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Open Transport Development and Integration of ICT and Transport

Final Report

August 2015

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integrated transport planning

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Document Control Sheet

Project Name	Open Transport Development and Integration of ICT and Transport
Client	World Bank
Project Code	1442
Project Manager	Neil Taylor
Project Director	Peter Armitage
Start Date	1st January 2015
Project Folder	F:\1442\
Team Members	Colin Brader, Peter Armitage, Neil Taylor, Ian Stott, Mark Dimond
Sub Consultants	Conveyal

Ver	File name	Description	Prepared	Reviewed	Approved	Date
3-0	F:\1442\Project Files \ Deliverables\FinalReport_v2-0.doc	Final	NT	CB	CB	25/01/16
2-0	F:\1442\Project Files \ Deliverables\FinalReport_v2-0.doc	Draft Final	NT	CB	CB	18/12/15
1-0	F:\1442\Project Files \ Deliverables\FinalReport_v1-0.doc	Client Submission	NT	CB	CB	25/08/15

Notice

EXECUTIVE SUMMARY

Integrated Transport Planning Ltd. (ITP) worked in partnership with the World Bank to support the Dhaka Transport Coordination Authority's (DTCA) efforts to take on new organizational responsibilities for transportation policy, regulation, coordination, planning and management for the Greater Dhaka. Open source software tools for editing public transport data using the open General Transit Feed Specification (GTFS), and accessibility-mapping, were provided in conjunction with hands-on training delivered in Dhaka as a means of building capacity among the DTCA and RAJUK (Dhaka Improvement Agency) teams against the following defined objectives:

- Assisting DTCA with data management and transport planning.
- Providing technical tools and training to build capacity among colleagues at DTCA.
- Deploying an accessibility-mapping tool for use in Dhaka.

The analysis contained in this report was undertaken on a pilot basis, with the aim of providing Dhaka and other cities with policy guidance and planning tools that facilitate the integration of accessibility planning into urban and transport planning processes. The pilot analysis seeks to demonstrate the capacity and benefit of accessibility analysis tools through sample results.

Activities delivered through the project

The project ran from January to August 2015, and involved the following activities:

Objective	Activities	Timing
Assist DTCA with data management and transport planning	• Review of DTCA's transport data and ICT capacity needs to inform remainder of study	Jan-Feb 2015
	• Develop and implement a Transport Data Hub to aid local transport data storage and sharing	Jun-Jul 2015
Provide technical tools and training to build capacity among colleagues at DTCA	• Workshop training sessions on using transport data for evidence-based transport planning	Feb, Apr, Jul 2015
	• Set-up GTFS Editor tool for DTCA and provide training to DTCA colleagues so they could use the tool independently to maintain GTFS data	Feb-Jul 2015
Deploy an accessibility-mapping tool for use in Dhaka	• Set-up Transport Analyst tool for Dhaka and provide accessibility mapping training to DTCA	Mar-May 2015
	• Use Transport Analyst to estimate accessibility impacts of planned BRT and MRT investments	Jul-Aug 2015

The project was highly collaborative, and involved a total of six 'hands-on' training workshop sessions delivered for DTCA across three site visits to Dhaka. These were supplemented by meetings with smaller groups to collate relevant datasets and explain the purpose of the project.

The key outputs delivered through the project were:

- A detailed review of DTCA's transport data needs relating to the Greater Dhaka area, taking into account datasets gathered for research projects supported by donor banks.
- A thematic catalogue of all datasets currently held by DTCA and RAJUK that are relevant to travel demand and transport in the Greater Dhaka region.
- A Transport Data Hub, hosted using Dropbox cloud storage until July 2018, with access shared between DTCA and RAJUK team members to provide a central repository for transport data collected through major transport projects in the city.

- Training and capacity building for the DTCA and RAJUK on the topics of open transport data, strategic evidence-based transport planning, accessibility modelling, and use of the GTFS Editor and Transport Analyst software tools.
- A set of GTFS feeds that model, at a high-level, the current operation of public transport services in the Greater Dhaka region, as well as all planned BRT and MRT routes that are yet to come into operation.
- Open access to the GTFS Editor and Transport Analyst software tools until September 2016. Neither of these tools tie DTCA and its local partners to a proprietary set of data formats or software providers. Both allow for open datasets to be exported and used in other transport modelling and GIS software tools.
- A set of draft open data sharing and collaborative working agreements based on those implemented in other similar cities.
- Analysis of public transport accessibility levels for a range of scenarios in Greater Dhaka, covering current bus networks and the planned delivery of all BRT and MRT routes in the city. All three scenarios were also contrasted on the basis of estimated levels of public transport accessibility for female residents of Dhaka, drawing on prior social research conducted by the World Bank.

Key project outcomes and findings

The project's findings can be separated into two broad strands: those which relate to the delivery of capacity building with the DTCA and RAJUK teams in Dhaka, and the findings from the accessibility modelling work by the project team.

The **capacity building** work delivered through this project has resulted in DTCA being able to share all of its transport data with local partners, and most significantly RAJUK. DTCA also has the option to extend access to other local partner agencies and consultants, and/or share commonly requested data files more publicly via its website. The DTCA team plans to upload datasets from current projects, such as BRT3 and MRT6, into the Data Hub structure established through this project. Consequently colleagues at DTCA and RAJUK are now better placed to take independent responsibility for transport data management in Dhaka, and support international donor bank efforts to improve the city's transport networks. This is underpinned by a clearer understanding of the range of open data formats relevant to urban transport systems, and the approaches other city authorities have adopted to open up their transport datasets (and the benefits of doing so).

The dedicated training relating to the GTFS Editor and Transport Analyst tools has given the teams at DTCA and RAJUK the skills they need to manipulate the Greater Dhaka GTFS data feeds created through the project, and apply them (alongside accompanying GIS data) to perform accessibility modelling analyses and visualisation. Applying this learning will enable DTCA's team to rapidly prototype and model the accessibility impacts of larger numbers of potential new transport lines (or reorganised bus networks), prior to investing time and resources in more detailed travel demand modelling that informs prioritisation of transport network improvements.

Findings from the **accessibility modelling** work delivered through this project demonstrated that current public transport accessibility levels are very low. By virtue of their faster operating speeds, and dedicated running lanes, the proposed BRT and MRT lines are expected to significantly increase the levels of public transport accessibility in the city region. When completed, all of the planned BRT and MRT lines will increase by around 30% the number of people living in the Dhaka

Metropolitan Area who can access Motijheel in Dhaka within 90 minutes by public transport and walking. Over 76% of the metro area's population will live within a 90 minute walk and PT journey of Motijheel, compared with 59% currently.

Estimated impact of BRT and MRT on the number of people who will live within 90 minutes of Motijheel by public transport

Scenario	Whole population
Base scenario	5,226,461
Base scenario + BRT	6,503,827
Base scenario + BRT + MRT	6,780,366

Prior research evidence suggests women are far less likely to use the existing network due to the threat of harassment and abuse. This study tested two different methodologies for estimating female accessibility using a reduced travel speed, and population-based estimates derived from best-available total population numbers. Based on these analyses it is possible to estimate that:

- Between 31% and 34% of the 3.7 million females who reside in Metro Dhaka are currently able to access Motijheel within 90 minutes travel time by public transport + walking.
- This is projected to increase to between 50% and 77%, depending on methodology used, of all females in Dhaka once all planned BRT and MRT routes are introduced.

The planned BRT and MRT lines are therefore expected to significantly narrow current public transport accessibility inequalities in Dhaka. Females will benefit from comparable levels of accessibility along the alignments of planned new routes – particularly in the direction of Mirpur, Kuril, Shymoli, and Gabtoli.

Opportunities for follow-up activity in Dhaka

This report identified the following potential 'next-step' activities for DTCA and RAJUK to apply the new capabilities they have developed through the course of this project:

- Using the existing GTFS datasets developed through this project to support additional practically-focused tasks. This could include modelling the impact of proposed BRT and MRT lines on local access to healthcare and education facilities, and employment opportunities. It may also involve establishing public transport accessibility benchmarks to key destinations in Greater Dhaka (% of population within a defined travel time by public transport to Farmgate) as a means of measuring the impact of future transit network and population distribution changes.
- Using the ongoing bus network reorganisation activities in Dhaka to update the GTFS feed for current and future bus-based public transport routes. An improved current GTFS dataset could be released publicly for consumption by online journey planning tools, while the more accurate future scenario could be used as the basis for detailed public transport accessibility appraisal to help prioritise the order of network reorganisation.
- Using the editing and analysis tools to capture other modes of transport in addition to buses, in particular the water-based transport that exists in Dhaka. Many different transport modes are supported by the GTFS specification, and analysis of their availability is possible using the tools provided.

- Facilitating a more integrated urban planning process to understand the transport implications of proposed new and master-planned developments, for example estimating the total population within a given travel time of a proposed scheme or land-use.
- Creating an open data webpage to facilitate the open sharing of key transport datasets. This would help to maximise the value of the Dhaka Transport Data Hub by increasing transparency and public engagement in transit reorganisation, encourage third parties (e.g. app developers) to create bus maps and journey planners for the city, reduce the amount of time DTCA spends responding to public requests for datasets.
- Developing proactive transport data collection regimes to ensure datasets collected through the course of strategic transport planning projects in Dhaka (STP, DHUTS, bus network reorganisation) are regularly updated for monitoring and operational improvement purposes.
- Migrating data onto the Transport Data Hub to the DTCA server when it becomes available, leveraging the thematic folder structure developed through this project.

In considering these potential next steps there is a need to recognize a change in the project environment. At the time of this project's inception the World Bank was preparing Dhaka BRT Line 3 project, which is expected to provide further capacity building training opportunities and support for DTCA, including on accessibility analysis and data management. By the time of preparing this final report, the BRT project has been dropped.

Lessons learned for successful replication

A number of lessons learned through this project will be relevant should World Bank or DTCA choose to replicate its outcomes in other locations. A common theme running through the lessons learned relates to ensuring software tools such as GTFS Editor and Transport Analyst are deployed in contexts where there is:

- A clear understanding of the local need for improved public transport data to power strategic transport planning and public information tools.
- A near-term strategic transport planning objective (in the case of Dhaka, planned BRT and MRT lines) against which the significant up-front effort needed to collate and edit public transport data can be aligned.

The willingness among local teams to take responsibility for maintaining, and exploiting such datasets after the project is complete. Broader lessons learned, which have been highlighted throughout this report, include:

- That significant effort and cross-government commitment is required if the high-level GTFS feeds used for this project are to be taken forward and used as the basis for digital public information services in the future.
- Involving important local stakeholders in project decision-making helps to secure their buy-in at key junctures of the project (for example when determining how to host open transport data) and the commitment of financial and staff resources that are needed to support a longer-term data strategy.
- That robust and ongoing data collection efforts would significantly improve the quality of baseline information that is available to support projects of this nature. The data hub established as a rudimentary by-product of the capacity building-focused TOR covering

ITP's involvement has potential to serve as a repository for all datasets created through public transport investment projects that are currently being undertaken in Dhaka.

- That intermediate technology solutions – such as the Dropbox data hub and file saving protocols developed in partnership with DTCA colleagues through this study- can provide a quick-launch option for more complex data-sharing platforms and approaches in the future.

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GLOSSARY OF TERMS AND ACRONYMS

ADB	Asian Development Bank
ALG	International consulting firm responsible for Dhaka bus reorganisation study
AVL	Automatic Vehicle Location
BBS	Bangladesh Bureau of Statistics
BRT	Bus Rapid Transit
BRT3	Bus Rapid Transit Line 3 (under construction in Dhaka)
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
DHUTS	Dhaka Urban Transport Network Development Study
DIY	Do-It-Yourself
DOTC	Department of Transport and Communications (Philippines)
DTCA	Dhaka Transport Coordination Authority
GB	GigaByte
GIS	Geographical Information Systems
GTFS	General Transit Feed Specification
ICT	Information and Communications Technologies
ITP	Integrated Transport Planning Ltd.
KOICA	Korea International Cooperation Agency
MRT	Metro Rapid Transit
MRT6	Metro Rapid Transit Line 6 (proposed for Dhaka)
NAS	Network Attached Storage
NMT	Non-motorised Transport
O-D	Origin – Destination
OSM	OpenStreetMap
PT	Public Transport
QGIS	QGIS is a piece of open source Geographical Information System software
RAJUK	Rajdhani Unnayan Kartripakkha
RSD	Road Standards Department
.SHP	Shape files, used by GIS programmes
STP	Sustainable Transport Plan (for Dhaka, prepared in 2005)
Tb	Terabyte

1 INTRODUCTION

1.1 Integrated Transport Planning Ltd. (ITP) was appointed by the World Bank to work with the Dhaka Transport Coordination Authority (DTCA) and support its efforts to take on new organizational responsibilities for transportation policy, regulation, coordination, planning and management for the Greater Dhaka. To achieve this, the project team deployed an accessibility-mapping tool, and provided technical tools and training in order to build the capacity of the DTCA team in relation to:

- Using the General Transit Feed Specification (GTFS), and associated open source software tools, as the basis for maintaining a record of all public transport routes and services in the Greater Dhaka region.
- Transport data management good practices that enable the DTCA team to take ownership and coordinate responsibility for transport datasets currently spread across team member's laptops and local/international consultancy teams.
- Using the open source Transport Analyst software tool as the basis for visualising public transport accessibility in Dhaka and evaluating the impacts of new routes/scenarios, as well as visualising reported inequalities in public transport access for females.

1.2 The project represented a pilot from which the project delivery team was aiming to learn key lessons to aid replication of the tools, techniques, and capacity building activities in other country contexts. The project was started when a separate investment project for Bus Rapid Transit was being prepared, having DTCA as the common counterpart. The expectation of the team, and DTCA, was to include an activity in the BRT project to build the capacity further to operationalize and scale up the use of the tools on which this project provided support.

1.3 Later the preparation for the BRT was suspended due to several reasons. While there are no other efforts ongoing at this moment, it is expected that DTCA will take the initiative further through activities funded by international donors or by Government of Bangladesh itself.

Purpose and structure of this report

1.4 This final report sets out the key findings from this project, and has been structured around the following sections:

- Chapter 2 provides an overview of the project's objectives and the methodology adopted by the project team to address them.
- Chapter 3 summarises the capacity-building activities delivered by the project team through collaborative working with colleagues at DTCA and other transport agencies in Dhaka. It highlights process learning recommendations that may be relevant for future similar projects in other locations.
- Chapter 4 presents our analytical findings, conclusions, and recommendations in respect of females' accessibility in Dhaka and the impact of Bus Rapid Transit (BRT) / MRT (Metro Rapid Transit) line proposals being implemented.

- Chapter 5 summarises conclusions and recommendations drawn from this study, including possible next steps for supporting further open transport data capacity building within the DTCA team.

2 PROJECT OBJECTIVES AND METHODOLOGY

Project objectives

2.1 The overarching objective for this project was to assist DTCA by helping the organisation's small transport planning team to build in-house capacity related to its new organizational responsibilities for transportation policy, regulation, coordination, planning and management across Greater Dhaka. Three interrelated sub-objectives were set out in the World Bank's Terms of Reference for the project. They were to:

- Assist DTCA with data management and transport planning.
- Provide technical tools and training to build capacity among colleagues at DTCA.
- Deploy an accessibility-mapping tool for pilot use in Dhaka.

2.2 The common thread linking these tasks was a commitment to data-driven transport planning and coordination efforts, and in particular the use of Open Data sources to help reduce the cost and effort associated with maintaining key urban transport datasets.

Methodology

2.3 The project particularly focused on developing knowledge, understanding and skills around evidence-based approaches to coordinating, planning and managing public transport services in the region. It drew on previous research, conducted on behalf of the World Bank by the consultants ALG, which set out bus network reorganization proposals designed to accommodate forthcoming Bus Rapid Transit (BRT) and Metro Rapid Transit (MRT) lines that were being planned and constructed in Greater Dhaka in 2015.

2.4 The project team's approach for building capacity around open transport data in Dhaka involved a high degree of collaboration and engagement, working in-country with the DTCA team. This was necessary both in terms of understanding the team's existing capabilities, as well as determining the value they placed on specific open transport data opportunities we were able to identify.

2.5 Table 2-1 summarises the activities conducted in relation to each of the project objectives listed above. These activities are discussed in more detail in Chapter 3.

Table 2-1: Delivered project activities mapped to objectives

Objective	Activities	Timing
Assist DTCA with data management and transport planning	• Review of DTCA's transport data and ICT capacity needs to inform remainder of study	Jan-Feb 2015
	• Develop and implement a Transport Data Hub to aid local transport data storage and sharing	Jun-Jul 2015
Provide technical tools and training to build capacity among colleagues at DTCA	• Workshop training sessions on using transport data for evidence-based transport planning	Feb, Apr, Jul 2015
	• Set-up GTFS Editor tool for DTCA and provide training to DTCA colleagues so they could use the tool independently to maintain GTFS data	Feb-Jul 2015
Deploy an accessibility-mapping tool for use in Dhaka	• Set-up Transport Analyst tool for Dhaka and provide accessibility mapping training to DTCA	Mar-May 2015
	• Use Transport Analyst to estimate accessibility impacts of planned BRT and MRT investments	Jul-Aug 2015

Learning objectives for DTCA and RAJUK

2.6 A set of learning objectives were defined for DTCA and RAJUK colleagues in relation to the capacity building aspects of this project. They are set out in Table 2-2 and have been used as the basis for determining the impact of the project in order to understand the outcomes they enable colleagues at DTCA and RAJUK to achieve using transport data stored in the Data Hub created through this project.

Table 2-2: Project learning objectives for DTCA and RAJUK

Learning objective	Project activities	Intended outcomes
Understand the importance of data, and data management for evidence-based transport planning	• Training on use of data • Review of available data • Collation of datasets • Transport Data Hub	Enable DTCA and RAJUK to jointly maintain the Data Hub established through the project, and strategically collect data through ongoing projects
Use web-based tools to create and manage a GTFS feed	• Training on open data • Set-up GTFS Editor tool • Training on GTFS Editor	Add value to collated data by editing GTFS models of transit in Dhaka - adding BRT and MRT. Learn about the role GTFS in powering online journey planners
Use common transport datasets to undertake accessibility mapping and modelling for Dhaka	• Training on accessibility modelling • Set up Transport Analyst • Training on using Transport Analyst	Use GTFS and population data files in the Transport Analyst tools to model and visualise the public transport accessibility of different areas of Dhaka
Understand and interpret the outputs in order to evidence the impact of transport network proposals	• Training on Transport Analyst • Presentation of results from accessibility modelling activity • Group interpretation of projected impacts of all planned BRT and MRT lines on accessibility levels in Dhaka.	Interpret visualised accessibility modelling outputs in order to appraise the projected travel time, and connectivity impacts of major public transport investments like the BRT and MRT lines being developed in Dhaka

3 CAPACITY BUILDING ACTIVITIES AND PROCESS LEARNING

3.1 This chapter has been structured around the key project tasks delivered by the project team over the course of the study. As well as detailing the approach used to deliver each capacity building activity, the tools and resources established for use by the DTCA team in Dhaka have been thoroughly documented and explained.

