seen in Figure 2) and the distance between each station is 300-500m (Santander cycles, 2017). There are 27 docking points, 15 or more bikes/spaces, and one payment and registration terminal in each docking station (Mulholland, 2008). The payment is done by debit or credit card, bicycles are sturdy and designed to be used each day for 10 to 15 times (Santander Cycles, 2017).



Figure 1: Robust technology for payment (in Paris)
Source: www.Vélib'.paris.fr



Figure 2: Double-row station (in London)
Source: alamy.com

New York BHS (known as 'Citi Bike'), the largest in USA, was first proposed in 2008 (NYC-DCP, 2011). There are 600 stations placed in every 1,000 feet or 3-4 minutes' walk and served with 10,000 bikes (Citi bike, 2017; Urbica, 2016). Using smart phone apps it is possible to find out the stations with available bikes or open docks (Holloway, 2012). The bicycle is designed with a unisex step-through frame; self-powered LED lights are visible when riding at night (www.citibikenyc.com). The rebalancing team shuttle bikes between full and empty stations using box trucks and bicycle trailers (Kaufman et al., 2015).

Hangzhou BHS started in May 2008 with 61 stations and 2,800 bicycles (Shaheen et al., 2011). Stations are available within 100m distance and each docking point is secured with camera to avoid theft (Babian, 2015). Easy to handle and low-cost cycles are used with card-based payment system (ESCI-KSP, 2016). Hangzhou Public Bicycle Service Development Co. Ltd. was established to integrate the BHS with public transport (Toggenburger, 2016). For the maintenance and operation of BHS system, local government of Hangzhou spends about 60-70 million Yuan each year (Radio, 2014).

Buenos Aires BHS (known as Ecobici) was first opened in 2010 with 72 bicycles and three manually operated stations; in 2017 the system had 3000 bikes and 29 stations distributed in every 650m (EcoBici, 2017). Manual or automated stations are strategically interconnected with 130 km long bike lanes. The stations are actually iron cages (as seen in Figure 3) with no locked terminals where an attendant keeps the records the users' information and helps with check-in or check-out of the bike including the payment; each station has 15 or more bikes (EcoBici, 2017).



Figure 3: Manual station and iron cages (Ecobici)
Source: BA Ciudad, 2013 & algopasabuenosaires.com



Figure 4: Single-row station and shade (Delhi)
Source: Goswami, 2017.

New Delhi Municipal Council (NDMC) established 50 BHS stations in October 2009 to provide pollution free last-mile connectivity for commuters (The Hindu, 2015). Delhi Metro Rail Corporation (DMRC) and Delhi Integrated Multi-Modal Transit System (DIMTS) provided bicycles for hire at metro stations and bus stops (DMRC, 2018). DIMTS introduced 'Planet Bikes' at eight stations along the BRT corridor and 'Rent-a-Bicycle' in three stations, and there are 10 to 20 bikes in each station (ITDP, 2015). Delhi BHS had two phases: the first part is 5.8 km with 5 stations; the second part is 8.7 km with 17 stations where followed cycle rental[1] in 14 stations and cycle sharing[2] system in 3 stations (Halder, 2017). Both manual and automated

1. Operated by a private bicycle rental company for longer trips/usage and the bikes are rented or returned in single location.
2. Technology-based self-service system operated by public transport service provider where users can collect the cycle in one location and drop off in another location.

docking are available, however, the docking point has no lock and an attendant is responsible in each station (DIMTS, nd). The stations are designed with roof (in Figure 4) but maintenance of the cycles and stations are poor (Goswami, 2017).

3.1 Salient Features of BHS Operating in Different Selected Cities

The BHS in six different cities, as discussed above, Paris first adopted BHS scheme in 2007 to make user friendly city to the tourist and promote tourist. Hangzhou BHS was designed as a large-scale initiative to promote cycling for solving last-mile transit problem as well as increasing employment opportunity. Though the standard coverage area of a BHS station is 300m to 350m (ITDP, 2013), the range may change with the size of total population and the density. The European cities (e.g. Paris, London) have BHS maintaining the similar factors such as ITS, system operation, bicycle features, and station etc. New York BHS designed the similar features that are in Paris. Buenos Aires 'Ecobici" promoted both manual and automated docking station which might be useful for developing countries like Bangladesh. Delhi BHS has cycle lane and stations along the BRT line which is quite different from other cities. Though initially solved last-mile transit problems, create obstacles to drop the cycle in the destination. The salient features of BHS in different cities are summarized in Table 1.

