IATSS Research 36 (2012) 56–65

Contents lists available at ScienceDirect

IATSS Research

Research article

Evaluating accessibility to Bangkok Metro Systems using multi-dimensional criteria across user groups

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ARTICLE INFO

Article history:
Received 11 September 2011
Received in revised form 23 December 2011
Accepted 5 February 2012
Available online 6 March 2012

Keywords:
Built-environment
Equity
Metro system accessibility
Sustainability

ABSTRACT

Metro systems act as fast and efficient transport systems for many modern metropolises; however, enhancing higher usage of such systems often conflicts with providing suitable accessibility options. The traditional approach of metro accessibility studies seems to be an ineffective measure to gage sustainable access in which the equal rights of all users are taken into account. Bangkok Metropolitan Region (BMR) transportation has increasingly relied on the role of two mass rapid transport systems publicly called "BTS Skytrain" and "MRT Subway", due to limited availability of land and massive road congestion; however, access to such transit arguably treats some vulnerable groups, especially women, the elderly and disabled people unfairly. This study constructs a multi-dimensional assessment of accessibility considerations to scrutinize how user groups access metro services based on BMR empirical case. 600 individual passengers at various stations were asked to rate the questionnaire that simultaneously considers accessibility aspects of spatial, feeder connectivity, temporal, comfort/safety, psychosocial and other dimensions. It was interestingly found by user disaggregated accessibility model that the lower the accessibility perceptions—related uncomfortable and unsafe environment conditions, the greater the equitable access to services, as illustrated by MRT — Hua Lumphong and MRT — Petchaburi stations. The study suggests that, to balance the access priorities of groups on services, policy actions should emphasize acceptably safe access for individuals, cost efficient feeder services connecting the metro lines, socioeconomic influences and time allocation. Insightful discussions on integrated approach balancing different dimensions of accessibility and recommendations would contribute to accessibility-based knowledge and potential propensity to use the public transits towards transport sustainability.

1. Introduction

Access to metro or any rail based transport system, including rapid elevated and underground transport, has become an outstanding issue for many societies in large cities as they aspire to shape the future with the use and implementation of efficient mass transport systems. Enhancing metro accessibility incorporates urban transportation policy and planning of cities to propagate sharing of alternative modes and to diminish car dependency. Coinciding with this, the conceptualization of "accessibility" for individuals has been defined [1,2] and has become an increasing criticism on long-term social sustainability [3]. Thus, the issue of equal access for all users has reached a crisis point in many expanding metropolises.

Unfairness in accessibility may be prevalent within Bangkok Metropolitan Region (BMR), Thailand — a metropolitan region including Bangkok and five surrounding provinces. BMR has two types of metros; namely, Bangkok Mass Transit System (BTS-Skytrain) and Mass Rapid Transit (MRT-Subway), which are located at the heart of the city adjacent to business centers. Running north–south of the inner city, the BTS has two main lines and the MRT has one line; covering distances totaling over 45 km.

Disadvantaged groups (e.g. women, the elderly and disabled people) seem to bear the burden of poor accessibility caused by only promoting high usage volume for typical users. A gender-oriented focus has shown that women have less access and tend to have multiple purposes to their trips [4]. At the same time, specific efforts should be made to investigate the capabilities and limitations of the elderly and the disabled in accessing such systems particularly in the realm of transferring modes within an existing metro system.

Although, many researchers and practitioners have undertaken metro accessibility assessments, their efforts, in general, have been central to spatial-based accessibility [5–7] or the economic values and location-based accessibility [8–10]. These were usually measured by the three indices of distance, time and cost.

These endeavors have not specifically focused on metro accessibility performance across groups in a social context. In addition, traditional approaches lack capturing of other forms of access indicators

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Peer review under responsibility of International Association of Traffic and Safety Sciences.

http://dx.doi.org/10.1016/j.iatssr.2012.02.003
0386-1112/

regarding multi-dimensional aspects. Questions have also been raised about the seemingly intrinsic and insurmountable access barriers which have arisen due to the design of the metro system. Discussions about the opportunity to access metro services across user groups can be judged in terms of socioeconomic, temporal [11], and behavioral [12,13] aspects.

The socioeconomic factors that are often given the most attention are those of affordability and service usability. The total cost of metro travel may be high due to encountering enormous transport costs from cross-mode transferring, which should be regarded across user groups. Inconvenient usability and confusion are often dominant problems for user groups, such as the elderly with their limited capabilities. In addition, psychosocial access predictors such as safety, social usefulness, trust, and comfort also need to be given more consideration [14–16].

According to a temporal aspect, two key factors are important for accessibility performance evaluation; namely, activity engagement [17] and the time opportunity of different user groups. The interaction of these two factors highlights the trip-making behavior of different gender groups and other user groups. Moreover, opportunity and equality to metro accessibility among user groups often remain invisible within dominant transport policy.

This study proposes to assess individual metro accessibility performance across user groups by applying multi-dimensional indicators. A new accessibility assessment framework was developed in this study based on a participatory and a sustainability approach. The chief goal of this paper is to investigate and to compare accessibility performance across groups, as the concern of equitable access (the opportunities and benefits of access to services across groups regarding multi-dimensional criteria are considered appropriate and satisfactory). The findings can be useful for improving ongoing metro projects and similar types of transit services in the study area and other cities. The assessment framework of this study can provide practical guidance for investigating accessibility performance of metro systems and other transport modes.