Throughout the chapter we have picked out key process learning recommendations, which may be of value in the context of successful replication for similar efforts in other contexts, in green text boxes like this one.

DTCA transport data review and ICT capacity needs assessment

3.2 Before first travelling to Dhaka, the project team reviewed all available data received from the DTCA via colleagues at the World Bank. This included the Dhaka Bus Network and Regulatory Reform Implementation Study and Design Work Final Report (2012) and previous World Bank gender equality studies related to transport (2000 & 2003). Accompanying GIS data files (in .SHP format) were also reviewed to understand the scope and scale of existing public and private bus services that operate in Greater Dhaka. This dataset was compiled from geospatial bus route data, and operational insights, gathered as part of the ALG report on bus reorganisation in Dhaka (2014).

Transport data and ICT capacity needs assessment

3.3 A collaborative review of DTCA's transport data and ICT capacity needs was completed early in the project. It was contextualised by DTCA's planned evolution, and strategic transport planning objectives related to the proposed BRT and MRT lines that are currently in advanced planning stages. DTCA envisages becoming responsible for:

- Strategic planning and business case development for new public transport systems.
- Operational monitoring, management, and oversight of new mass transit systems.
- Strategic reorganisation of existing public transport routes.
- Regulation of reorganised public transport routes and services.
- Strategic traffic management and road network planning.

3.4 Work on these mass transit projects has, to date, been led mainly by international donor banks and consultants acting on their behalf. Consequently, the knowledge and datasets created in Dhaka are spread across multiple agencies. Moving forward it is desirable for the DTCA to play a more central role in devising and defining strategic, evidence-led transport policies; and in doing so take responsibility for the underlying datasets.

3.5 The Transport Data Needs Assessment Report (Appendix A) produced by the project team mapped out a relatively common suite of transport datasets that are considered essential to enabling DTCA to evolve into an organisation capable of fulfilling the roles above. This covered key data themes of: roads and traffic, public transport networks and operations, travel demand, land use and population, and transport analysis outputs. The exercise drew on experience from working in other megacities that have grown rapidly and are now grappling to establish appropriate transport management functions. In doing so it set out

the types of data typically held by metropolitan transport agencies, file formats used, and tasks undertaken by an agency to manage and maintain current datasets.

3.6 The following observations and knowledge gaps emerged from the review:

- The DTCA team is familiar with all the common file formats used to maintain transport datasets, with the exception of GTFS (training on which was delivered in this project).
- Data sharing between agencies in Dhaka currently happens on a piecemeal basis that relies heavily on personal contacts between staff members, rather than formal process.
- DTCA does not always receive the technical data and analytical files from consultancy partners that underpin reports and strategy documents.
- DTCA staff most commonly share data with colleagues at RAJUK (land-use and geo-spatial data), BRTA (data on public transport operations, drivers and vehicles), Dhaka City Corporations (public services), and Road Standards Department (RSD – road alignments and engineering data).

3.7 While internet connectivity was not a barrier, the lack of server/shared data storage means key transport datasets are spread across the team's laptops. Limited ICT capability and resources within DTCA mean the team relies on informally appointed external contractors.

Existing technical capability, coupled with DTCA's limited financial resources, act to limit the technical complexity of transport data management options that can be sustained in Dhaka. As such an intermediate technology option (a simple cloud-based Transport Data Hub) that is part of a longer-term roadmap towards a more technically complex service (open data sharing platform) was considered more immediately achievable. Such an approach may be relevant in other similar contexts where in-house ICT skills are limited.

Determining Transport Data Hub requirements

3.8 Through the project team's dialogue with DTCA colleagues on their transport data and ICT capacity and needs, it became clear that establishing a simple form of Transport Data Hub that allowed for basic data sharing within the organisation, and with partner delivery agencies, was a key priority. This was implemented through this project, rather than the envisaged bus franchising database which was considered to duplicate an initiative being pursued by the Bangladesh Road Transport Corporation (BRTC) and Korea International Cooperation Agency (KOICA). They are understood to be building a digital database of transport operators and bus vehicles in Dhaka.

The process of presenting the project team's independent analyses on transport data and ICT needs and capacities, and allowing them to guide informed decision-making by DTCA colleagues, helped to achieve buy-in from key stakeholders at DTCA. It also ensured the project outputs will meet the organisation's jointly defined needs and priorities. This approach could be readily adopted into other similar future projects, where there may previously have been a tendency for donor banks and international consultants to lead rather than support local stakeholder organisations.

3.9 Table 3-1 sets out the summary of options discussed with DTCA colleagues, which sparked considerable debate in relation to each option's respective merits and affordability.

Table 3-1: Options for developing a Transport Data Hub in Dhaka

Option		Description	Data	Costs	Skills needed	Sustainability & Scalability	Examples
1	**Server within DTCA**	Network attached storage drive or network connected PC in DTCA offices.	- Static - Closed	$1,000 setup for Network Attached Storage drive $0 ongoing maintenance	Basic ICT and networking skills. Management of file structure / version / backup.	Easy to maintain and no recurring costs. Hard to scale beyond DTCA.	N/A
2	**Cloud-based storage / FTP site**	Internet hosted storage service such as Google Drive, Microsoft One Drive Dropbox, Box, or Google Apps for Work. Files are stored, shared and accessed via the internet	- Static - Closed	$0 setup $5-15/user per month recurring charges for some services	Basic ICT skills only. Management of file structure / version / backup.	Easy to maintain, but recurring costs an issue in Dhaka. Limited scalability	ITP set up a Dropbox Pro account for Cebu City Government to enable data sharing on big data projects
3	**Open data website page**	Open transport datasets are shared publicly on a page of the existing DTCA website via downloadable links. And potentially via the GTFS Data Exchange website.	- Static - Open	$ Unknown External web-design service in Dhaka currently used by DTCA.	Website development and page editing.	Relatively easy to maintain, but rely on external help. Inherently scalable	DOTC (Philippines) set up pages on its site, for open data and transit data.
4	**Third party open data site / platform**	Open transport datasets published by DTCA are released via third party software tools such as SOCRATA.	- Static - Dynamic - Open	SOCRATA charges $5,000-$15,000 month	Data management, basic ICT skills, ability to manage contractors	High recurring costs & scope for more complex data increase challenge. Very scalable.	Kenya Open Data website is built on SOCRATA platform.
5	**Proprietary public open data sharing platform**	Open transport datasets published by DTCA are released on a web-platform managed by DTCA/central government e.g. re-using the CKAN codebase.	- Static - Dynamic - Open	$0 to use code, but needs software development expertise to setup.	Software programmer needed to setup and maintain.	Skills may be a barrier. Partnership for Open Data can assist. Very scalable.	Official Brazilian government data portal is built on CKAN's platform, as is the UK government portal.

3.10 Cloud-based storage (Option 2) was selected by DTCA and jointly implemented through the course of the project. The main reasons for choosing this option were:

- The lack of ICT and networking skills required to set-up and maintain this option.
- The team is already familiar with Dropbox tools, but previously limited to 2GB capacity.
- Password protected encryption and off-site security was reassuring.
- Each major DTCA project generates between 5-10 gigabytes of data, so 1 terabyte of storage was deemed sufficient capacity for the medium to long term.
- Free alternatives to Dropbox either did not exist at the time of conducting this review (Microsoft One Drive), or place file-size limitations that were considered too restrictive for the largest GIS and imagery databases maintained by RAJUK (Google Drive).

3.11 The team's only slight concern was over whether it can meet storage rental costs over the long-term, which is subject to sign-off from the Project Director (Anisur Rahman) and Project Executive. Of the other options considered, the first was discounted based on the lack of ICT capability within DTCA; while options 3, 4, and 5 are possible future initiatives. Aside from a general lack of enthusiasm for making data freely and publicly available, the identified technical capacity constraints within the DTCA mean it is currently unlikely that a public open data sharing platform could be sustained beyond the project-specific efforts of international donor banks and their consultants.

To deliver a public open data sharing platform in the future, DTCA is likely to require:

- Individuals who are passionate about opening-up data in Dhaka, with a specific remit and resources to maintain any publicly released datasets.
- An official mandate from central government ministers/senior DTCA officials.
- Support from/collaboration with international agencies like Partnership for Open Data.
- Initially, a website-developer who is capable of placing links to data files stored in the Transport Data Hub from a page on the DTCA website.
- Longer-term, data specialists and software programmers capable of taking automatically updated datasets (e.g. BRT vehicle positions/speeds from Automatic Vehicle Location - AVL - systems) and turning them into open data feeds that can be released through a searchable public open data platform.

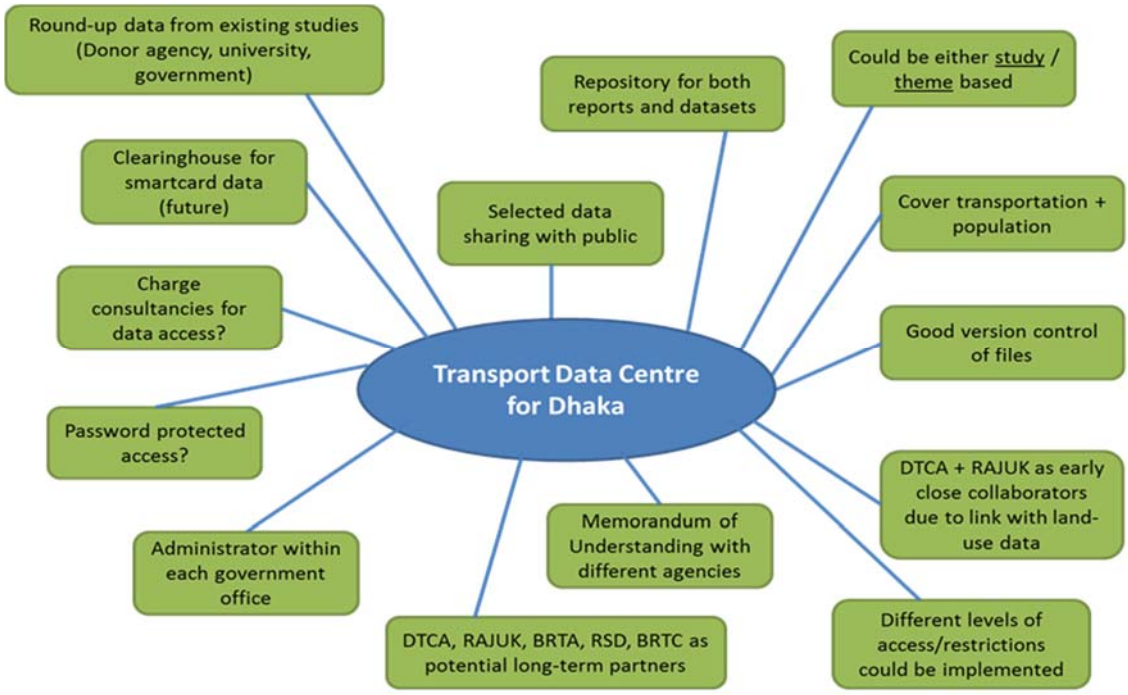
Developing and implementing the Dhaka Transport Data Hub

3.12 Building on the transport data needs and local capacity assessment task, described above, the project team worked with colleagues at DTCA to establish a cloud-based Transport Data Hub for Dhaka in line with their jointly-defined priorities and requirements (Table 3-2 and Figure 3-1 respectively).

Table 3-2: Agreed priorities for the Dhaka Transport Data Hub

Immediate	Future
Keep all existing transport data and reports in one place	Support operational monitoring & management of BRT/MRT
Sharing data… • Within DTCA • With other Gov't agencies • With external orgs (ADB/World Bank)	Support enhanced traffic management & road network planning
	Inform reorganisation & regulation of public transport routes
Inform strategic design and planning of new transport lines	Provide better public transport information for travellers

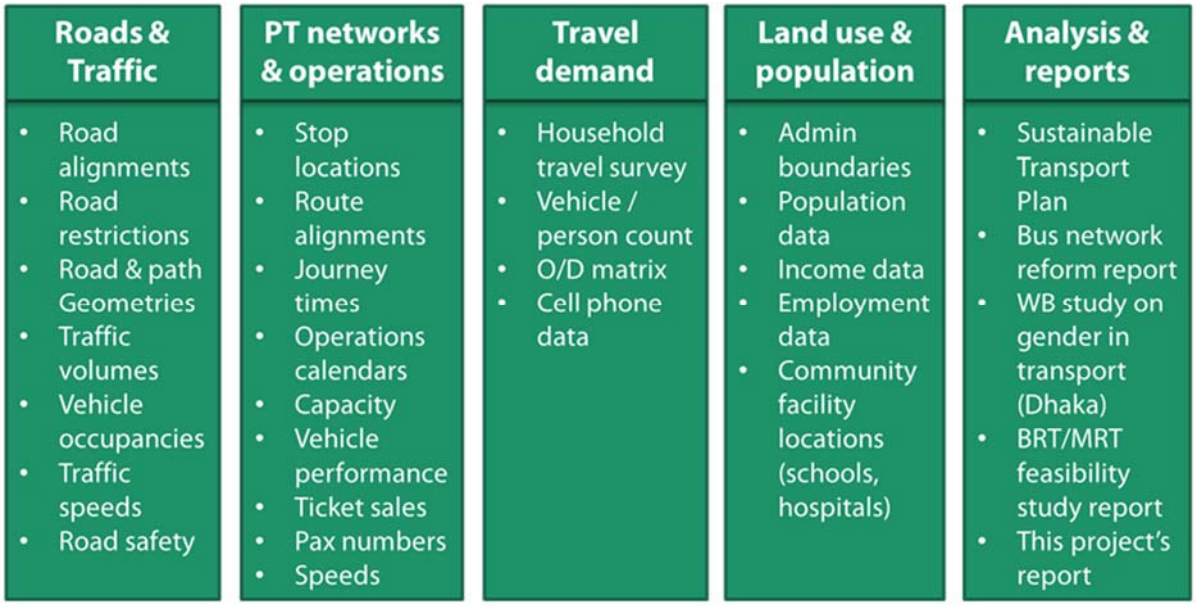
Figure 3-1: Identified transport data hub requirements from DTCA dialogue



3.13 The initial proposal for the structure of the Transport Data Hub (Figure 3-2) was expanded through discussion with the DTCA team. The Hub was subsequently designed to accommodate thematic datasets related to transport infrastructure (water/road/rail -ways, pedestrian routes, parking), freight, Non-Motorised Transport (NMT - walk, cycle, pedicab), and trip-generation arising from new land uses/developments. It was also structured so that datasets could be stored and retrieved both:

- Temporally – in relation to the project or study through which they were collected.
- Thematically – in relation to the topic the dataset covers.

Figure 3-2: Initial proposed structure for Dhaka Transport Data Hub



3.14 Data collated from DTCA colleagues in relation the DHUTS (2010) and Strategic Transport Plan (2005) projects was used to build a first version of the Data Hub, which was shared via ITP's Dropbox account for initial review and comment. The datasets collected for these projects included household travel survey data, cordon count data, traffic count data, trip generator locations, household income surveys, travel time and vehicle occupancy data, core GIS data on land-use and socio-demographic topics, and final report documents.

DTCA Dropbox account

3.15 ITP set up a Dropbox Pro account (1Tb storage) on behalf of DTCA in order to store the Data Hub's contents.

3.16 After logging-in a user lands on a home screen at which the 10 folders around which the Data Hub is structured can be viewed (see Table 3-3). These folders can be customised, as desired, by DTCA colleagues and are intended to provide the starting point for an evolving Dhaka Transport Data Hub. New datasets can be added to the existing folders, or into new folders, where appropriate.