Table 1: Salient features of the BHS operating in different selected cities

System	Paris	Hangzhou	New Delhi	London	BuensAires	New York
BHS name	Vélib'	Hangzhou public bicycle	Green bike	Santander bike	Ecobici	Citi Bike
Purpose	Tourist attraction	Last-mile traffic	Promote sustainable transport	Reduce traffic jam & pollution	Promote tourism	Promote eco-friendly transport; mode switch to cycling
Station coverage	300 meter	100 meter	-	300-500 meter	650 meter	1000 feet (300 meter)
Coverage area	Whole city	Whole city	5.8 km (1st phase); 8.7 km (2nd phase)	Whole city	Whole city	55 neighborhood
Number of stations	1451	3000 (initially 61)	5 (at BRT) & 8 (at Metro station)	1900	200	600
Number of bike	15000	70000 (initially 2800)	3800	Started with 6000	3000	10000

System	Paris	Hangzhou	New Delhi	London	BuensAires	New York
Free hire time	30 minutes	60 minutes	-	30 min	60 minutes	45 minutes
Usage fee	After free period, €1 ($1.1) for 1st hour, €3 ($ 3.3) for 1.3 hr, €7 ($7.75) for 2hr	After free period, $0.15 for each hour	Rs 10 ($0.13) for 4 hours & Rs 5 ($0.07) for additional hour	After free period, £2 ($2.45) for every 30 min	Free of cost	$12 per day
Membership fee	-	$ 30	Rs 100 ($1.32)	£90 ($110)	Free of cost	$163
Bill payment system	Debt or credit card	Smart card	Integrated smart card /common mobility card	Debt or credit card	Registration card	Smart card
User interface technology	Yes (smart card readers at station)	Yes (smart card readers at station)	Yes (smart card readers at station)	Yes (smart card readers at station)	Some stations manual & some automated	Yes (smart card readers at station)

All the cities have adopted 2nd or 3rd generation BHS, and the positive role of government towards BHS was remarkable. However, it is often challenging for the government in financing, marketing, operating, and maintenance of the scheme. Even though Hungzhau BHS is operated by own financing and marketing of the government, undoubtedly needed involvement of both public and private sector for success. Nevertheless, it is a rudimentary challenge for developing country cities to adopt BHS based on experience from the Global North.

4. MAJOR FEATURES AND CHARACTERISTICS OF BHS

Existing literature reveal that BHS around the globe has witnessed four different stages of change (see Figure 5). The first generation of BHS was introduced in Amsterdam (Netherlands) in July 1965 (Shaheen et al., 2011); were afflicted by theft, vandalism, unregulated users to pay a deposit and return the bike to a fixed location. The second generation was first introduced in 1993 at La Rochelle of France (ITDP, 2013); regulated through a deposit system where bicycles were unlocked with a coin deposit and refunded on bicycle's return (Shaheen et al., 2011). The third (or current) generation BHS was first opened in Rennes (France) in 1998 (Shaheen et al., 2011). The third generation scheme incorporated advanced technologies for bicycle

reservations, pick-up, drop-off, and information tracking to combat vandalism and theft through the use of GPS technology and secure docking stations (Shaheen et al., 2011; ITDP, 2013). The concept of fourth generation BHS was introduced by Midgley (2011); integrate new technology such as power assisted bikes, solar-powered docking stations and use of smart phone applications for real-time updates.

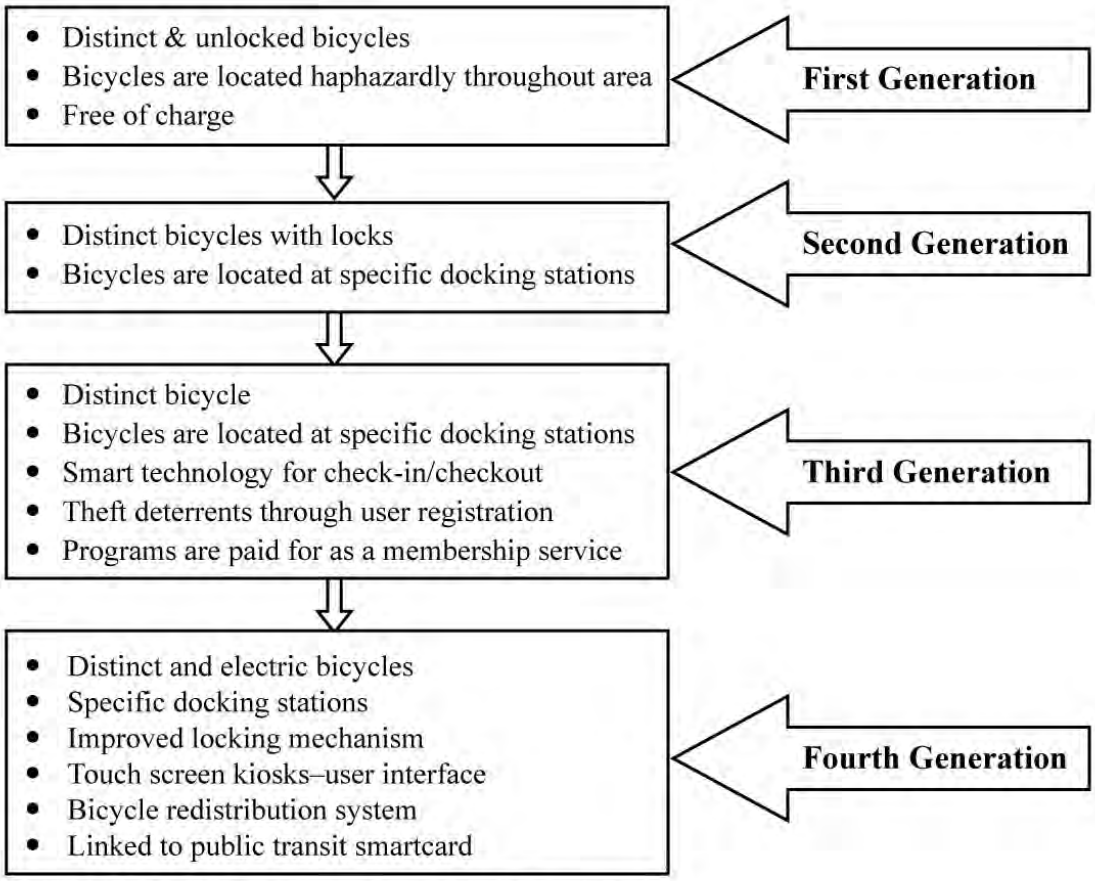


Figure 5. BHS of different generation and their characteristics
Source: Shaheen et al. (2010); Edited by the Authors.

Based on the performance of existing systems of BHS across the globe, ITDP has developed planning and design guidelines or the key characteristics of the systems and outlined in eight guiding elements for BHS (ITDP, 2013; SUTP, 2016). The salient features of the BHS derived from six studied cities, as discussed in previous section, are given below under those eight guiding elements:

i) Coverage Area: The whole city or 10 sq. km with around 10-30 bikes for every 1,000 residents. Small systems do not work (Burden & Barth, 2009). Lin et al. (2013) argue that the system should have sufficient number of stations in right locations so that they are within a convenient walking distance and users can easily find them.

ii) System Size: The dense areas of the city require bicycle-to-population ratio of a minimum of 10 to 30 bikes per 1,000 residents to meet the demand. Each station should carry enough bicycle to avoid frustration when users cannot find a bike (Lin et al., 2013). Successful medium and large systems have 2 to 2.5 docking stations for each bike in service.

iii) Station Guideline: An ideal station density is 10 to 16 stations per sq. km (14 stations per sq. km is equivalent to 36 stations per sq. mile or one station in every 300m). Lin et al. (2013) argue with existing examples that BHS stations should not be located more than 300-500m from important origins and destinations of traffic.

iv) Station Placement: Typical options for station location are on-street parking spaces or vacant space in roadside landscaping strips or areas beneath flyovers and foot over-bridges or private property near large commercial and housing developments.

v) Bicycle Guideline: The bicycle should be 'universal design' and customized, strong but light weight frame with adjustable seat, secure and low maintenance cost.

vi) Docking Style: The docking stations could be of different types; for example, fixed-permanent or fixed-portable or flexible; dockless or docked.

vii) Intelligent Technology Systems (ITS) and Payment Mechanisms: Use of modern ITS such as smart cards to lock or unlock bicycles in docking station, GPS device in bicycles to track the location, Radio Frequency Identification Device (RFID) on the users' smart card to allow making payments, relevant control center and mobile app or website portals.

viii) Redistribution Process: Monitoring of bikes and redistribution to ensure availability of bikes in all stations.

5. RESULTS FROM THE CASE STUDY: POSSIBLE BHS IN DHAKA

This section reports on the results derived from the case study conducted in Uttara Residential area and provides the plan for introducing BHS.

5.1. Cyclists and Cycling Trips

Bicycle trips for most of the respondents are for short distance; for instance, for 21 (42%) of them are within 2 km and for 17 (34%) are 2 to 4 km whilst only for 12 (24%) are longer distance. Bicycle trips for almost 17 (34%) of them are for work whilst for 15 (30%) are for education purpose. Figure 6 shows the typical reasons of existing bicycle users for using their cycle as a travel mode for short trips. A total 44 (88%) of the respondents consider that bicycle is cheaper than any other mode whilst 38 (76%) of the respondents mentioned that by using bicycles they are able to avoid traffic congestion and for 34 (68%) are to fulfilling their travel needs. A very small portion mentioned the causes such as exercise, health or hobby; though surprisingly about 39 (78%) respondents mentioned that they consider bicycle is safer than motorized vehicles.