Table 3-3: Dhaka Transport Data Hub Structure

Title	Contents	Sorted by
00-User Guide	This user guide	-
01-Analysis and Reports	All reports and data from major transport studies conducted in Dhaka.	Study title
02-Land use and Population	Data on land use, place names, building outlines, administrative boundaries, land condition, population and demographics	Dataset name
03-Roads and Traffic	Data on road networks and bridges, traffic counts, vehicle and passenger counts, traffic speeds, traffic model zone areas	Dataset name
04-PT Networks and Operations	Data on rail and bus routes, bus terminals and rail stations, proposed BRT and MRT lines, passenger/operator surveys. A possible place to store summaries of smart card data exported from the clearing house that DTCA is currently working to implement	Dataset name
05-Travel Demand	Data on bus passenger counts, O-D counts, identified trip generators, household interview surveys, traffic and public transport passenger surveys.	Dataset name
06-Freight	Data on freight routes, truck counts, driver surveys, volumes of freight transported.	Currently empty
07-Airport and Air Travel	Location and boundary of airport land	Dataset name
08-Data Sharing	A place to temporarily store and share data with other agencies (e.g. RAJUK)	Currently empty
09-Open Data	A place to store public open datasets, which could be linked from the DTCA website	Currently empty

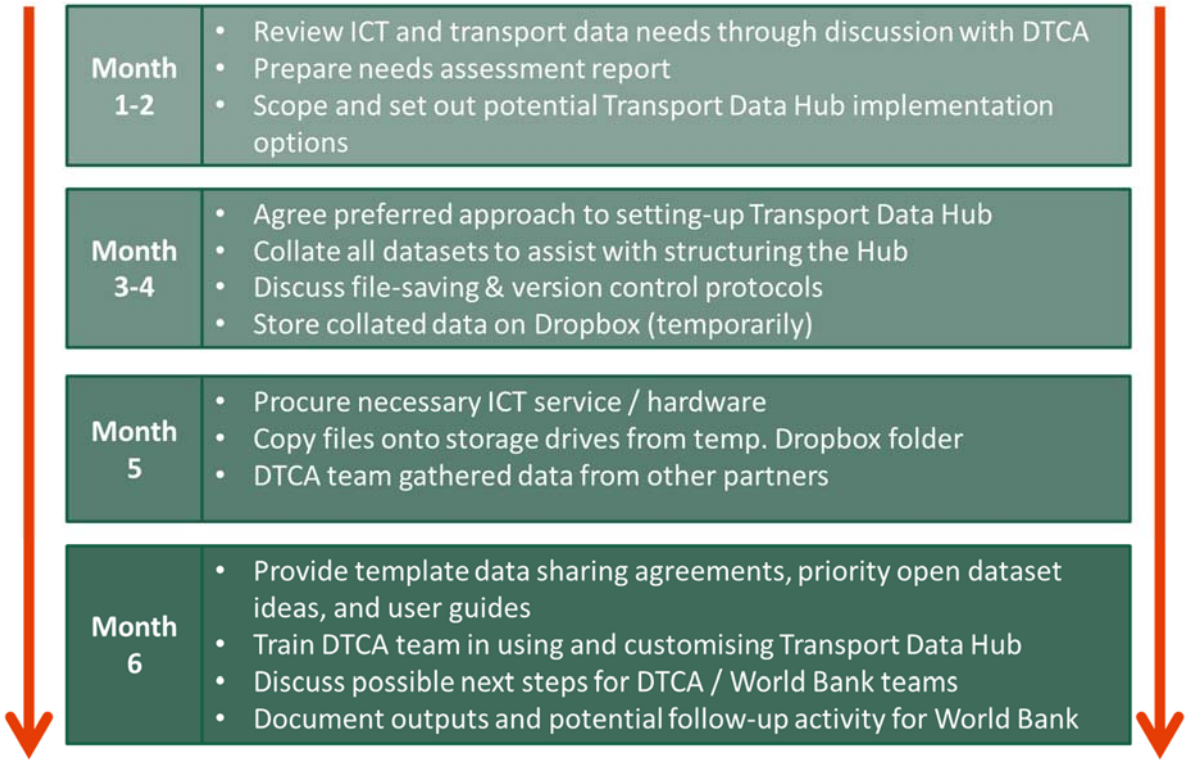
3.17 The project team provided training on the Transport Data Hub in Dhaka in July 2015, walking 10 members of the DTCA and RAJUK teams through the process of logging-in and using the tool. To accompany this training session, and follow-up discussion with the DTCA team, the project team produced the following resources; which have been appended to this report:

- User Guide, setting out key file sharing features of Dropbox and suggested protocols for file-sharing and database maintenance (Appendix D).
- Thoughts on agency collaboration and data sharing that DTCA can use to draw-up formal agreements (as needed) that define which datasets it will share with other agencies, and what they will offer in return (Appendix E).
- A template Terms of Use agreement for third party users of any public open datasets (Appendix F).
- A list of key requirements for the development of an Open Data Webpage (option 3) so that DTCA can build these into any future Terms of Reference for website development, and a shortlist of the top 10/20 datasets held by DTCA that are likely to be most popular, and therefore are worthy of being included on an Open Data Webpage (Appendix G).

3.18 These user guides and supporting materials may be of use to colleagues at DTCA, and the World Bank when seeking to broaden the Transport Data Hub to other cities in Bangladesh, or for other similar future projects. The project team's workflow for implementing the Dhaka Transport Data Hub is set out in Figure 3-3 and may also be useful.

The Data Hub Dropbox will remain available to DTCA and RAJUK until July 2018, and provides a legacy from this project until such time as DTCA sets up an in-house server.

Figure 3-3: Dhaka Transport Data Hub implementation workflow

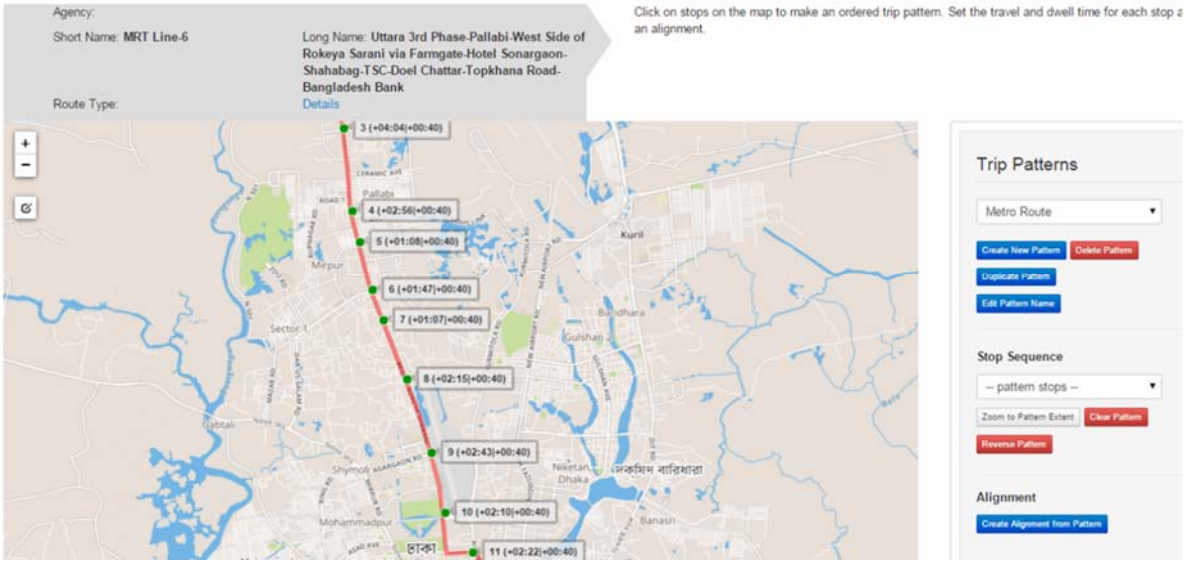


GTFS Editor software set-up

Compilation and validation of GTFS dataset for Dhaka

3.19 Prior to travelling to Dhaka for a first meeting with DTCA colleagues the project team set-up an instance of the open source GTFS Editor software tool, so that the draft GTFS dataset received from colleagues at the World Bank could be validated and finalised (screenshot at Figure 3-4). The software tool remains fit for purpose on a research basis, and has continued to evolve through successive open transport data and capacity building projects, some of which have been funded by the World Bank. The research instance of GTFS Editor established for this project was hosted by ITP on behalf of the DTCA team.

Figure 3-4: Screenshot of GTFS Editor showing proposed MRT line 6 route



3.20 Creating the GTFS dataset for Dhaka required the project team to assimilate all GIS bus route data and import the .SHP files into GTFS Editor. The route datasets had already been labelled by the World Bank Task Team, and contained the main bus stop locations in Greater Dhaka that were identified through ALG's report on bus network rationalisation.

3.21 The routes contained in the GTFS feed received by the project team are understood to represent the current public and private bus services operating in Dhaka. The feed included primary stop locations, but did not contain service schedules (which do not exist on the majority of routes) or operating headways (which are hugely affected by local traffic conditions at different times of day). To overcome these required fields the project team used the average headway data and operational speeds presented in ALG's report to make the following assumptions:

- Average speed of 8.75 Km/hr.
- Average of 8 minute service frequency in each direction along bus routes.

3.22 These assumptions were applied globally to all current bus routes in Dhaka for which .SHP files were available from the ALG study.

Creating GTFS Scenarios

3.23 Using this GTFS dataset as a baseline, subsequent scenarios were developed to cover the accessibility modelling parameters being explored through this project:

- Current bus network + all proposed BRT lines (~2020-2025).
- Current bus network + all proposed BRT & MRT lines (~2020-2035).
- Variations of each scenario to reflect an informed estimate of current transport services in Greater Dhaka that females are prepared to use.

3.24 The definitions for each of these scenarios are discussed in greater detail in Chapter 4.

In preparing the GTFS datasets for each scenario, the project team drew on the best-available baseline GTFS dataset relating to current bus routes that operate in Greater Dhaka and combined this with informed estimates of headway and operational speeds. The resulting GTFS feeds created through this project are sufficient as the basis for research and analysis, but would not be accurate enough to power online journey planners (the main application for GTFS in most cities).

More detailed bus data collection in similar future projects, such as that conducted in Metro Manila in partnership with the University of the Philippines and Department of Transport and Communications, would enable city authorities to release a GTFS feed and set-up a basic public transport journey planning website as an additional output.

Interactive training session to familiarise and train DTCA on GTFS Editor

3.25 As part of the process of constructing the GTFS datasets, described above, the project team led a half-day interactive group training session with 5 members of the team from DTCA and RAJUK. The training session took place at DTCA's office and covered the following topics:

- An introduction to all functions of the GTFS Editor tool.
- Detailed walk-through of the workflow for creating an agency, adding new stops, adding a new route, and schedule information.
- Hands-on demonstration of the export of GTFS feeds for subsequent uses. This prompted questions from colleagues at DTCA and a useful follow-up discussion about how this data could benefit members of the public.

- A demonstration of the GTFS Exchange portal, and explanation of how the GTFS feed could be published there and on the DTCA website, so that software developers could use it to build public digital journey planning apps/websites.
- Individual practice (with project team Q&A) on using GTFS Editor to enter route, stop, and service frequency data. This focused on Dhaka's planned BRT and MRT routes and informed the project team's subsequent work to define these GTFS scenarios.

3.26 The training materials from this session can be found in Appendix B and C to this report. They comprise an introductory presentation to open transport data and GTFS (Appendix B), and the GTFS Editor user training guide (Appendix C).

The training sessions in GTFs editor, and the research-quality GTFS feed provided represent the potential start of a process for building and maintaining a more accurate GTFS feed for the city of Dhaka. There is currently no set structure in place to maintain the GTFS feed, since this was not an objective of the project. The current GTFS feed is considered to be robust enough for high-level accessibility analyses, but not for the specifically detailed information that would be required to power journey planning apps. This would be a logical next step for DTCA to pursue (potentially with support from World Bank / other donor agencies)

For comparison; in Manila, for which the GTFS-Editor tool was originally developed, nearly 200 staff across multiple agencies were trained on its use. National budget was allocated towards its maintenance, an official memorandum was signed between agency heads indicating their commitment to maintain the feeds, and the national government committed to hosting the feeds and the application (which, at the time of writing are understood to still be in use. Substantial media and outreach efforts were undertaken to ensure bottom-up demand for maintenance of the feed.

It is clear that replicating this experience in Dhaka would require greater resources, and national government buy-in, than were available at the time of conducting this pilot study. Building this interest, through continued knowledge exchange and capacity building, would be a logical follow-up activity for donor bank Task Team Leaders working on major transport projects in Bangladesh.

Using Transport Analyst software for accessibility analyses

3.28 The project team set-up an instance of the open source Transport Analyst software tool to perform scenario-based transport accessibility modelling using the GTFS datasets described earlier in this chapter as the input. Like GTFS Editor, the software tool remains fit for purpose on a research basis, and has continued to evolve through successive open transport data and capacity building projects (some of which have been funded by the World Bank). The research instance of Transport Analyst established for this project was hosted by ITP on behalf of the DTCA team.

3.29 The process of compiling the datasets needed to conduct accessibility analyses using Transport Analyst has been described in detail at the start of Chapter 4 of this report, but briefly involved:

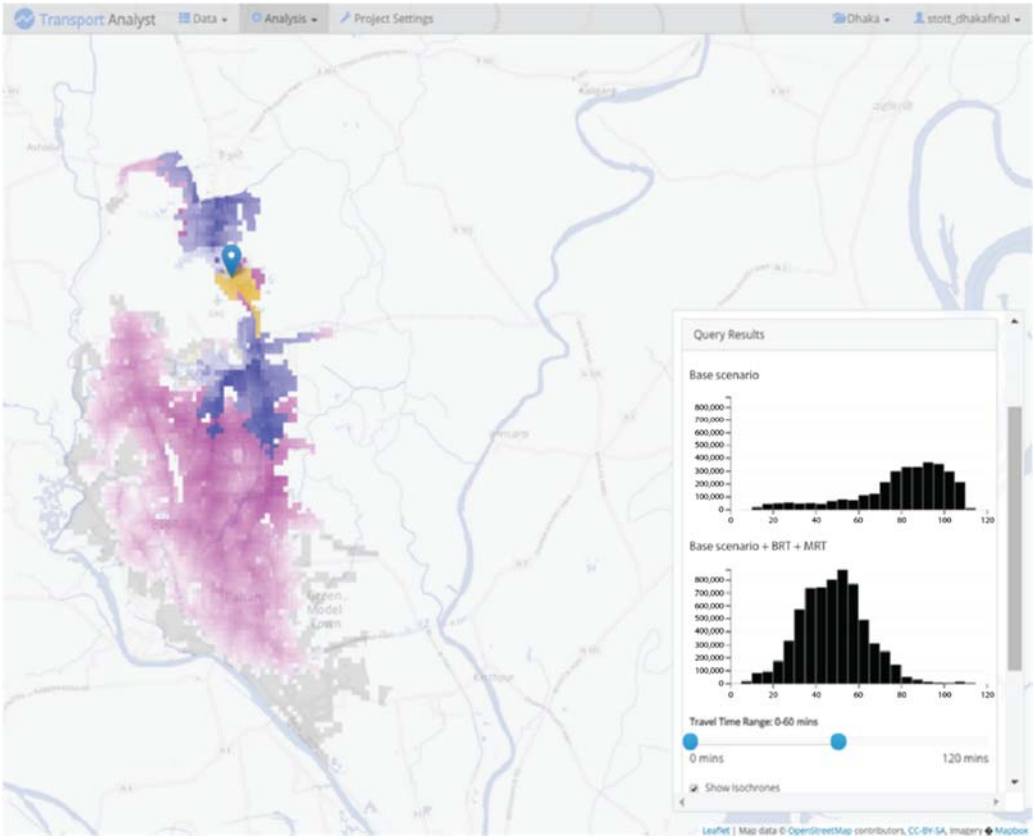
- Checking available OpenStreetMap data for Dhaka, to ensure sufficient coverage of key local roads and footpaths for the Transport Analyst routing algorithm to build a graph of all potential trip origins and destinations.
- Cleaning and validating GTFS datasets using GTFS Editor for each of the scenarios described earlier in this chapter, primarily to ensure local bus routes match with OpenStreetMap (OSM) road network data and they each contain operating schedules and calendars (required for a valid GTFS feed).

- Associating population data for Dhaka wards to appropriate geospatial administrative boundaries and, where necessary, disaggregating these datasets into smaller areas so as to enable accessibility to be related to the places where Dhaka's inhabitants live.

3.30 Having assembled these datasets for each scenario (as defined in Chapter 4), the project team was able to import and sequentially process them in turn using Transport Analyst's Single Point Analysis tool. The resulting accessibility outputs and histograms have been reported in detail in Chapter 5, and include visualisations of the estimated inequality of public transport accessibility for females in Greater Dhaka. Exporting the underlying output data as .SHP GIS files permitted further quantitative analyses of the estimated numbers of people who will be able to access defined locations in Dhaka within 90 minutes travel time by public transport under each scenario.

3.31 Figure 3-5 represents a sample output from the project team's analyses using Transport Analyst. It illustrates the considerable extent of improved travel times (blue shading) and increased coverage within 90 minutes of travel (pink shading) that will be delivered over the current bus system through the combined implementation of BRT and MRT routes being planned for Dhaka. This is reflected in the two histograms for the current situation (Scenario 1) and the proposed BRT + MRT future scenario (Scenario 2).

Figure 3-5: Sample Transport Analyst output from Dhaka analyses



Population data were not available for the geographic area to the south of the Buriganga river. Consequently the accessibility plot does not appear in this location, even though future BRT lines may serve this location.

A demo instance of Transport Analyst has been made available to World Bank staff by Conveyal LLC at: http://wb-analyst.conveyal.com/login. The site includes a simple tutorial and demo data for Mexico City, and we understand a full version of the tool could be made available on a permanent basis to all World Bank technical staff (and their local counterparts/consultant teams if funding can be provided) if desired. Such an approach has the potential to mainstream the delivery of accessibility modelling from one-off research tasks (such as this project in Dhaka) so it can be applied to all sustainable urban transport planning projects funded by the World Bank.

It is pertinent to note that Transport Analyst is a supply-driven tool, which doesn't take into account such factors as demand, transit system capacity. Instead it provides a quick way of evaluating the potential impact of major transport infrastructure initiatives before more detailed (and more resource-intensive), demand-side analyses and travel demand models are developed to demonstrate the likely impacts on capacity and traffic levels. In this context tools like Transport Analyst can be used to reduce the overall cost of transport modelling activities, by ensuring such efforts are targeted at public transport proposals that have potential to transport the greatest numbers of people to/from specific locations.

Transport Analyst training for the DTCA team

3.32 As part of the final project visit to Dhaka, the project team led a half-day interactive group training session with 8 members of the team from DTCA and RAJUK. The training session took place at DTCA's office and covered the following topics:

- An introduction to accessibility modelling covering: theory, techniques, and the basics of Transport Analyst; alongside some simple GIS data presentation techniques.
- Accessibility modelling in Dhaka, focusing on input datasets and model scenarios used in this project.
- Detailed instruction on how to use Transport Analyst, covering: importing data from GTFS editor, importing demographic data, producing accessibility maps and statistics, comparing scenarios.
- Key findings from ITP's analyses derived from the Transport Analyst tool's outputs, including: current estimated accessibility inequalities experienced by females, the impact of planned BRT and MRT lines on general accessibility, and the impact of BRT and MRT on Dhaka females' accessibility.

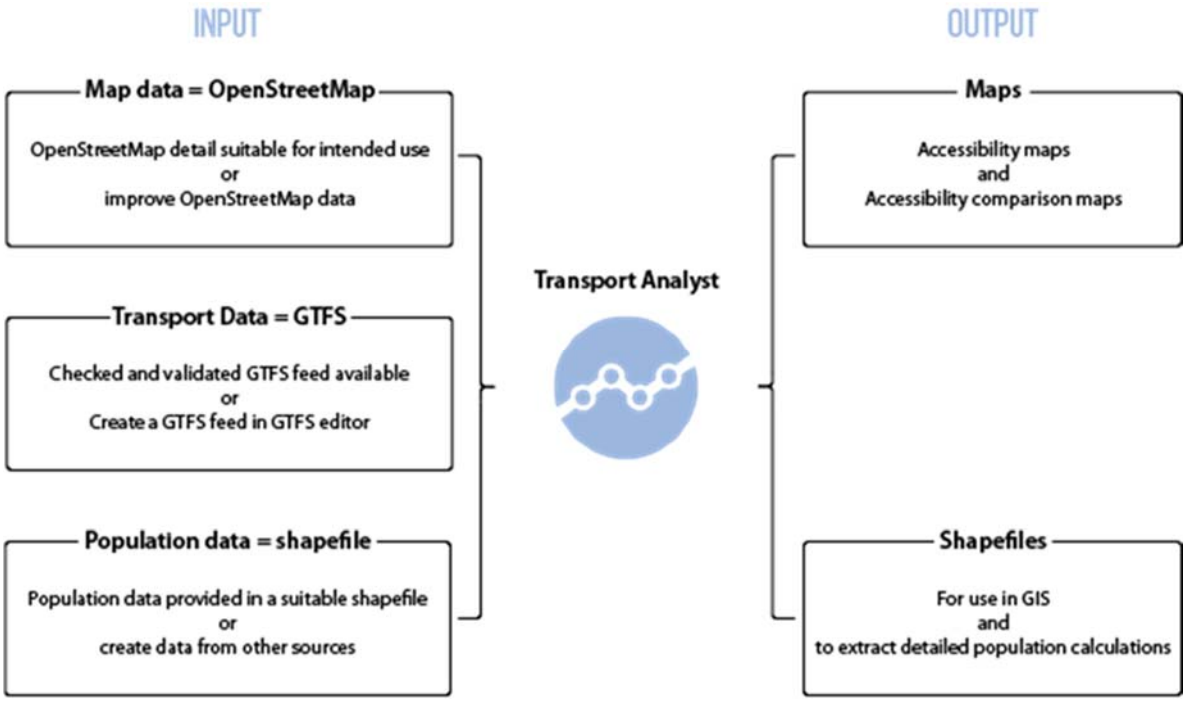
3.33 The training materials comprise a presentation outlining the key principles of transport accessibility modelling (Appendix H), and the Transport Analyst user training guide (Appendix I).