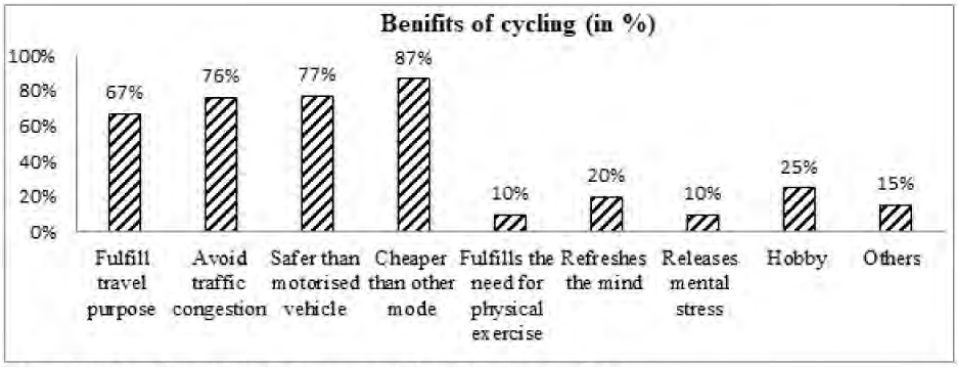


Figure 6. Benefits of cycling reported by existing cyclists

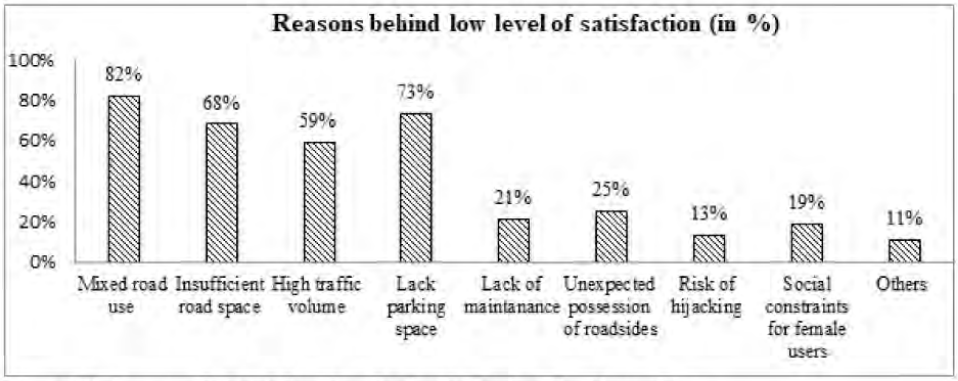


Figure 7. Reasons behind low level of satisfaction for the cyclists

Whatever, 48 (96%) respondents are not satisfied with the existing cycling infrastructure facilities of the city. The major causes for dissatisfaction, as shown in Figure 7, are: mixed road use (82%), lack of parking facilities (74%), insufficient road space (68%). This result, the cycling facilities in Dhaka city is very poor, is similar to the findings of Rahman (2009 and 2008).

5.2. Road Width and Cycling Infrastructure

Roads in Uttara residential area are mostly very wide compared to other parts of the city and they are smooth and well furnished with some basic street furniture (shown in Figure 8). In terms of the width, roads in Uttara are three types, as shown in Table 2.

Table 2. Type of roads and width in Uttara

Type of Road	Width (feet)
Primary	80-100
Secondary	60-80
Tertiary	25-40



Figure 8. A typical secondary road in Uttara R/A

There is no bicycle lane or bicycle parking area available in Uttara residential area of Dhaka. During field observation, it was found that a number of vehicles are parked in the carriage way parallel to the footpath. There is no separate space provided for cycle parking and therefore cyclists often face many problems. Only 6 (12%) respondents are satisfied with the existing bicycle infrastructure whilst 44 (88%) respondents are willing to use the BHS if it is available. A total 29 (58%) respondents reported their willingness to pay an hourly fee of Tk 20 whilst 6 (12%) mentioned Tk 10 and the remaining 15 (30%) respondents mentioned Tk 30 for using BHS. Intelligent technology payment and locking system could be applied using card or smart phone apps. A total 38 (76%) respondents are willing to pay by mobile phone app and the remaining 12 (24%) are willing to pay by card for hiring a bicycle. To prevent cycle theft, certain options would require validating the identity of the bicycle users. For identity validation, 25 (50%) respondents suggested for using mobile app whilst the use of general packet radio service (GPRS) and radio- frequency identification devices (RFID) mentioned respectively by 4 (8%) and 1 (2%) respondents.