This user guides and supporting presentation may be of use to colleagues at DTCA, and the World Bank when seeking to broaden the use of Transport Analyst to other cities in Bangladesh, or for other similar future projects.

4 IMPACT OF BRT AND MRT ON ACCESSIBILITY IN DHAKA

4.1 Predominantly conducted between project visits two and three, the following chapter outlines the accessibility modelling work that ITP undertook using Transport Analyst. This work focused on assessing transport accessibility in Greater Dhaka so as to make comparisons between accessibility for the general population and females.

4.2 The diagram below shows the data inputs and outputs to Transport Analyst, these will be described further and demonstrated in the results in this chapter.



Datasets and assumptions used

Map data

4.3 Transport Analyst uses OpenStreetMap (OSM) for all its base mapping. A brief review of the OSM data for Dhaka city was undertaken and it was deemed sufficiently complete and suitable for the intended application of accessibility modelling at a city-wide scale. We note that there is always scope for improvement to OSM and, where project budgets allow, we advocate that such improvements are investigated and undertaken with a team of local mappers who can carry this work forward in the future.

Bus data for Dhaka

4.4 Basic GTFS data for all current bus routes in Dhaka was provided by the World Bank, and derived from ALG's 2014 public transport reorganisation review. This data was subsequently imported into GTFS Editor and cleaned, which allowed for routes to be corrected to follow the road network (not just straight lines between bus stops as per the GTFS default), checking bus stop ordering for anomalies, and setting route speeds to match the average operating speed (reported in ALG's 2014 report) of 8.75 km/h.

4.5 To create a valid GTFS feed a timetable and calendar have to be included. These were included in the bus data. Bus frequency was set at 8 minutes (taken from ALG's 2014 report) in the absence of more specific data on a route-by-route basis, and all services were set to run on all weekdays between 6am and 10pm. In reality we recognise there is likely to be considerable variability of service headways and operating hours, but these assumptions were necessary to inform the subsequent accessibility modelling in the absence of more accurate data on a route-by-route basis.

4.6 The GTFS feed for Dhaka bus routes was exported from GTFS Editor and imported directly into Transport Analyst as a new scenario - called 'Base Scenario'.

Unfortunately, a GTFS feed was not available for the proposed restructured bus network in Dhaka (to be prompted by the implementation of BRT and MRT lines). This has been outlined in ALG's 2014 study report, but it was outside the scope of this study to encode the route proposals into GTFS. This represents a logical follow-up activity for DTCA from this project.

BRT data

4.7 Data on the proposed route alignments, station locations, and operational headways for all planned BRT lines in Dhaka were derived from a combination of ALG's report on public transport reorganisation (2014) and dialogue with colleagues at DTCA working to deliver the planned routes. Through the course of delivering the GTFS Editor training sessions, and ongoing dialogue with DTCA staff members who have been part of the BRT feasibility work, we established 25 km/h as a sound average operational speed for all of the planned BRT lines (including dwell times). A service frequency of 5 minutes was used, although as previously stated, the frequency once this high has no impact on accessibility calculations.

4.8 The BRT data were exported in a separate GTFS feed from GTFS Editor, which was then imported into Transport Analyst as additional services to the base bus network to create a new scenario titled 'Base + BRT'. All proposed BRT lines (Lines 1, 2, and 3) were included in the project scenarios in order to demonstrate the capacity and benefit of the analysis tool.

MRT data

4.9 As part of the Data Hub data collection effort DTCA shared GIS shapefiles with ITP's team which included detailed route alignment and stop locations for all the lines which make up the proposed MRT system for Dhaka (not just MRT line 6). This data was used to create the GTFS feed for MRT, with insight from DTCA informing the definition of an average operating speed of 36 km/h was used, with a 5 minute operating frequency.

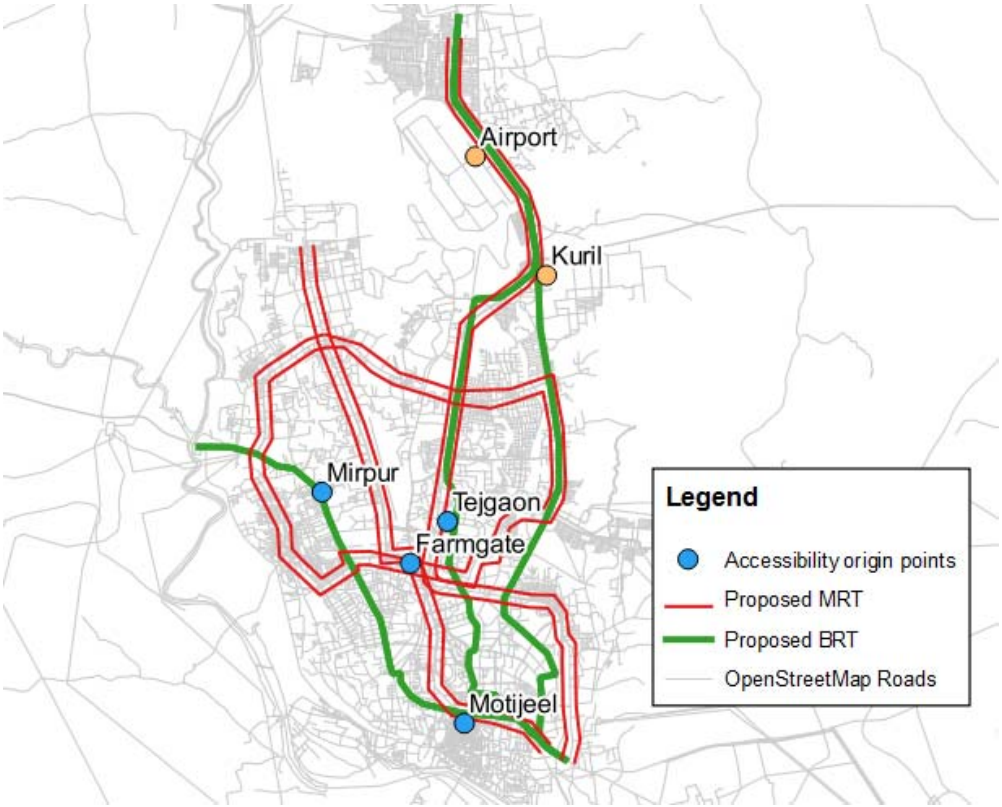
4.10 The MRT dataset was exported as an independent GTFS feed from GTFS Editor, and was subsequently imported into Transport Analyst as additional services to the base bus network with BRT to create a new scenario - 'Base + BRT + MRT'. All proposed MRT lines (Lines 4, 5, and 6) were included in the project scenarios in order to demonstrate the capacity and benefit of the analysis tool.

Network Map

4.11 For reference, the full extents of the BRT and MRT networks are illustrated in Figure 4-1. The green lines show the proposed BRT routes between the south and north of the city, whilst the double-red lines show the proposed MRT routes (MRT4, MRT5 and MRT6). BRT line 3 and MRT line 6 are at a more advanced stage of development than other lines.

4.12 Other proposed BRT and MRT lines have not been included, as data regarding their exact routes was not available, and population and land use data for the corresponding areas was incomplete. However the training component of this work has furnished the DTCA team with the tools and the skills to rapidly perform accessibility analysis similar to that reported above. When the necessary data becomes available these can be exploited to examine the impact of proposed new transit schemes.

Figure 4-1: Proposed BRT and MRT network extents



Population data

4.13 We obtained population data in MS Excel format for the Greater Dhaka metro area through discussions with BBS (supported by DTCA) on our team's first project site visit. This spreadsheet data was then combined with GIS data of ward boundaries for Greater Dhaka, which was obtained from RAJUK.

4.14 Once combined, these files created the shapefile data needed by the Transport Analyst software tool. The highest level of resolution in which the population data for Greater Dhaka were available was Ward level, and this breaks the metro area down into 105 wards. Transport Analyst works by creating centroids for such population areas/zones and calculating the travel time to/from these. Although this methodology did work with 105

zones, the outputs generated often result in un-intuitive looking outputs in locations where larger Wards (zones) are given the same score across their full geospatial extent.

4.15 To solve this problem we broke the Ward areas down further using a grid pattern. This resulted in much smaller zones and produced more accurate map-based outputs. By applying this methodology we made the crude assumption that population is distributed evenly across each individual ward. Although in reality this is not the case, such an approach is necessary where more finely grained population data (e.g. associating individuals with accurately geo-coded home locations or smaller administrative areas) it was felt this assumption was acceptable in this circumstance. Consequently the total number of zones mapped and included in our analyses increased from 105 to 8,683.

4.16 No future year population estimates were available (or known to exist), therefore the base year population numbers were used for future year scenarios (no population growth is assumed in the future year analysis). This will mean any change trends of population accessible with public transport shown by the model are accurate, but precise numbers are likely to be below where they would actually be given the population of Dhaka is known to be increasing rapidly.

4.17 In future, other external datasets may be appropriate if local data is not available or not sufficiently detailed. For example, WorldPop[1] makes available population estimates in 100m x 100m grid cells for many Asian and African countries from UN data, which would be suitable for conversion to use in Transport Analyst and is of a high enough resolution to require no further disaggregation. For this work, however, we chose to use existing data from DTCA partners to emphasise the possibilities with locally-produced datasets.

Summary of accessibility modelling scenarios

4.18 Table 4-1 summarises the different accessibility scenarios tested by the project team using the datasets described above.

Table 4-1: Summary of Dhaka accessibility modelling scenarios

Scenario name	Description
Base scenario	• Accessibility using current bus route networks • Current population data
Base + BRT	• Accessibility using current bus route networks + all planned BRT lines • Current population data
Base + BRT + MRT	• Accessibility using current bus route networks + all planned BRT and MRT lines • Current population data
Base scenario (females)	• Accessibility of females using current bus networks, walking and rickshaws • Current female population data
Base + BRT (females)	• Accessibility using current bus route networks, walking and rickshaws + all planned BRT lines • Current female population data

[1] WorldPop www.worldpop.org.uk

Base + BRT + MRT (females)	• Accessibility of females using current bus networks, walking and rickshaws + all planned BRT and MRT lines • Current female population data

4.19 The results of each scenario have been presented in the subsequent sections of this chapter, along with detailed descriptions of assumptions applied in relation to each tested scenario.

Challenges and limitations

4.20 The process of obtaining the population data from BBS would have been far simpler if there were better lines of communication between DTCA and BBS. We believe BBS may hold data in a higher resolution, or that is associated with GIS shape data, given we saw maps in BBS publications that illustrate this dataset (suggesting it has been geocoded, but was not made available for this project). The disaggregation of data across a grid of zones is a good solution to the problem of high level data, but it is hard to replicate for someone without good GIS experience, and therefore can be a hard skill to pass on when compared to using tools such as GTFS Editor and Transport Analyst which are designed to be used by non-technical staff.

4.21 The population data we used relate to the 2011 Census and were not projected into the future for the MRT and BRT delivery scenarios, which is an identified limitation of the accessibility analyses delivered through this project. The future transport scenarios have, unavoidably, been compared against current population data; and therefore serve to demonstrate the impact of Dhaka's BRT and MRT proposals against the population distribution from the 2011 Census. In sharing the findings from this study we advise that trends, rather than population data, are used as the basis for consideration.

4.22 We also attempted to obtain other census fields so that we could map the accessibility of these metrics (e.g. employment activity, people in full time education) using the Transport Analyst application, but datasets were not made available to our team by BBS.

Another follow-up task to this study for colleagues at RAJUK and DTCA would be to use the latest available population datasets from BBS as the basis for the accessibility plots in Transport Analyst. These population datasets could be temporally related to both the current public transport situation (2011-15), as well as future population projections that align with the estimated timeframes of BRT and MRT network implementation (2020-2035 respectively).

Current transport accessibility in Dhaka

4.23 The following maps report on the accessibility levels in Dhaka for all scenarios. To do this in a static report we selected four example locations to give consistent results. By visiting the online instance of the Transport Analyst tool the maps and results can be obtained for anywhere in the modelled region. The location chosen for the majority of the reporting within this report was downtown (Motijheel) in Dhaka, with Farmgate, Shymoli Shumela Intersection and Teigaon used for further analysis.

- Motijheel was chosen as it is understood to be a key trip attractor which, based on the network of all transport options, is not overly biased towards one mode of travel over another.
- Farmgate was selected, because it represents an existing major transport hub in Dhaka that demonstrates the best levels of current accessibility in Dhaka.
- Shymoli Shumela Intersection is where Dhaka's main hospitals are located, and therefore represents an important location in respect of access to healthcare treatments.
- Tejgaon represents a major employment centre, with various factories and industries located in this part of the city.

4.24 At the time of undertaking this work it was not possible for the Transport Analyst tool to reliably compile regional accessibility analyses. Selecting the four key locations described above was a practical approach to overcoming this limitation.

4.25 All model runs illustrated in this section show outputs for up to 90 minutes travel time by public transport and walking from this location. In basic outputs with no comparison the accessible areas are shown in yellow, with the darker colour representing a shorter travel time (left hand image below). For figures where a comparison is being presented, the yellow represents no change in accessibility, blue shows improved travel time, and pink depicts areas that couldn't previously be reached within 90 minutes by public transport:

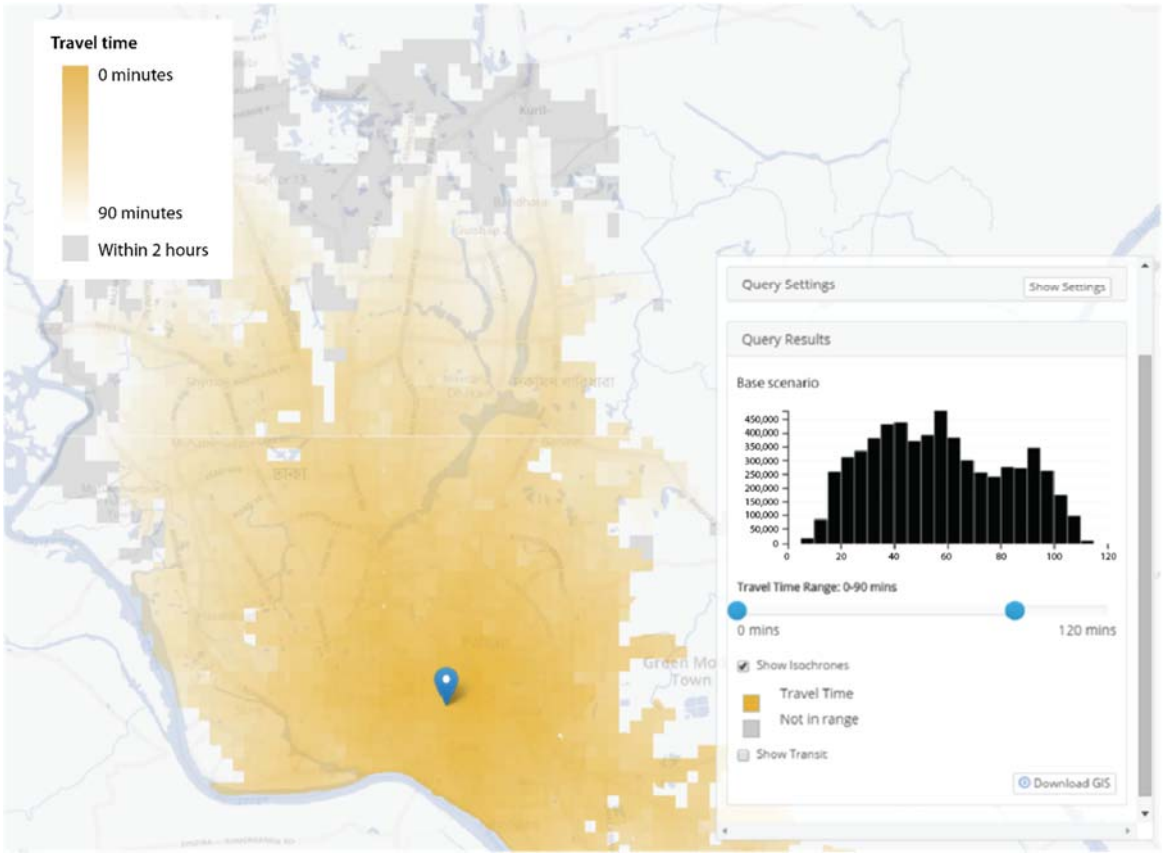
Base Scenario (current bus-based accessibility)

4.26 The baseline scenario was established based on the following data:

- Existing bus routes only
- Network speed of 8.75 km/h

4.27 Figure 4-2 shows how the relatively slow speed of the current transport system only allows for a limited amount of accessibility within Greater Dhaka. In particular, northern and western parts of Greater Dhaka are outside a 90 minute journey from the Motijheel area. This includes a large section (almost half) of the city population, as shown by the graph alongside the accessibility map. A 90 minute journey (very light shading) is not sufficient to reach some areas in the far north and west.

Figure 4-2: Base scenario public transport accessibility



Population data were not available for the geographic area to the south of the Buriganga river. Consequently the accessibility plot does not appear in this location, even though bus services may operate to this location.