5.3. Proposed Planning Guidelines for BHS in Uttara of Dhaka City

Despite having the existing limitations and obstacles of cycling, there are potentials for operating BHS in Dhaka city. In accordance with the features and characteristics mentioned in Section 4, this section outlines the proposed guidelines for introducing BHS in the case study locations considering the socio-demographic and traffic characteristics of the area and Dhaka city.

Coverage Area: The proposed BHS system coverage area in Uttara Residential area is around 8 sq. km.

Number of Docking Stations: A total 50 docking stations for Uttara residential area so that each station covers approximately 1 sq. km. This range of 1 km is similar to the BHS in Delhi. Considering the population in Uttara as of 2011, each station will serve around 3,500 persons within 1 km.

Location of Station and Design: Figure 9 shows the proposed station locations for the case study location - Uttara residential area – in Dhaka city. The key parameters considered for identifying the docking station locations are:

- Close to the recreational places (e.g. park, playground);
- In front of education or administrative institution (e.g. school, college, faculty);
- In the market or close to shopping places;
- The places where usually many people gather; and
- Outside the student hostels or residential hotels.

All the docking stations will be automated station. The proposed design for the docking stations are shown in Figure 10, linear single-row station with a shade for both locations.

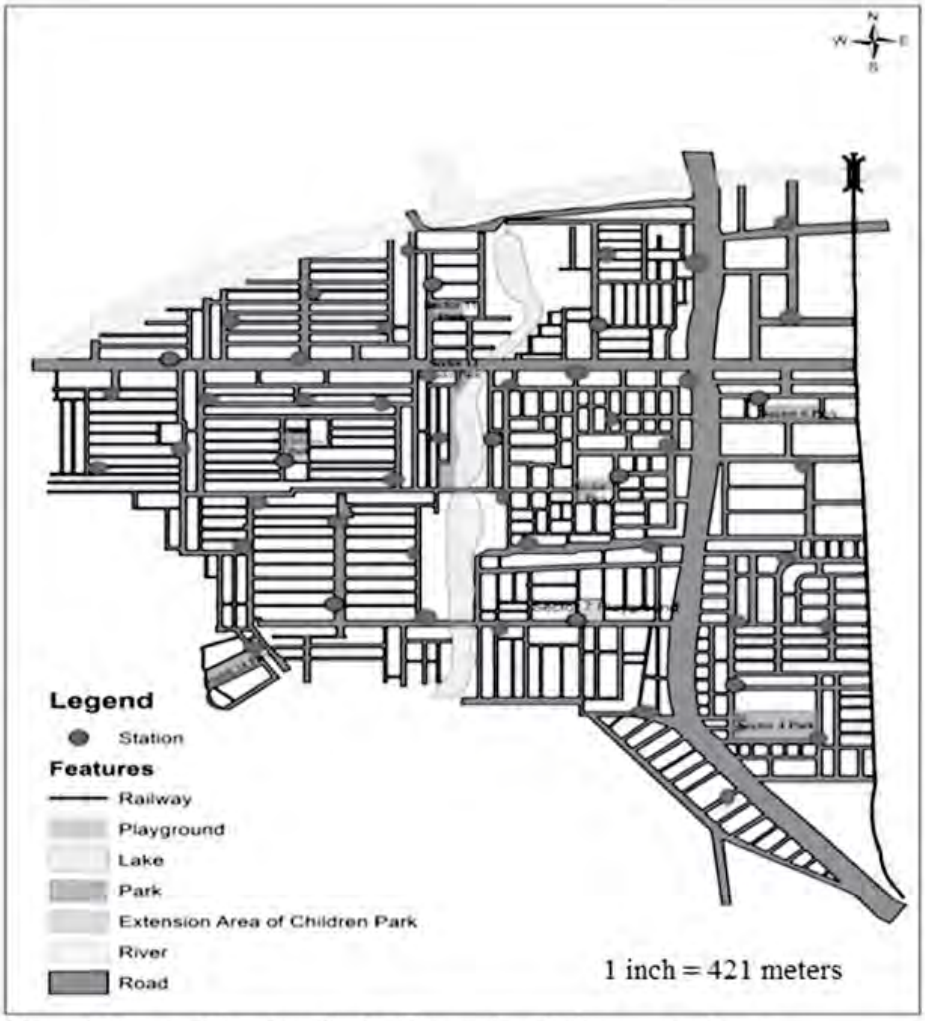


Figure 9: Proposed locations for docking stations in the case study area



Figure 10. Proposed design of docking station for the study area
Source: Adopted from Centre for Green Mobility (2015) by authors.

BHS System Size: Each station will have, as suggested by ITDP (2013), at least 15 cycles and 22.5 docking stations (1.5 docks for each bike in service). Thus, the scheme at Uttara will have 750 cycles.