Impact of BRT on transport accessibility

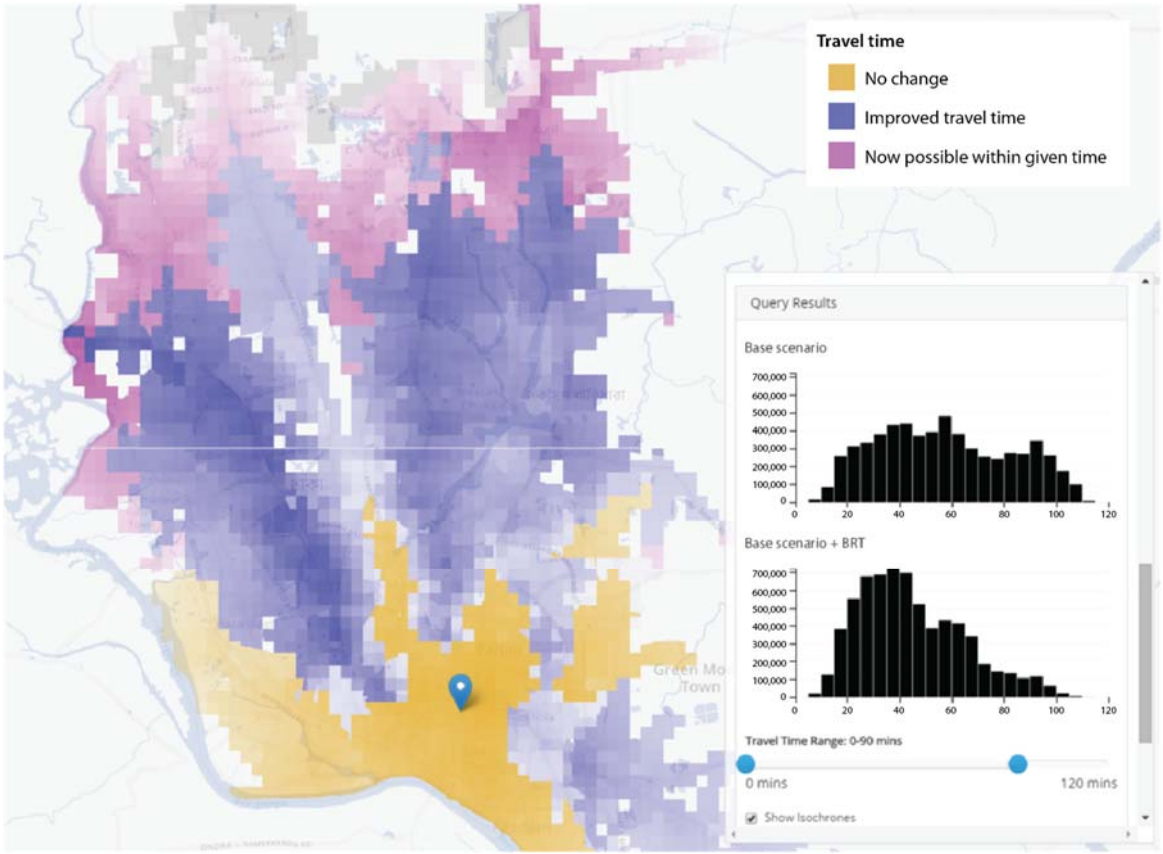
4.28 The BRT scenario represents an extension of the baseline by adding the city's planned BRT network on top of the existing bus network. Key assumptions are:

- Existing bus routes with an average speed of 8.75 km/h.
- BRT network with an average operating speed of 25 km/h.

The geographic extents of the routes used for the proposed BRT are shown towards the end of this chapter, in Figure 4-15.

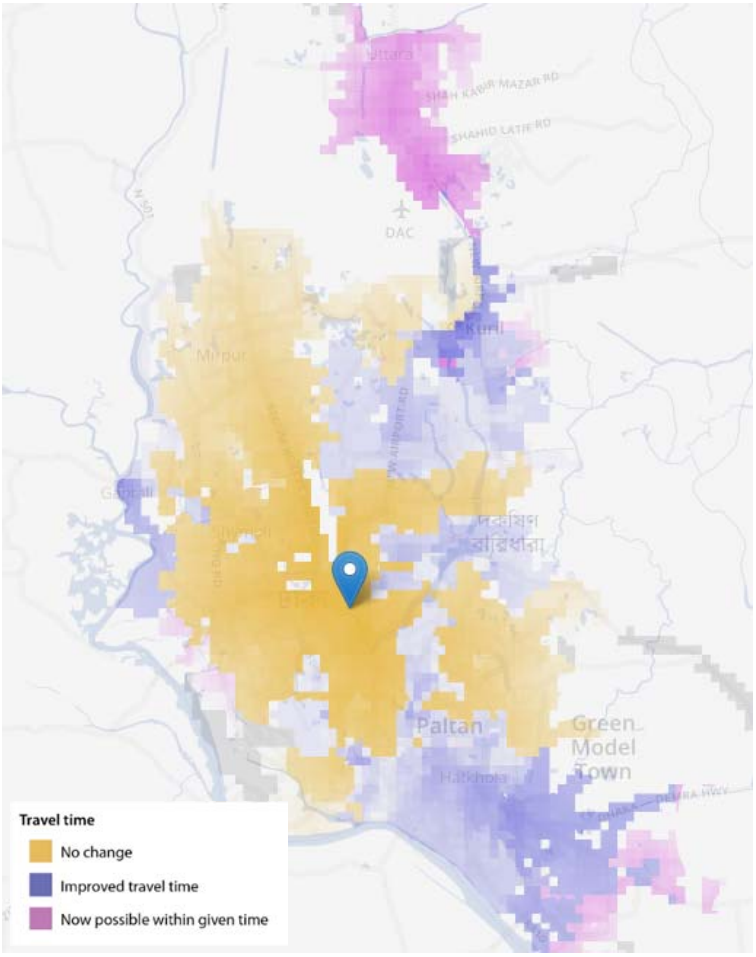
4.29 Figure 4-3 shows the improvement BRT makes when it is added to the baseline scenario made up of the existing network of bus services. Heading north along the BRT corridors journey times are greatly improved, and new areas of the city (Gabtoli to the North West, and Gulshan and Badda to the North East) are now within a 90 minute public transport journey of downtown in Motijheel. Note in the associated graphs a far greater proportion of the city's population are within 90 minutes of travel from the selected point.

Figure 4-3: Base scenario vs. Base scenario + BRT



4.30 Considering the proposed BRT in terms of different municipal services allows the examination of likely transport benefits for these services. The analysis was therefore repeated to estimate the increased accessibility from locations important to healthcare, existing transport, and industry. Figure 4-4 shows the extra accessibility provided by the BRT from a point at the transport hub in Farmgate. Substantive extra service within the 90 minute threshold is provided in the far southeast and northeast of the city (around the airport), whilst improved journey times are available in the east of the city generally.

Figure 4-4: Base scenario vs. Base scenario + BRT from Farmgate



4.31 The added benefits to medical and hospital services of the BRT are illustrated below, in Figure 4-5. Due to the location of these services in the north of the city, less benefit is experienced from the BRT compared to other areas. However, there is some increased coverage or reduced journey time within the 90 minute threshold around the south and the Kalabagan area. In Figure 4-6, the significant extra benefit of the BRT to industry and employment can be seen, as Tejgaon is considerably more accessible within 90 minutes, in particular when travelling either north or south.

Figure 4-5: Base scenario vs. Base scenario + BRT from Shymoli Shumela Intersection

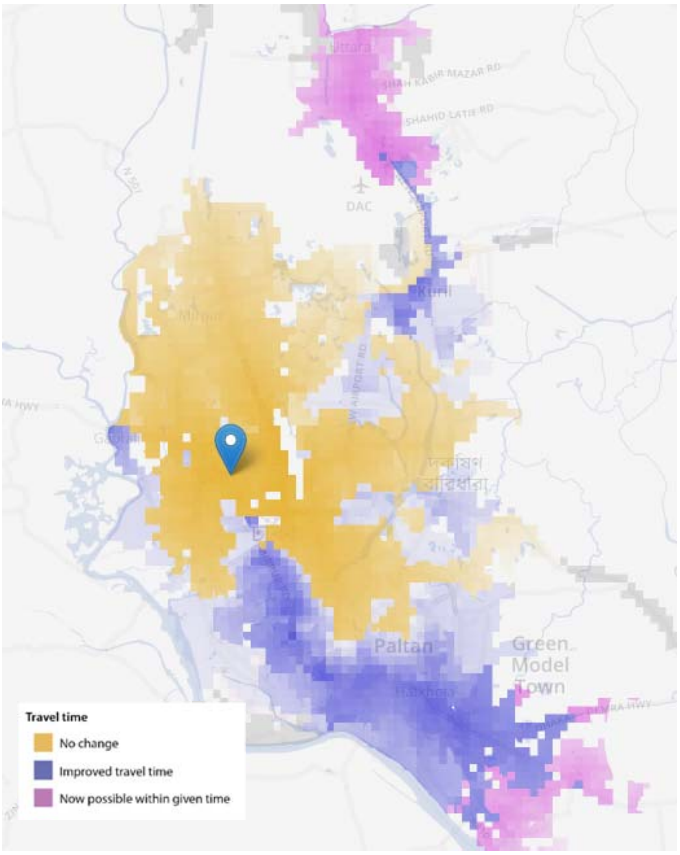
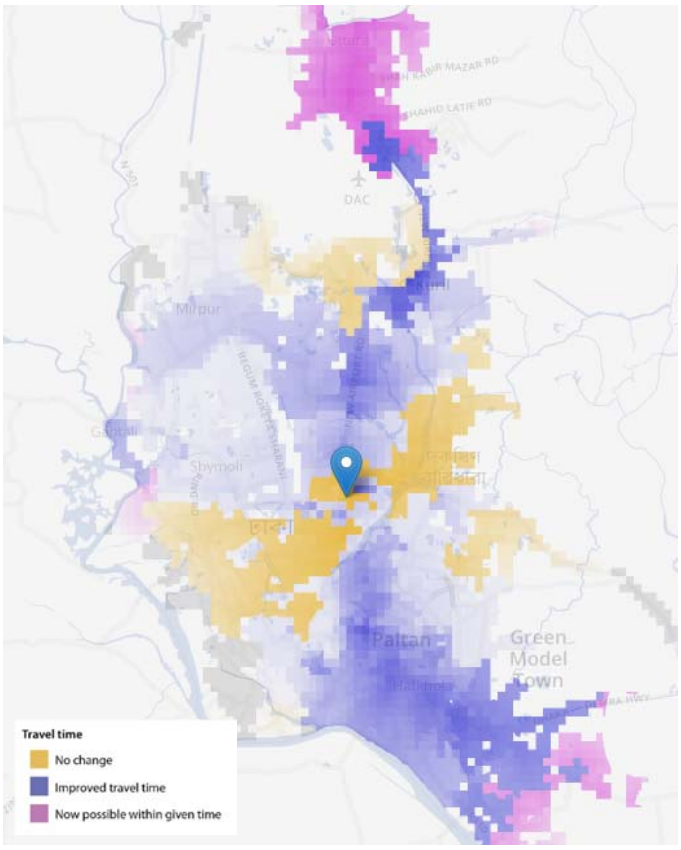


Figure 4-6: Base scenario vs. Base scenario + BRT from Tejgaon



Impact of BRT + MRT on transport accessibility

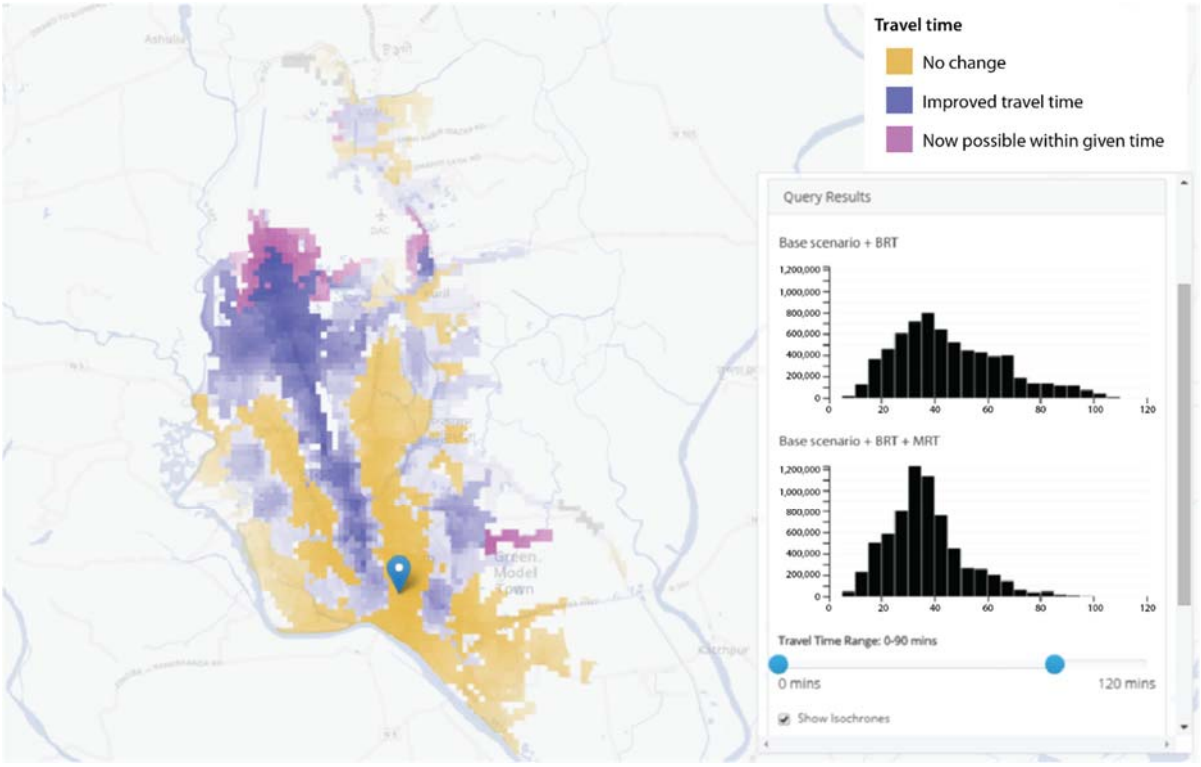
4.32 The BRT + MRT scenario builds iteratively on the BRT scenario, by adding in all the MRT lines that are proposed for development in Dhaka. Key assumptions for this scenario are:

- Existing bus routes with an average speed of 8.75 km/h.
- BRT network with an average operating speed of 25 km/h.
- MRT network with an average operating speed of 36 km/h.

The geography of the routes used for BRT and MRT are shown towards the end of this chapter, in Figure 4-1.

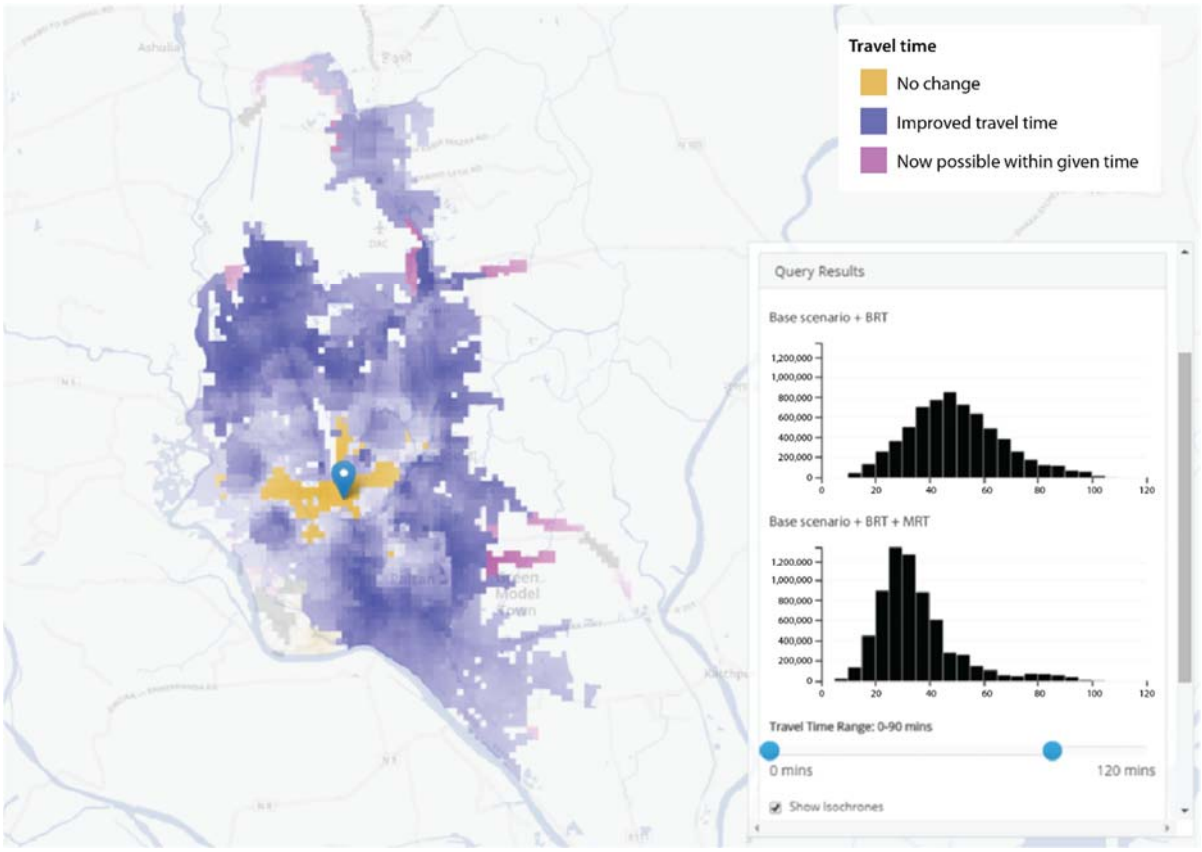
4.33 Figure 4-7 shows the improvement BRT+MRT makes when it is added to the 'base + BRT' network. At the speeds noted above, it is clear that coverage is extended in the north of the city, and journey times are improved (blue patches) around MRT stations in the east, west, and south. New coverage is also available in the far north of the city in the proximity of the airport due to the new MRT line. Not shown by the accessibility plot is the extra capacity provided by MRT: by adding in the MRT network it is clear that not only will capacity be improved, but there will be significant improvements in terms of service coverage (pink shading) and travel time (blue shading).

Figure 4-7: Base scenario + BRT VS Base Scenario + BRT + MRT



4.34 The Motijeel origin point selected in the above examples is only indicative of accessibility from one point in the south of the city. Further analysis was undertaken to estimate the potential benefit of the proposed MRT to different services. As expected, considering accessibility from other points served by proposed MRT lines also shows greatly improved travel times (or expansion of accessible areas). Figure 4-8 shows an example with the origin point moved to the Farmgate area. Journeys from this point are quicker for almost all destinations, including parts of the north of the city such as the airport area and Mirpur.

Figure 4-8: Base scenario + BRT VS Base Scenario + BRT + MRT, from Farmgate



4.35 The benefit of the proposed MRT to healthcare services (in particular, hospitals) is shown in Figure 4-9, using an origin point close to Shymoli Shumela Intersection. This shows greatly increased accessibility within the 90-minute threshold relative to the BRT scenario, with almost all of the city for which data is available having either new coverage or shorter journey time, including the far southeast of the city where there is substantive new public transit availability.

4.36 Finally, the extra accessibility around the industrial area at Tejgaon is shown in Figure 4-10. Here one can see that many areas in the north and east of the city experience reduced journey times from Tejgaon, though (perhaps surprisingly) less benefit is seen in the southeast of the city. Closer investigation shows that this may be due to the geography of the proposed MRT lines around the east of the Motijeel area, requiring users from Tejgaon to either change lines or take a circuitous route.

Figure 4-9: Base scenario + BRT VS Base Scenario + BRT + MRT, from Shymoli Shumela Intersection

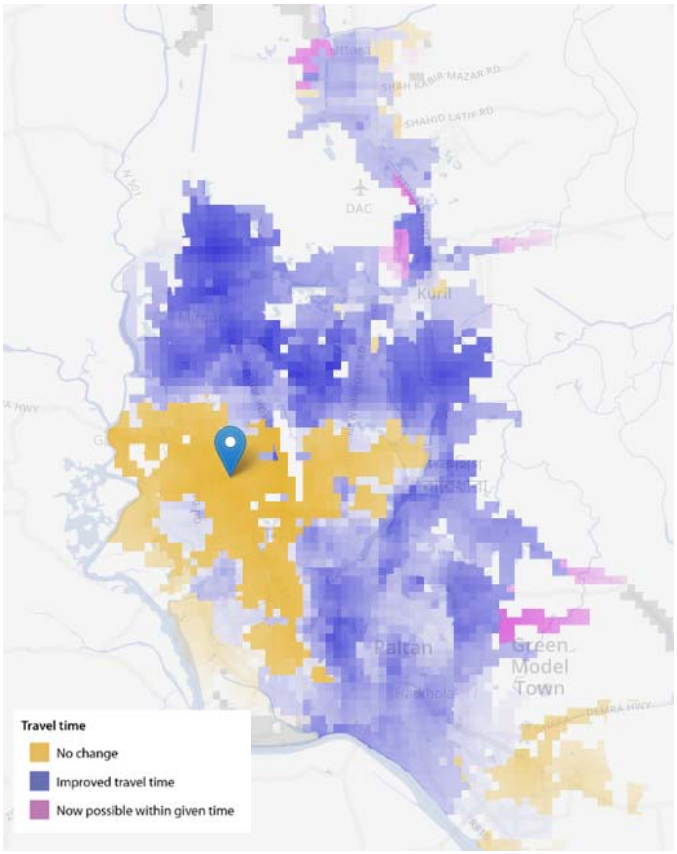
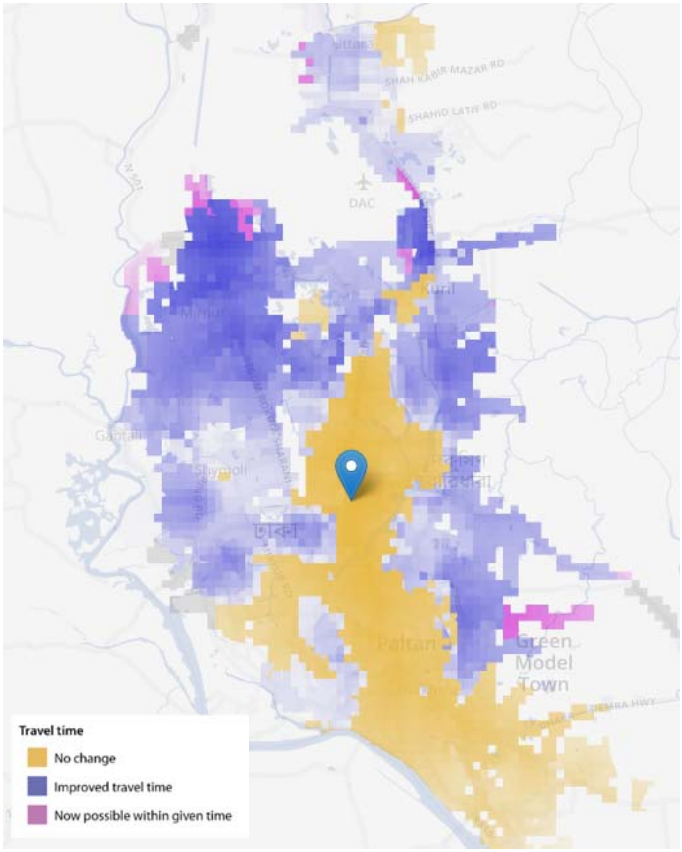


Figure 4-10: Base scenario + BRT VS Base Scenario + BRT + MRT, from Tejgaon



Summary

4.37 As would be expected given the relatively slow average speed of existing bus services, existing levels of public transport accessibility in Dhaka are poor. The addition of BRT and MRT lines with notably higher operational speeds will improve accessibility for a significantly larger proportion of the region's population. Table 4-2 summarises the total population living within ninety minutes travel time of the downtown area of Motijheel, to which we measured comparative public transport accessibility. With the introduction of BRT lines the accessible population increases by 25% over the baseline scenario. With the introduction of both BRT and MRT the population that can access Motijheel within 90 minutes travel time increases by 30% compared to the baseline.

Table 4-2: Population within 90 minutes by public transport from Motijheel

Scenario	People living within 90 minutes PT travel of Motijheel		
	Number	%	Increase (from base scenario)
Totals	*8,292,007*	*100%*	
Base scenario	5,226,461	63.0%	
Base scenario + BRT	6,503,827	78.4%	1,277,366
Base scenario + BRT + MRT	6,780,366	81.7%	1,553,905

Impact on females' transport accessibility in Dhaka

4.38 As identified by two previous World Bank studies[2,3], women in Dhaka are less likely to use public transport due to overcrowding and harassment from men. Instead women choose to use private modes of transport such as private cars or rickshaw, while females on lower incomes have little option but to walk - often spending up to two hours travelling to and from work.

4.39 The situation in Dhaka reflects World Bank and academic evidence from work elsewhere. In a report on female accessibility in Buenos Aires, Argentina[4], it was found that on average women must travel at significantly lower speeds due to the more limited transport options available to them. This is not just due to availability of suitable transport, but because women tend to have more complex travel needs that are influenced by their responsibilities for household tasks such as arranging childcare and running errands. Women with children, in particular, were also found to be more likely to make a greater number of trips in a day ('trip rate') than males (p3).

4.40 The *travel time budget* hypothesis, supported in the findings of the above work, is also pertinent to scenarios in Dhaka. Since the amount of time available for travel by individuals in a day is fixed, if only slower transport modes are available to females, then the geographic region that can be reached is smaller for that individual - greatly limiting access to employment, services and other opportunities.

4.41 Based on the information contained in the prior World Bank gender study reports, and through discussions with DTCA staff on project visits to Dhaka, we created a transport scenario for use in Transport Analyst for the purpose of modelling females' transport accessibility in relation to their male counterparts. This scenario used the same network as the whole population scenario (base scenario) but, supported by work such as that referenced above, used a travel speed of half that of the 'Base' scenario to represent the disadvantage and reduced mobility that women travelling in Dhaka experience[5].

4.42 When modelling BRT and MRT scenarios we assumed these new forms of transport will better cater for females needs, and will do so at an equal level to their male counterparts. Consequently we have used the same parameters as for the whole population, and are able to comment on the estimated changes in accessibility levels resulting from the introduction of these new public transport options in Greater Dhaka.

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[2] Study on Gender Dimensions in Dhaka Urban Transport Project (2000). Available online at: http://siteresources.worldbank.org/INTGENDERTRANSPORT/Resources/bangurbantransport.pdf.

[3] Integrating Gender into World Bank Financed Transport Programs (2003). Available online at: http://documents.worldbank.org/curated/en/2003/06/6451833/integrating-gender-world-bank-financed-transport-programs-case-study-lesotho-integrating-gender-ireland-aid-financed-rural-roads-access-program

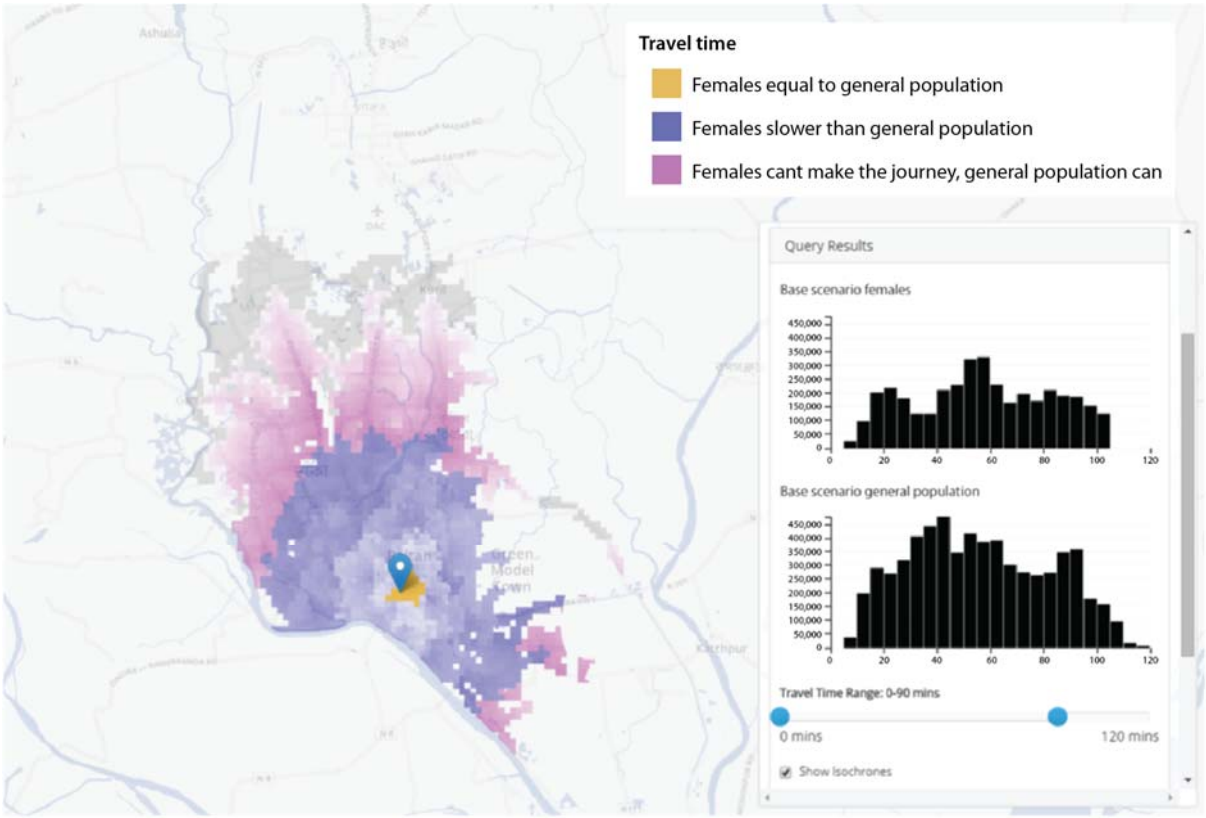
[4] Gender, Travel, and Job access: evidence from Buenos Aires. Available online at: http://siteresources.worldbank.org/INTURBANTRANSPORT/Resources/2014-Feb-5-Gender-and-Mobility.pdf

[5] The Buenos Aires project found women more likely to use public transport than the general population. However, in Dhaka this is expected to be different due to the issues raised in paragraph 4.35. For more information, see (3) above.

Current transport accessibility in Dhaka for females

4.43 Figure 4-11 shows a comparison between public transport accessibility for the whole population and that experienced by females in Greater Dhaka. As would be expected, due to the use of a travel speed of half that of the base scenario; the whole population has faster or greater access in all areas compared to females, except for the immediate area surrounding downtown Motijheel where walk speeds of males and females are assumed to be the same.

Figure 4-11: Base scenario females vs. base scenario general population

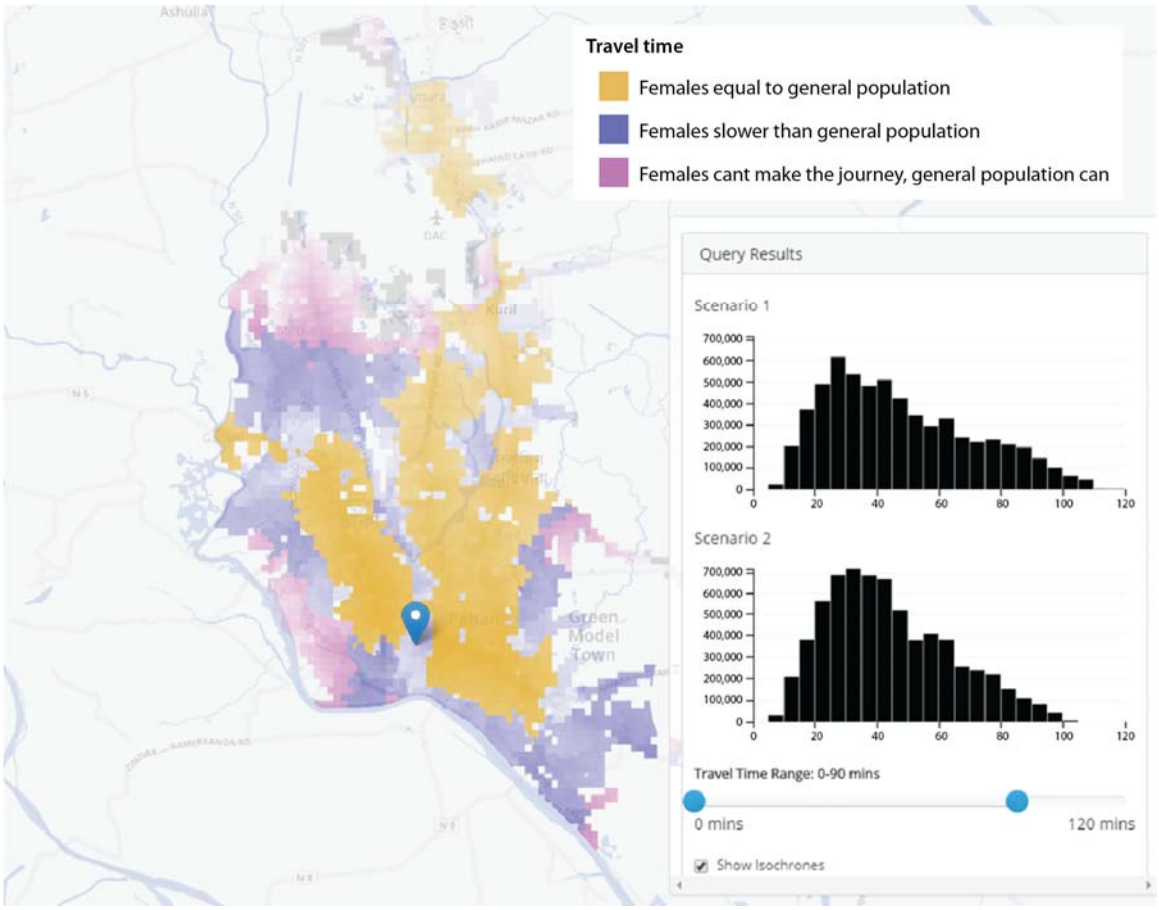


Impact of BRT on transport accessibility for females

4.44 Figure 4-12 shows a comparison between public transport accessibility levels for the whole population and females' accessibility after all of the planned BRT lines have been introduced in Greater Dhaka. The areas shaded yellow represent locations where public transport accessibility has been improved for females to the same extent as for the whole population. Areas shaded blue represent locations that females are now able to access within 90 minutes, but at a slower speed than the general population (resulting from documented reticence to use existing bus services). Areas shaded pink represent areas of Dhaka that females will be unable to access within 90 minutes travel time without using existing bus services.

4.45 The BRT corridors show up as two clear lines from the north of Motijheel (yellow shading), and represent the locations where accessibility between females and the whole population is expected to be equalised to the greatest extent.

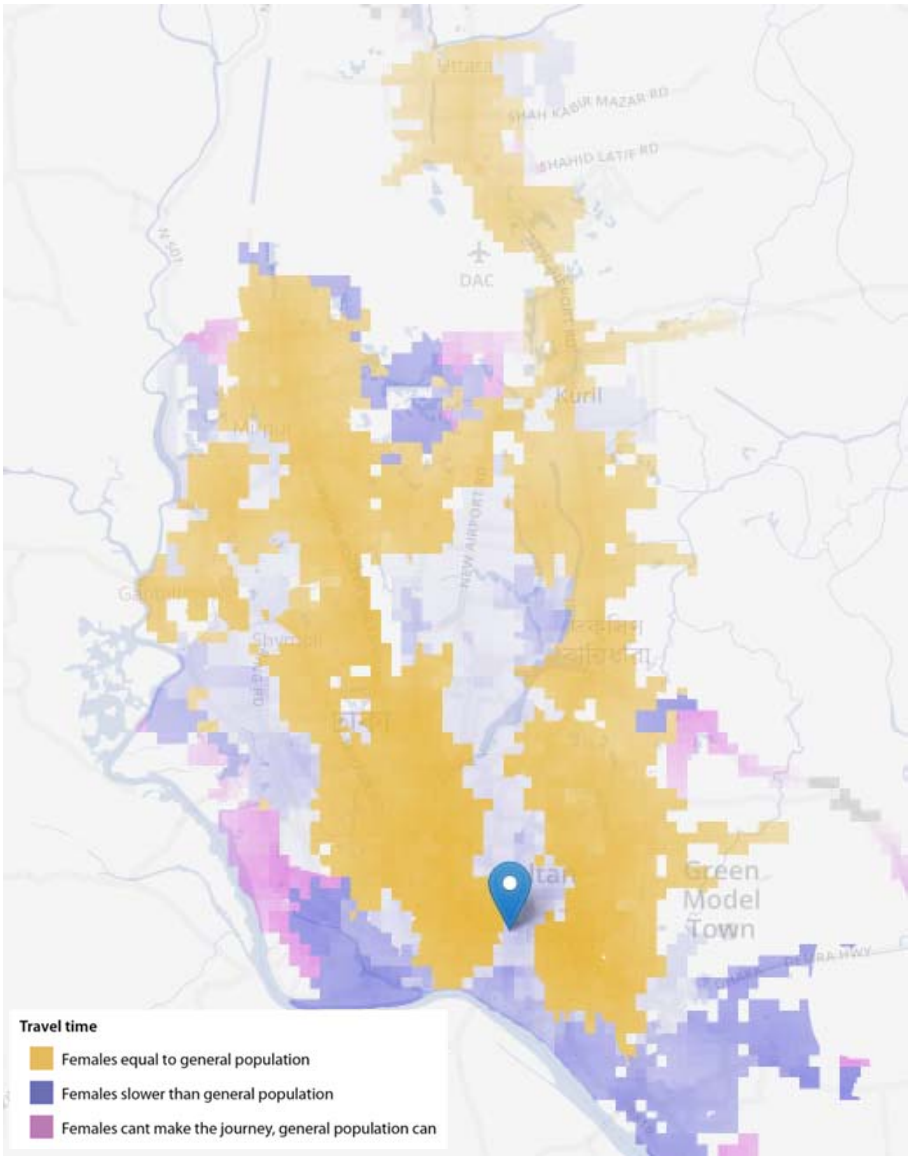
Figure 4-12: Base scenario females + BRT vs base scenario general population + BRT



Impact of BRT + MRT on transport accessibility

4.46 Figure 4-13 presents a comparison of 90 minute public transport accessibility for the general population compared with that for females after all planned BRT and MRT routes have been introduced in Greater Dhaka. The effect of the additional introduction of the proposed MRT routes is that Mirpur and Kuril in the north of the city-region are anticipated to become equally accessible for females as they are for the general population. Blue and pink regions on this map (particularly around Motijeel and Tejgaon) denote areas that women are less likely to be able to access in the 90 minutes threshold time, resulting in poorer accessibility.