Bicycle Guideline: Unisex frame and adjustable seat positioning, light load carrying front basket, rear and front lights, and GPS enabled bicycles to avoid vandalism.

Redistribution Process: Five redistributing vehicles are proposed for Uttara so that each of them could serve around 12-15 stations.

ITS and Payment Options: Two payment options are proposed, one for visitors (or occasional users) and the other for the regular (or annual) users, as shown in Figure 11 Modern ITS are suggested. Occasional users will able to use bicycle with mobile applications. With the specific mobile app, they would able to check the availability of cycle in any given station and could send text massage for hiring a cycle. The user will receive a pin number to unlock the bicycle from docking station. The fees applicable for using BHS will be deducted by the operator automatically from the balance of mobile user. During the unlocking process, the user will require to perform two tasks: (i) to provide NID number through bar code reader for identification, and (ii) to insert the pin number which received in the mobile massage before unlocking a bicycle. On the other hand, the annual user needs to be registrated with his/her NID number, a passport size photograph and a deposit of Tk 500 per year. Every registered member or annual user must have a unique pin number with which able to unlocking the docking station for collecting a bicycle.

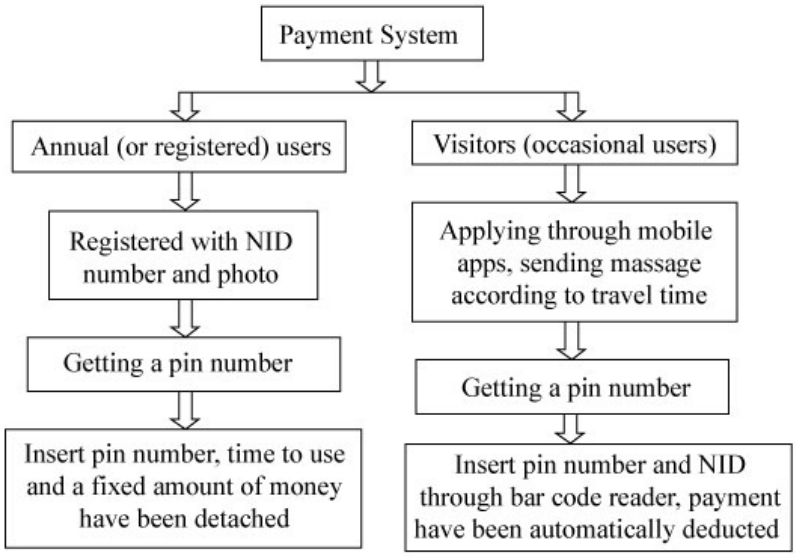


Figure 12. Proposed payment process for the study area

Operational Model and Marketing of BHS: The operation of BHS in different cities are usually run on different business model or arrangements between the government (or local authority), operators (business entity or private sector) and the advertising partners. This arrangement mostly depends on the local context (particularly the socio-economic and political or governance aspects), technical capacity of the operator or city authority to run the system, experience of the government in PPP projects, and so on. Dhaka North City Corporation (DNCC) could play a very important role as an operating entity as well as maintaining the BHS in Uttara residential area. The private organizations (e.g. transport providers, bicycle clubs or manufacturers, IT developer, advertising agencies, financing partners, etc.) could also play a pivotal role in implementing and managing the BHS. Moreover, DNCC authority could also outsource private agencies for providing BHS in respective locations.

A well planned and designed bicycle share system requires befitting identity and good promotion for better and successful implementation. Therefore, the BHS for Dhaka city would require to consider the following aspects:

- Colorful texture with the name logo and tag line in bicycle and docking stations;
- Strong involvement of electronic and print media for publicity campaign and thus awareness generation of mass people about sustainable transport and the role of bicycling; and
- Political influence or support from the top of the respective authority to support the scheme.

5.4. Estimated Cost for Proposed BHS

The system cost for proposed BHS has been calculated considering the cost of equipment, infrastructure, information technology system, control centre, preparation of website, etc. The average cost based on Center for Green Mobility (2015) was considered. The estimated capital cost for the proposed BHS are shown in Table 3.

Table 3: Estimated capital cost for proposed BHS in Uttara residential area of Dhaka city

Item or Category	Unit Cost (Tk)	No. of Unit	Total Cost (Tk)
Bicycle	16,536	750	12402,000
Station	53,300	50	2665,000
Barcode Reader	2,900	50	145,000
Control center	4193,800	1	4193,800
Website	260,000	1	260,000
Redistribute Vehicle	1040,000	5	5200,000
Total			24865,800

Source: Center for Green Mobility (2015) and modified by Authors.

5.5. SWOT Analysis for Implementing BHS in Dhaka City

It is important to understand the possible strengths, weakness, opportunities and threats (SWOT) of BHS scheme, the planning guidelines provided in Section 5.3, before implementing in the case study location of Dhaka city. Table 4 shows different aspects of SWOT analysis. There are sufficient road spaces available in the study location for providing docking stations. There are wide roads or open space in front of the schools or shopping malls or parks and playgrounds in

Uttara residential area where mass people usually gather. Once the public will be informed about the scheme, they will be willing to use the bicycle service. The bikeshare scheme was explained to the respondents and almost all of them showed willingness to use the BHS service. Moreover, the BHS would be very helpful for the commuters using public transport as access or egress mode. However, the main challenge for BHS in Dhaka is the absence of cycle lane, lack of space for bicycle parking, and infrastructure related to cycling. Not having separate cycle lane or cycling related infrastructure may increase the likelihood of accident occurrence. Even though many modern ICT gadgets are widely available now-a-days and people in Dhaka are using those, yet a very little portion is using these technologies for travel purpose. The initiatives from the government to improve cycling infrastructure and increase the proportion of cycle trips in Dhaka is not yet visible. Moreover, the cost of a bicycle required for BHS is comparatively higher than the conventional one.

Table 4. SWOT analysis for implementing BHS in Dhaka

STRENGTHS	▪ 36 (72%) of the respondents perceive that cycling is safer than motorized vehicles. ▪ 16 (32%) of the respondents use cycle for work trips whilst 15 (30%) for education. ▪ 43 (86%) of the respondents are willing to use BHS. ▪ Sufficient space are available beside roads in front of the park or open space, where many people gather, for docking station. ▪ Smart phone with internet access is available for many people. ▪ People using smartphones will be capable to use mobile applications for BHS easily.	▪ No strategic plan of transport agencies or city authority for having BHS. ▪ Lack of separate bicycle lane; very limited initiatives from government for separate bicycle lanes. ▪ Lack of cycling friendly infrastructure and environment. ▪ Lack of cycle parking facilities; 36 (72%) of the respondents consider bicycle parking are unsafe. ▪ Unwillingness of middle and higher-income groups for using bicycle. ▪ Many people cannot use or not aware using IT system.	WEAKNESS
OPPORTUNITIES	▪ Environment friendly and cheaper mode; provide quick and easy access in congested areas. ▪ Reduce dependency on motorized vehicles, traffic congestion and pollution. ▪ Possible to integrate with BRT and Metro, thus make transit users self-dependent for feeder mode by providing access &/ egress legs. ▪ BHS system can generate few employments. ▪ Reduce travel cost and time for short distance. ▪ Provide easy access for visitors/tourists.	▪ Possible vandalism and stealing of cycle. ▪ Weather condition is not conductive for cycling too long. ▪ High initial investment required for implementing BHS. ▪ Inadequate/inappropriate knowledge in using information technology (e.g. GPS, RFID, Smart card etc.). ▪ Challenges for common people in using docking station to unlock bicycle. ▪ Increased number of road accidents due to not having bicycle lanes.	THREATS

Nevertheless, there are opportunities to introduce BHS in Dhaka city. The BHS may help people of the middle and lower-income groups by enabling them to save travel time and reducing costs related to travel. This is clearly evident, as the field survey data showed, bicycle as a travel mode is mostly used by people of lower and lower middle-income groups. Moreover, BHS would able to provide last-mile services to the transit users, as the construction of BRT and Metro is on-going, when they are integrated properly.

6. DISCUSSION

Even though there are some barriers such as absent of cycle lanes and inadequate parking space, warm and humid weather condition not conducive for cycling, absent of modern IT application in transport sector, etc. for cycling in Dhaka city; there are much potential to promote cycling and introducing BHS. Many other cities in the Global South such as New Delhi and Buenos Aires have already implemented and operating BHS successfully despite having cycling related problems that are very similar to Dhaka city. Moreover, the weather condition and socio-economic situation of people in Dhaka are almost similar to the weather and socio-economic conditions in Delhi. The docking stations of BHS in Delhi and Buenos Aires are designed with roof/shade because of humid/warm weather condition (to protect from extreme weather events such as rain, storm, heat of sun) whilst most of the docking stations in London, New York, Hangzhuo and Paris are without a shade or roof.

Almost in all the cities having BHS have a city-wide network of separate bicycle lane. However, yet there is no such separate bicycle lane in Dhaka - which is one of the major drawbacks for promoting bicycling and perhaps introducing BHS. Nevertheless, there are a few cities in Asia where BHS is already implemented and the bicyclists usually share the same road space or lane with other traffic (operate in mix-traffic environment). Supporting IT system for operating, maintenance and payment procedure of BHS are directly linked with modern technical aspects which may not be possible for all the cyclists or users in Dhaka to learn easily or cope with the system very quickly. However, as a large number of people have access to mobile phones and internet facilities, they would able to learn how to use the mobile app to unlock the bicycle from docking station within a short time.