Figure 4-13: Base scenario females + BRT + MRT vs. base scenario general population + BRT + MRT



4.47 Despite this projected equalisation of accessibility, there remain areas of the city (particularly to the south of Motijheel) that will be less accessible for females when compared with that for the whole population. These areas may be considered to represent opportunities for future investment in more inclusive public transport options that better meet the needs of females.

4.48 As noted previously in this report, the estimated improvements in accessibility are also predicated on the assumption the proposed BRT and MRT lines address the issues females experience in respect of harassment and overcrowding, which currently act as barriers to using bus services in Greater Dhaka.

Summary

4.49 Table 4-3 summarises the population of females residing within 90 minutes of the Motijheel area of downtown Dhaka. In the base scenario the proportion of all females residing within

ninety minutes' public transport travel time of Motijheel is 34%. With the introduction of BRT this increases to 68%, while the introduction of BRT and MRT are projected to increases this further, to 77%. The accessibility of the Male population is also displayed in the table for comparison.

Table 4-3: Female and male population living within 90 minutes PT travel of central Dhaka

Scenario	Female population		Male population		Whole population	
	Number	%	Number	%	Number	%
Totals	*3,685,727*	*100%*	*4,606,542*	*100%*	*8,292,269*	*100%*
Base scenario	1,259,435	34.1%	2,959,466	64.2 %	4,218,901	50.9%
Base scenario + BRT	2,515,777	68.2%	3,656,437	79.3 %	6,172,214	74.4%
Base scenario + BRT + MRT	2,854,372	77.4%	3,784,813	82.2 %	6,639,185	80.1%

4.50 The estimates of change in female population accessibility resulting from the implementation of BRT and MRT lines in Dhaka are derived from a different model methodology than the male values presented in the table above. As such they are not directly comparable, and the trends they reveal are considered a more reliable output than the absolute numbers. The estimates reported for 'Whole Population' in Table 4-3 are a summation of the values output by the two different accessibility models (male and female accessibility), and as such the estimated potential for improvement represents a more realistic assessment of the combined accessibility experienced by both females and males using public transit in Dhaka. This is also the reason why the Whole Population values presented in Table 4-2 (which are derived from a separate, whole population accessibility model) do not correspond with those calculated and presented in Table 4-3.

Alternative approach to calculating accessibility impacts for females

4.51 An alternative approach was also used to approximate the benefit of proposed new transit lines, to provide a comparator for the estimated numbers of females living within 90 minutes of central Dhaka. This was achieved by using a rough assumption that 50% of women within Dhaka are users of buses under the current situation. This approach also allows us to estimate the minimum number of females who are likely to benefit from the new BRT and MRT routes, given we can estimate the number of females who will not use the current bus network. The exact figure may be substantially higher, but nevertheless it helps to calculate a useful indicator of an approximate trend.

4.52 In the current situation, the number of females using buses can therefore be estimated as approximately:

*(Whole population in base scenario * Proportion of population that is female) * 50%*.

From this, an estimate of the number of females likely to consider using existing bus services and BRT, after the implementation of BRT can be calculated as:

> *(Whole population using BRT and existing bus services * 44%) – (Females currently not using buses)*

The total female population value from the Dhaka population data used in this study (as reported in Table 4-3) and the whole population accessibility model estimates reported in Table 4-2 were used as the basis for applying the calculations described above. The resulting values are reported in Table 4-4, and it is important to note that they reflect an underestimate of the degree of improved accessibility that will be received by females in Dhaka. This is because the estimation approach set out above assumes the same number of females that are currently estimated not to use public transport will continue to not use public transport in each of the future BRT and BRT+MRT scenarios.

Table 4-4: Female population likely to use transit in different proposed scenarios

Scenario	Female population		
	Number	%	Increase (compared to base scenario)
Totals	3,685,727	100%	
Base scenario female:	1,149,821	31.2%	
Base scenario female + BRT:	1,711,862	46.4%	**562,041 (+48.9%)**
Base scenario female + BRT + MRT:	1,833,540	49.7%	**683,719 (+59.5%)**

4.53 The findings in this section of our report demonstrate that the introduction of BRT and MRT will have a significant impact on journey times, and therefore public transport accessibility, in Greater Dhaka. Assuming they are delivered with appropriate priority from road traffic, the operational speeds of these new public transport services will increase from low existing levels (8.75 Km/h) and provide more predictable journey times. The result is expected to be a more inclusive and robust public transport network that connects a wider area of the city region.

4.54 Assuming the BRT and MRT services are all delivered in an inclusive manner such that accessibility, safety and security are ensured for all travellers (but particularly females); their benefit is expected to have the greatest impact on Dhaka's female population - whose average travel speeds we estimated to be roughly half their male counterparts as a result of females' understandable reticence to travel in overcrowded vehicles where they risk harassment and abuse. Even without any related inclusivity improvements to the existing bus network (e.g. to complement the improvements delivered through BRT and MRT lines), the public transport accessibility levels for females are envisaged to be much closer to those enjoyed by the whole population[7].

[7] One significant learning point from other developing cities where mode choice is currently constrained is that, where mass transit systems are introduced for the first time, they often quickly become heavily utilised

Land Use and Accessibility

4.55 To better understand the potential benefit of the proposed BRT and MRT lines, an accessibility analysis was also performed with respect to the different types of land use in the city. Unfortunately, limited data was available regarding the exact types of land use, and much of the land in the south of the city is marked as mixed use, but some initial accessibility analysis is provided below. It should also be noted that for some areas in the north and east of the city, GIS data was available but it was not labelled sufficiently for use in this analysis.

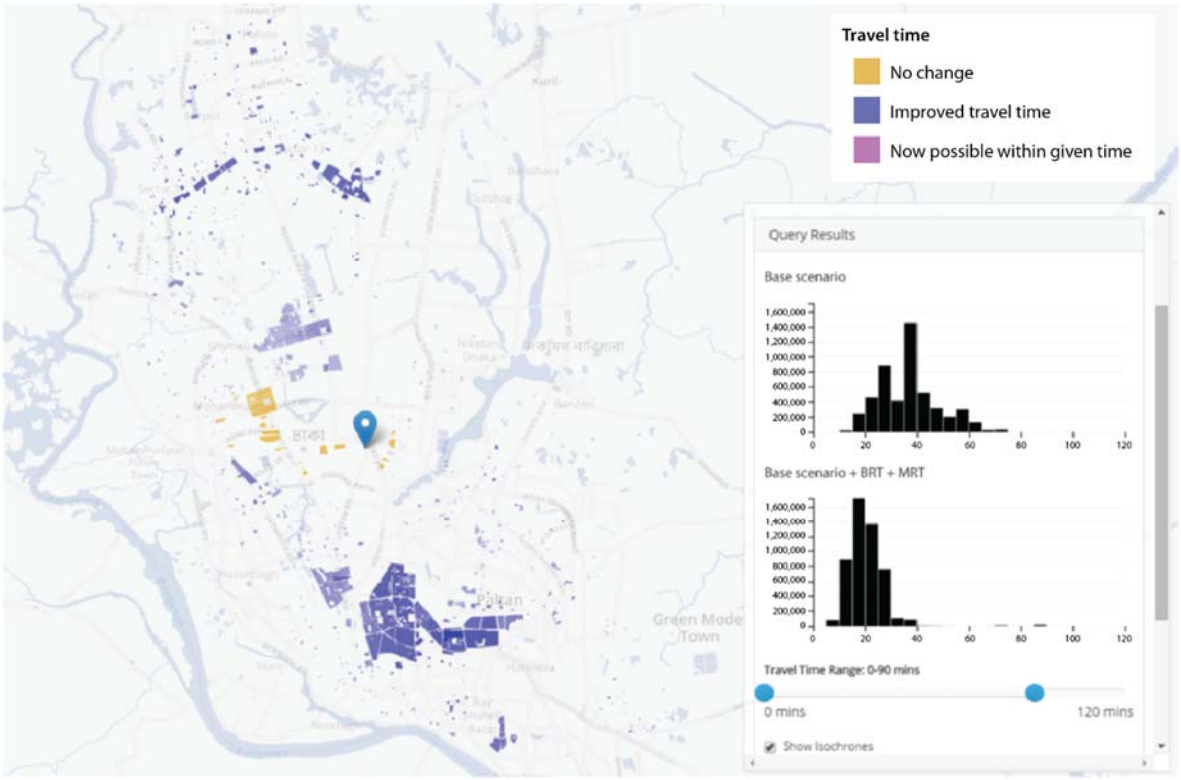
Educational land use

4.56 In order to estimate the different availability of educational and research facilities within the city with respect to the proposed transport network, the individual areas for different land parcels were calculated for use in accessibility analysis. Whilst this does not account for the exact type of educational institution or its capacity, it provides a useful indicator for the locations of services of different kinds and a basis for estimating capacity.

4.57 Figure 4-14 shows a comparative accessibility analysis by area for these facilities under both the existing transit network and under the BRT+MRT scenario (with all proposed changes having been implemented) from an origin at the Farmgate transport hub. Under the latter scenario, journey time is improved to all educational facilities except those closest to the origin point, with approximately 2 million square metres of 'education and research' land use within a 20 minute travel time.

and placed under significant operational stress. As such we note there is scope for the new BRT and MRT lines to become 'victims of their own success', as they are sequentially rolled out and unlock supressed demand for faster journey times. Consequently, the overcrowding they are being designed to help address (which creates many of the conditions in which females reported experiencing abuse or harassment), may be replicated on the new routes. Although it is impossible to model the consequences of future overcrowding of public transport investment in Dhaka, we assume the additional capacity created through delivery of the MRT and BRT lines will (over time) be matched with investment in existing local bus services. As such, it is reasonable to suggest that females will find it easier to travel around the city using both new and existing transport modes.

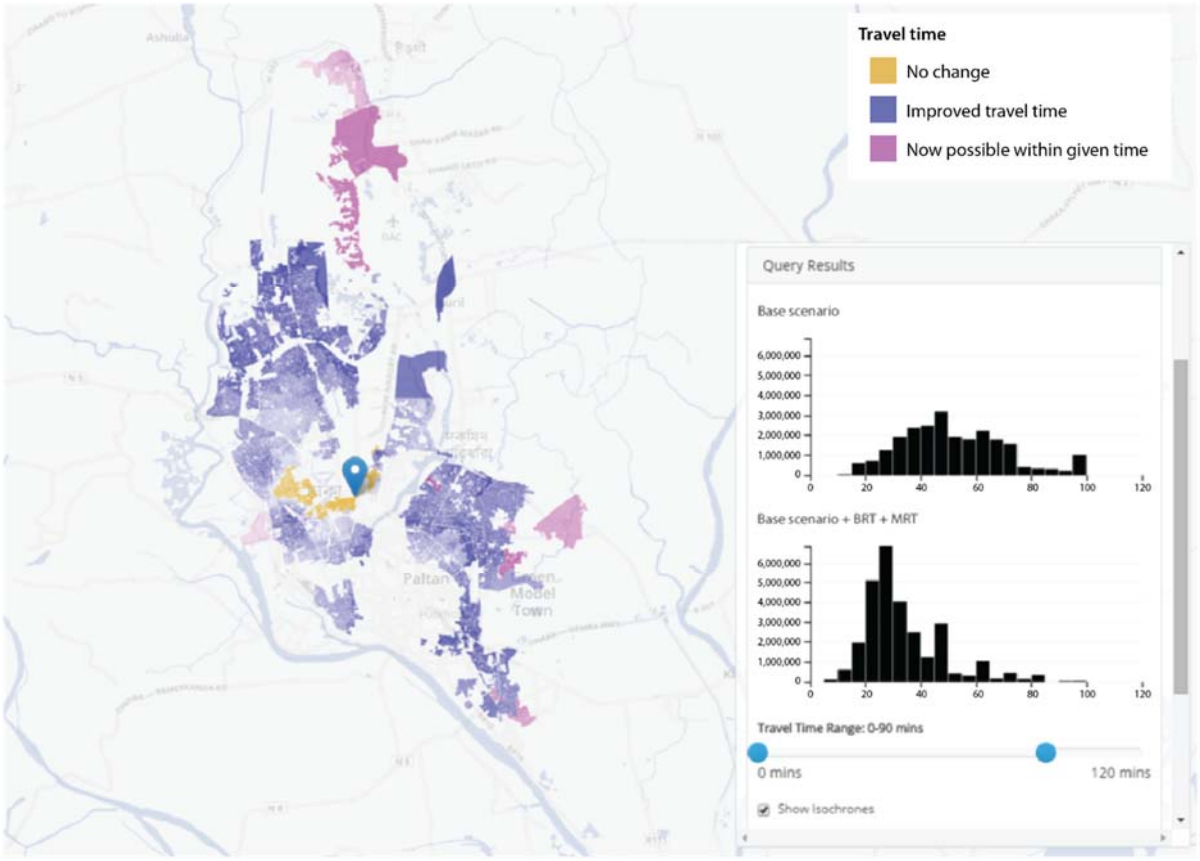
Figure 4-14: Accessibility of education and research institutions



Residential Land Use

4.58 An accessibility analysis was also performed for residential areas of the city. This allows the examination of housing availability with respect to transit provision. The same method as above, based upon the total areas of individual land parcels, was used to calculate this information. Unfortunately, more detailed data (such as the housing density in particular neighbourhoods or areas) was not available, but again this provides an estimate of the typical travel times between central parts of the city and residential areas of different sizes.

Figure 4-15: Accessibility of residential areas



4.59 The analysis in Figure 4-15 shows the differences in accessibility to residential areas between the base and BRT+MRT scenarios. The analysis is based around an origin point close to the Farmgate transport hub. With the exception of a small area very close to the origin point, shorter travel times would be experienced to almost all areas with the proposed new lines, and a far greater proportion would be within 40 minutes' travel from Farmgate. In addition, some residential areas to the north and east of the city would now be inside the 90 minute travel time threshold.

4.60 The potential changes in accessibility for areas with other types of land use could unfortunately not be investigated due to insufficient data or coverage. For example, whilst the general accessibility analysis earlier in this chapter considers the whole city and includes an analysis with the origin point in Tejgaon, much of the industrial area to the east of the city is not sufficiently labelled in land use data, limiting the type of analysis that can be performed. In future studies, types and locations of employment opportunities or industrial areas can be incorporated into accessibility analysis, to verify the exact value of proposed transit improvements (for example counting employment opportunities or factory size).

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Through this project assistance as provided to DTCA in order to help the organisation's small transport planning team to build in-house capacity related to its new organizational responsibilities for transportation policy, regulation, coordination, planning and management across Greater Dhaka. The key objectives of the project were to:

- Assist DTCA with data management and transport planning.
- Provide technical tools and training to build capacity among colleagues at DTCA.
- Deploy an accessibility-mapping tool for use in Dhaka.

5.2 The associated learning objectives for project capacity-building activities were fully met through the in-country training, research, and strategic data management advice delivered by the project team. This concluding chapter summarises the project outcomes in respect of each of the three objectives above, summarises lessons learned and identifies opportunities for future activities led by DTCA and RAJUK.

Assisting DTCA with data management and transport planning

5.3 As a result of this project, colleagues at DTCA and RAJUK now manage access to their own 1Tb Dropbox repository that contains the reports and underpinning data generated by recent transport studies in Greater Dhaka. Based on discussions at the training session held in July 2015, DTCA is already sharing access to the Data Hub across its own team and with colleagues at RAJUK. It also has the option to extend access to other local partner agencies and consultants, or to share commonly requested data files more publicly via the DTCA website. The DTCA team plans to upload datasets from current projects, such as BRT3 and MRT6, into the Data Hub structure established through this project.

5.4 Following the six days of training sessions delivered in Dhaka, the DTCA team now has a much clearer understanding of the range of open data formats that are relevant to urban transport systems. As well as understanding how city authorities in other developed and emerging countries have benefitted from opening-up their transport datasets, the team gained specific knowledge about the GTFS standard and the way it can be managed and analysed using open source software tools. This new knowledge focuses particularly on the use of GTFS, Open Street Map, and Census-derived population data to perform accessibility modelling and mapping.

The impact of this capacity building activity is that colleagues at DTCA and RAJUK now have a clearer understanding of the importance of data in underpinning strategic transport planning and network management. Through the Data Hub's inception the DTCA team has catalogued all of the datasets it holds, so they can be readily searched and retrieved for use in future transport planning projects. Colleagues at DTCA and RAJUK are now better placed to take independent responsibility for transport data management in Dhaka, and support international donor bank efforts to improve the city's transport networks.

The Data Hub stored in Dropbox will remain available until June 2018 as a legacy of the project. At this point DTCA will have the option to renew the storage or transfer the files to an alternate location with no vendor lock-in, maintaining ownership of its data.