Introducing and implementing wide scale BHS in Dhaka city may provide opportunity for providing transport access to many people, last-mile services for transit users, and promoting modal share of bicycle trips. Qian and Niemeier (2019) showed that locating stations in proximity to disadvantaged communities has potential to increase household access (by bike and bike-to-transit) to jobs and essential services and can close accessibility gaps between mobility constrained populations and critical services. Effective public participation from all strata of the society in planning, designing and implementing BHS is very crucial for the success. BHS would improve travel experience of public transit users by providing last-mile services. The metro and BRT systems are expected to be operating in Dhaka within few years. Thus, the city would have scope for reducing traffic congestion and air pollution from transport sector. There are potentials for integrating BHS with the metro and BRT systems, however, further detailed studies are needed on this topic.

However, transferring the salient features of BHS and the lessons learnt from the system that are operating in other cities in Bangladesh contexts should be done with high cautious. Without considering the socio-economic condition of city dweller as well as location-specific detailed analysis of transport infrastructure and built environment, traffic characteristics, behaviour pattern of people, and governance system of local administration would be risky to implement.

The location and spatial distribution of docking stations is one of the key factors for successful BHS. A large portion of trips in Dhaka city are for short distance and many people take a rickshaw ride even for a trip less than 500m (Rahman, 2013), therefore, the docking stations need to be placed sufficiently close to home or work and other frequent destinations. Very high density of population in Dhaka is another challenge for BHS and also opportunity. It is important that the system guarantee the availability of bicycles (Lin et al., 2013). Due to high density the system would require many stations and docks in the station as well as quick efforts for redistribution of bicycles among the stations. Having more docking stations would increase investment costs as well as operating costs.

This research had few limitations. The sample size for interview of the existing cyclists is not big (50 samples) and there was no female respondent. Given that the modal share of bicycle in Dhaka is less than one percent and the number of women cyclists is very few (Rahman, 2009), it is not surprising that all the 50 cyclists are male. However, the responses from cyclists are not the main part of this research (a supplementary to validate or cross-check the information), and in-depth discussion with experts was done to support and validate the information. Uttara is a planned residential area for higher or higher-middle income groups, therefore, it would be wise not to generalize the findings of this research for other parts of the city or for all the socio-economic groups of the society.

7. CONCLUSION

The concept of BHS has existed for almost 50 years, however, only in the last decade they have significantly grown around the globe. The BHS are increasingly popular in many countries because of its social, environmental, and transport benefits. In many cities around the globe there are BHS. The enormous growth of BHS all over the world in the past ten years has done a great deal to encourage the bicycle as the mode of choice for urban commuting (ITDP, 2013). The BHS can serve as an alternative mode of public transport where people have access to cycles that can be used across a network of closely spaced stations. Many countries have already adopted this scheme with positive experience. However, yet there is no BHS in Bangladesh.

The main purpose of this paper was to assess the possibility of implementing BHS in Dhaka city. Knowing the salient features of BHS and operational experience from other cities might be helpful for Dhaka or similar other city to implement BHS by modifying some of the features so that they are fit with the local contexts. Therefore, review of BHS operating in six different cities were done and empirical study was conducted in Uttara residential area of Dhaka city. Based on the review results and empirical data from the case study location as well as considering the socio-economic condition and traffic situation, detailed guidelines are provided for implementing BHS.

Results from the case study and the SWOT analysis reveal that there are potentials for implementing BHS in Dhaka city. However, there are several challenges which need to be addressed before introducing BHS. It was found that most of the respondents, the existing bicycle users in Dhaka, are very willing to use the bicycles of BHS if the system is available. The BHS could help reducing several transport problems of the city such as air pollution or congestion, and thus contribute towards achieving sustainable urban transport to make the city livable. However, transferring the lessons learnt from BHS operating in other countries to the Bangladesh contexts should be done with cautious. Without considering local contexts such as socio-economic condition, built environment and traffic characteristics, behaviour of people, financing and governance system of local administration and the location-specific detailed analysis of BHS would be risky to implement. Therefore, first need to overcome the obstacles and uncertainties of BHS including the weakness and threats of cycling for the city.

This paper provides new knowledge and suggestions for implementing BHS in Dhaka city which may greatly enhance the use of bicycles. The findings would be helpful for implementing BHS in other cities (in Bangladesh or other countries) similar to Dhaka. Further research could be on cost benefit analysis of BHS, public perception about BHS, the extent to which BHS can improve transport access of poor people and in disadvantaged communities, changes in modal share and travel behavior due to BHS, integrating BHS with other modes such as metro or BRT systems.

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