Providing technical tools and training to build capacity among colleagues at DTCA

5.5 The research instances of the GTFS Editor and Transport Analyst software tools implemented through this project enable colleagues at DTCA and RAJUK to implement the knowledge gained through capacity building workshops. As a result of the training delivered in Dhaka, the local team is now able to manipulate GTFS datasets and use them in combination with GIS data files to model the accessibility impacts of different public transport scenarios. DTCA and RAJUK can use this new capability to forecast the impact of different public transport scenarios on access to different types of opportunity (jobs, healthcare and education facilities).

5.6 The techniques learned by colleagues at DTCA and RAJUK are also relevant to the development and maintenance of GTFS feed for the purpose of powering online journey planning tools. The team at DTCA highlighted this as a possible activity for follow-up work which would be valuable for both Dhaka residents and visitors alike. It will be particularly valuable if Dhaka's bus network reorganisation proposals are implemented in-line with the recommendations from the ALG study published in 2014.

5.7 The software resources established though this project will remain available to the team at DTCA until September 2016, during which time the project team will monitor the extent they are being used. This usage insight will help inform any case for longer-term investment in hosted instances of the tools. At this point DTCA will need to determine whether the value of GTFS Editor and Transport Analyst is worth the estimated annual cost (~$10,000 per annum) required to host and maintain the cloud servers through which the tools are delivered.

5.8 If they elect not to continue using the tools there is no penalty for doing so. There is no vendor lock-in to the tools, so DTCA and RAJUK remain free to take the GTFS and GIS data files they own and manipulate them with different software tools. At the time of delivering this project, there were few other options available for open-source transport modelling and intelligence using GTFS. Since that time, operators such as Remix (formerly TransitMix), Conveyal, OpenTripPlanner and Trillium have all produced either new products or substantial improvements to existing offerings. Some of these are available at competitive prices, whilst some are free but require technical expertise to install and maintain.

Applying this learning will enable DTCA's team to rapidly prototype and model the accessibility impacts of larger numbers of potential new transport lines (or reorganised bus networks), prior to investing time and resources in more detailed travel demand modelling that informs prioritisation of transport network improvements. Immediate activities to model access to healthcare and education facilities, and employment opportunities represent logical follow-up tasks for DTCA to aid deeper understanding of proposed BRT and MRT proposals.

It is recommended to determine whether there is value in maintaining the GTFS dataset, and cloud-based tools introduced through this project based on the extent to which they have been used since the completion of the current study.

Deploying an accessibility mapping tool for use in Dhaka

5.9 The Transport Analyst tool deployed through this project has been used successfully by the project team, and colleagues at DTCA and RAJUK, to calculate the projected accessibility impacts of all BRT and MRT routes planned for implementation in Dhaka. As noted above, the web-based tool remains freely available for continued use by DTCA and RAJUK until September 2016. It offers scope for the local team to undertake more detailed accessibility modelling and mapping analyses in relation to local transport planning objectives.

5.10 The research using the current bus route and service frequency data available from the previous ALG study (2014), and evidence from prior World Banks studies on gender inequality in Dhaka, demonstrated that current public transport accessibility levels are very low. By virtue of their faster operating speeds, and dedicated running lanes, the proposed BRT and MRT lines are expected to significantly increase the levels of public transport accessibility in the city region.

5.11 On the basis of the latest available Census data, the total population of the Dhaka Metropolitan area was counted to be around 8.3 million people in 2011, 44% of whom are female. Table 5-1 suggests that, when completed, all of the planned BRT and MRT lines will increase by 20% the number of people living in this area who can access Motijheel in Dhaka within a 90 minute journey by public transport and walking. The introduction of all new modes of travel in Dhaka will mean that over 82% of the metro area's population will live within a 90 minute walk and PT journey of Motijheel, compared with 63% currently.

Table 5-1: Estimated impact of BRT and MRT on the number of people who will live within 90 minutes of Motijheel by public transport

Scenario	Whole population
Base scenario	5,226,461
Base scenario + BRT	6,503,827
Base scenario + BRT + MRT	6,780,366

5.12 On the basis that all of the planned BRT and MRT lines will deliver public transport service conditions that are more acceptable for females (who currently seek to avoid overcrowded buses due to the threat of harassment and abuse), this population group is forecast to experience the greatest increases in public transport accessibility levels. Two different approaches to estimating the impacts on female accessibility were used, which reveal that:

- Between 31% and 34% of the 4 million females who reside in Metro Dhaka are currently able to access Motijheel within 90 minutes travel time by public transport + walking.
- This is projected to increase to between 49% and 77%, depending on methodology used, of all females in Dhaka once all planned BRT and MRT routes are introduced.

5.13 These statistics suggest that the planned BRT and MRT lines will significantly narrow the current public transport accessibility gender inequality gap that exists in Dhaka. They will provide females with comparable levels of connectivity along the alignments of planned new routes – particularly in the direction of Mirpur, Kuril, Shymoli, and Gabtoli.

5.14 One design consideration for the BRT and MRT lines, and their respective carrying capacities, is the potential for these services to be overwhelmed by mode-switching and supressed demand for faster journey times as they are sequentially completed and become operational. This is pertinent if their operation is to avoid replicating the overcrowded conditions in which females report experiencing abuse or harassment.

Transport Analyst represents a valuable tool for DTCA, RAJUK and other agencies in Dhaka. It may be used to explore the accessibility impacts of new public transport proposals, and forecast land-use changes in the future; as well as to better understand the areas of Dhaka that are currently poorly connected by public transport. The project team's work to understand and visualise the challenges experienced by females when using public transport in Dhaka could also be further expanded. Surveys that explore the specific bus routes that females are able to use in comfort at different times of day, and those they avoid, could inform more finely-detailed accessibility analyses.

Opportunities and potential next steps

5.15 A number of opportunities exist for colleagues at DTCA and RAJUK to apply the new capabilities developed through this project, which are documented in this sub-section.

Improving the quality of GTFS data (DTCA)

5.16 The GTFS dataset created as a by-product of this project was established from data collected as part of ALG's bus network reorganisation study (2014). The data are consequently 'high level' and rely on average bus operating speeds and headways which represent a best approximation of the way the bus network operates.

5.17 A logical next step would be to use the ongoing bus network reorganisation activities in Dhaka, which are likely to redesign the network to accommodate planned mass transit services, in order to update the GTFS dataset and ensure it is fit for public release to aid journey planning tools and updated bus network maps. Public information provided in Bangla/using images will be key to explaining how a re-organised bus network operates.

5.18 The user guides and supporting materials that document the workflow established through this project provide the basis for a localised approach to using GTFS Editor to facilitate this process.

OPPORTUNITY	DTCA could use GTFS to record individual bus route data
ACTIVITY	Detailed surveys of all bus routes, stop locations and journey times
OUTCOME	More accurate accessibility modelling and online journey planning

Opening up existing datasets to third parties (DTCA + RAJUK)

5.19 DTCA recognised there may be some value in opening-up selected transport datasets, and the project team provided a list of datasets that it recommended could be prioritised for release as public open data (See Appendix G, or here in the DTCA Data Hub). The only barrier to opening-up the data DTCA currently has is the website that would be used to

promote its availability. This could take the form of a dedicated site (e.g. data.dtca.bd), or - most simply - a page on the existing DTCA website (e.g. www.dtcb.bd/data).

5.20 The project team prepared a list of key requirements for the development of an Open Data Webpage (option 3) so that DTCA can build these into any future Terms of Reference for website development. The implementation of the project team's recommendations would be a logical next step towards maximising the value of the Data Hub, by:

- Increasing transparency and public engagement in discussions about transport network management and planning in Dhaka.
- Making datasets like GTFS available for app developers and bus operators wishing to create bus maps and journey planners for Dhaka public transport passengers.
- Saving DTCA officers' time when responding to common data requests from members of the public, academics, donor banks, and consultants.
- Raising the profile of the transport data collection and analysis activities of DTCA.

5.21 This project could be delivered by DTCA independently (with assistance from a local software developer), or as part of a larger public transport planning initiative such as the implementation of BRT and MRT.

OPPORTUNITY	Use DTCA and RAJUK websites to openly share public datasets
ACTIVITY	Link relevant Data Hub contents to existing government webpages
OUTCOME	Increase transparency, encourage third party transport information provision, and reduce time spent handling data requests

Merging data from the Transport Data Hub into DTCA's forthcoming server (DTCA)

5.22 DTCA's current project to establish a data server within its Nagar Bhaban office presents a near-term opportunity to build on the Transport Data Hub structure created through this project. Although the project team has limited insight into the purpose and content that will be stored on DTCA's proposed server, we propose the following are likely to be logical next steps for integrating the Transport Data Hub within it:

- Drawing on, and amending as necessary, the folder structure created through this project as a means of storing strategic reports and their datasets for the team within DTCA.
- Continuing to use the Transport Data Hub for collaborative data sharing with external partner agencies and consultants (e.g. serving data to the DTCA website or through shared folders). The cloud-based nature of the existing Data Hub will avoid DTCA having to share access to its own file-server with external agencies (adding security), and bring redundancy in the form of off-site duplicate copies.

OPPORTUNITY	Evolve Transport Data Hub to DTCA's own server in the future
ACTIVITY	Maintain folder structure and migrate to new server when ready
OUTCOME	Support DTCA's future ICT goals and accelerate use of new server

Further accessibility analysis under different data themes

5.23 Due to limited data available to DTCA and the project team, the accessibility analysis undertaken was relatively limited compared to what is technically feasible using more precise or wider ranging data. In paragraphs 4.56 and 4.58 above, accessibility of educational and residential areas was modelled using the transit network and the proposed BRT and MRT lines. Detailed data for other themes, in particular employment, can be used in a similar way. For example the number of jobs accessible from a particular city centre location can be estimated. This can use existing local data or that from international sources such as WorldPop (www.worldpop.org.uk).

OPPORTUNITY	Estimate detailed employment accessibility using current and proposed network
ACTIVITY	Obtain precise geographic data for types and locations of employment
OUTCOME	Detailed employment and infrastructure intelligence to support proposed schemes

Additional training for DTCA through current and future projects (DTCA + donor agencies)

5.24 The project team's dialogue with DTCA colleagues through the course of the project identified the following topics for additional training and support:

- Real-world application of Transport Analyst accessibility modelling tool outputs in common GIS software tools (e.g. QGIS), to specifically cover the following topics in a learn-by-doing context:
  - Determining estimated numbers of people living within defined public transport travel time isochrones of key locations in Dhaka.
  - Using Transport Analyst outputs to identify current areas of poor connectivity, to complement the bus network reorganisation project, and determine where additional public transport service coverage would complement planned BRT and MRT lines for Dhaka.
  - Testing BRT and MRT line impacts on modelled changes to population distribution and land-use in Greater Dhaka, to explore the effect these variables may have on public transport accessibility levels.
  - Testing BRT and MRT forecast/actual passenger data in comparison with accessibility modelling estimates of potential connectivity for people living within areas around the new transport corridors.
- Interrogating improved GTFS data to determine transport supply levels and capacities at given times of day, for comparison with travel demand data (e.g. from household surveys and cell phone datasets) to deepen understanding of how existing public transport supply relates to demand.

- Development of routine data collection regimes to ensure that datasets being collected through the course of strategic transport planning projects in Dhaka (STP, DHUTS, bus network reorganisation) are regularly updated for monitoring and operational improvement purposes.

OPPORTUNITY	Consolidate transport data management skills among DTCA team
ACTIVITY	Further training framed around 'live' projects & research questions
OUTCOME	Support further capability-building and independent application of strategic, data-driven, transport planning activities in Dhaka

Transport Modelling in the wider Planning context

5.25 Integrating GTFS-based transport modelling with the wider urban planning needs of a city is an important step in building an efficient public transit network. The Transport Analyst tool supports the industry standard format for geographic information system data ('shapefiles') which can be used to understand the transport accessibility of specific urban developments.

5.26 Similarly, the tools presented can be used to model other types of transport to those already tested. The GTFS specification supports eight different transport modes, and additional local types of service can be added using the GTFS Editor software. This means that travel time across a city can be modelled using the Transport Analyst software, even for less common types of transport such as cable cars and water transport.

5.27 In Dhaka this may be particularly important since there is substantial provision of water-based transport to the general public. Frequent or high-capacity services can be recorded in GTFS using the Editor software, and assigned an appropriate frequency or timetable. The resulting feed data could not only be used for accessibility modelling, but in public-facing journey planners which are aware of water transport services.

5.28 Furthermore, it would be possible to use the tool to estimate accessibility to spatial areas covered by RAJUK's master planning for the Dhaka Metropolitan Area. For example, the amount of employment land/forecast new dwellings that are within defined travel time boundaries of specific locations within the city could be estimated using tools like Transport Analyst. This would allow for comparative analysis of packages of spatial options in relation to different transport network scenarios (e.g. current, future with BRT & MRT) and better inform the master planning process when land is being formally allocated for development.

OPPORTUNITY	Better integration of data tools with the planning process, both for transport and building schemes
ACTIVITY	Incorporate other transport modes in Dhaka (eg water-based) to the produced GTFS feed
ACTIVITY	Model transport accessibility of proposed spatial allocations for residential/employment land using Transport Analyst prior to approval
OUTCOME	Better integration of planning processes between built environment and transport schemes.

Lessons for replicating support with open transport data & ICT in other locations

5.29 A number of lessons learned through the course of delivering this project will be relevant should World Bank or DTCA choose to replicate its outcomes in other locations. Table 5-2 sets out these lessons learned, the context in which they may be relevant, and the agencies to which they are applicable.

5.30 A common theme running through the lessons learned relates to ensuring software tools such as GTFS Editor and Transport Analyst are deployed in contexts where there is:

- A clear understanding of the local need for improved public transport data to power strategic transport planning and public information tools.
- A near-term strategic transport planning objective (in the case of Dhaka, planned BRT and MRT lines) against which the significant up-front effort needed to collate and edit public transport data can be aligned.
- The willingness among local teams to take responsibility for maintaining, and exploiting such datasets after the project is complete.

Table 5-2: Lessons for successful replication and future development

Lesson	Context	Applicable for…
Achieve cross-government and international agency support for public open data sharing prior to embarking on projects that will create open datasets as an output	This helps to achieve the scale necessary to develop web-based open data platforms that can host data created through this type of initiative (potentially across multiple cities in a country), and avoids the piecemeal approach instigated in Dhaka through this project	• World Bank TTLs wishing to conduct similar projects in other countries • DTCA and RAJUK teams seeking to involve other local agencies • Other city's transit agencies
Establish funding protocols for procuring Software-As-A-Service and call-off support, which demand on-going expenditure	It is often easier to justify one-off capital investment, than apportion revenue budget for software and training. This inhibits sustained use of cloud-hosted software tools beyond discrete projects, and lasting capability building.	• World Bank TTLs wishing to conduct similar projects in other countries • DTCA and RAJUK teams seeking to procure ICT and training services
Involve key local stakeholders in project decision-making, whilst guiding them with technical expertise and recommendations	Presenting a range of technical options to the DTCA and RAJUK teams, and encouraging debate around them, secured buy-in from an empowered set of project partner - increasing the likelihood of sustained adoption	• World Bank TTLs wishing to conduct similar projects in other countries • DTCA and RAJUK teams seeking to involve other local agencies
Establish robust and ongoing data collection efforts to improve data quality for other analyses/public information	In Dhaka the data on bus service operations were collected through a previous project. The high-level of detail was acceptable for strategic analyses of BRT and MRT investment proposals, but not sufficient for finer-grain analysis or reliable online journey planning information service.	• World Bank TTLs wishing to conduct similar projects in other countries • DTCA team seeking to update GTFS datasets in the future • Other city's transit agencies
Identify appropriate intermediate technology for data hosting where technical capability not present, before attempting full 'open data' platform	A thorough review of data hosting options (presented in Table 3-1) identified numerous levels of service provision appropriate to different stages in the open data development process. This table could act as a reference for the options available to different projects in the future.	• DTCA and RAJUK officers responsible for maintaining open transport datasets developed through this project
Establish a repeatable, and localised, workflow for data collection and management when using the GTFS Editor and Transport Analyst tools	User guides and project documentation offer a basis on which to establish localised workflows for using tools like GTFS Editor and Transport Analyst in other contexts. Fitting these around existing transit data collection and planning efforts is more successful than creating and sustaining totally new workflows	• World Bank Task Team Leaders wishing to conduct similar projects in other countries

Lesson	Context	Applicable for…
Create or maintain data representing *proposed* network changes in a standardised format, such as GIS or GTFS, to allow modelling of improvements to PT network	A hypothesised GTFS feed for the BRT and MRT networks in Dhaka had to be produced in order to model and analyse effects on accessibility. To get maximum possible benefit from a data-centric approach, network development proposals should be captured using standard data formats (irrespective of the actual software used for analysis) to maximise the tools available for decision making.	• World Bank Task Team Leaders wishing to conduct similar projects in other countries • DTCA colleagues involved in BRT and MRT lines moving towards construction
Obtain the best possible census and population datasets to maximise the effectiveness of modelling and analysis.	The analysis undertaken for DTCA had to use ward-level population, employment and education statistics disaggregated to a finer geographic scale. This approach is not ideal, and limits the effectiveness of transport model comparisons. Better accessibility modelling would be possible using exact data from smaller geographic areas.	• World Bank Task Team Leaders delivering projects in Dhaka • DTCA and RAJUK colleagues who have established relationships with local data owners
Consider hosting or funding permanent, free at point-of-use, instances of web-based tools such as those used in the delivery of this project so they can be offered as permanent resources for cities	DTCA colleagues were unsure whether the software tools are affordable in the long-term. A donor-supported suite of tools would reduce the cost of implementing future projects and ensure the tools remain in constant development, allowing for improvements to functionality to meet the needs of local users like the DTCA team in Dhaka.	• World Bank Group, and donor funding partners, with an interest in working across multiple cities and countries with similar transport data objectives
Carefully select data hosting options with future scalability requirements in mind.	Scalability was a minor concern through this project, given the focus on capacity building and the limited sources of local data available at the outset. In other contexts it would be appropriate to have considered the extent to which datasets may be dynamically updated (for example from real-time public transport schedules/highway sensors) and the need for cloud hosted servers to be able to accommodate the exchange of data through protocols such as GTFS Real Time (RT) and, potentially custom Application Programming Interfaces (APIs). Significantly larger-scale data servers, and connectivity bandwidth, would be needed to support this type of dynamic data environment.	• World Bank Task Team Leaders delivering projects in locations where potential to harness automatically generated data sources exists

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