2. Metro accessibility systems in BMR, Thailand

BMR is a metropolitan region, which is comprised of the Bangkok Metropolitan Area (BMA) and five surrounding provinces (Samutprakan, Nontaburi, Nakhonpathom, Pathumthani and Samutsakhon), covering roughly 7583 km^2 with an estimated population of about 10.4 million (around 16% of the total population of Thailand).

In December 1999, two skytrain (BTS) routes started operating in the BMR. The Bangkok Metropolitan Authority (BMA) assigned a 30-year concession, which was to be privately financed, to Tanayong Plc. Five years later in 2004, the second metro system, the Mass Rapid Transit Subway (MRT) was officially launched. The Mass Rapid Transit Authority (MRTA) granted the Bangkok Metro Company Limited (BMCL) a 25-year concession to operate the service. Both the skytrain and the subway systems were built in the Central Business District (CBD) of Bangkok, which includes downtown areas of Siam, Silom, Sathorn and Sukhumvit Road.

Consideration needs to be given to the item inventories of both metro systems in the prospect of the availability and quality in enhancing metro accessibility. Regarding facility design and ticketing systems, Table 1 presents the existing conditions of metro access facilities, fare rates and incentives of selected stations.

As for ticketing, present fares for the BTS Skytrain and the MRT Subway are operated and calculated on a different basis. The fares are high when compared with buses and vans, and there is no fare transfer between the systems. The BTS offers passengers a 'Smart Pass' in four types: *BTS SKY Smart Pass*, *30-Day Smart Pass* (for students and adults), *Magnetic Pass* (1 day pass), and *Single Journey Ticket*. The MRT offers two types of ticket: *Single Journey Token* (for adults and children) and *Stored Value Card*. Both ticketing schemes have been designed for various time durations. Disabled people can use the service free of charge, provided they hold a disabled I.D. card.

Walking access facilities at stations are unfriendly for all user groups, but especially for the aged and the disabled. The design limitations are not only found in walking conditions, but also in the availability of basic facilities, such as elevators or any other instrumental support. Parking services are available at some stations and fees are high, with the exception of BTS — Mo Chit station where parking services are offered free of charge.

3. Approach and methodology

3.1. Approach

This study contributes to the balanced integration of multifaceted concepts of accessibility, such as built-environment, transport connectivity, socioeconomic, psychosocial, temporal and equity dimensions, for assessing metro accessibility performance with sound theoretical and empirical methods. In addition, accessibility assessment concerns not only typical user groups but also disadvantaged groups, such as women, the elderly and the disabled, through mixed-tool investigation and multi-stakeholder involvement by using the case study of metro systems in BMR, Thailand. Actions start at the clarification of questions such as, 'how do all user groups properly access the metro systems?' and 'what are the differences in their accessibility performance across user groups?' The evaluation process of the study is in combination with various aspects of metro accessibility based on a proper set of indicators, together with a well-structured study and concept, to manifest appropriately the metro accessibility performance.

3.2. Methodology

3.2.1. Selection of site stations

The key criteria used for selecting site stations was the ability for each station to give the expected example of all user groups, especially the elderly and disabled people. This is a limitation because such groups were found only in a small proportion of all users. In addition, they would demonstrate the various characteristics of functions of stations (terminal, interchange and typical stations), built-environment and facilities that can be visibly measured and provide adequate data supporting the research process. After the pre-survey, three BTS Skytrain stations (*Mo Chit*, *Saphan Taksin*,and *Chong Nonsri*), and three MRT Subway stations (*Chatuchak Park*, *Hua Lumphong*, and *Petchaburi*) were selected to assess the metro accessibility performance in BMR, Thailand.

3.2.2. Selection of indicators

First, a tentative set of indicators was conducted by reviewing and interviewing the representative stakeholders from various sectors such as local authorities (BMA), metro businesses (Bangkok Mass Transit System Public Company Limited (BTSC) and Bangkok Metro Public Company Limited (BMCL)), Mass Rapid Transit Authority (MRTA), Office of Transport Policy and Planning (OTP) and other interested groups. Second, a set of hypothesized indicators was adjusted and categorized into sustainability criteria. In this stage, 30 questionnaires comprising the indicator set were sent by email and by post to interdisciplinary experts related to multi-dimensional accessibility, in order to weigh a score using a five-point Likert item [18] to give the researchers a suggestion of selected indicators for assessing metro accessibility in the BMR. At the second stage, a total of 20 indicators and criteria were left as shown in Table 2. Third, factor analysis and reliability tests were created [19,20]. Initially, Kaiser–Mayer–Olkin (KMO) [21] and Bartlett's tests were applied to measure the sampling adequacy and to indicate the suitability for such analysis [22]. To check the validity of this structure, a reliability test was carried out to

Table 1
On-site facilities and feeder connectivity at the studied stations.

On-station facilities	Conditions	BTS stations			MRT stations		
		Mo Chit	Saphan Taksin	Chong Nonsi	Chatuchak Park	Hua Lumphong	Petchaburi
Facilities for pedestrian and bicycle access	1. Sidewalk	The width is between 1 and 3 m.	The width is between 1 and 3 m.	The width is between 1 and 3 m.	The width is between 1 and 3 m.	The width is between 1 and 3 m.	The width is between 1 and 3 m.
	2. Bicycle parking	n/a[a]	n/a	n/a	n/a	n/a	n/a
	3. Way link between Park and Ride	Link with more than 2 entrances	Link with 1 entrance	n/a	Link with more than 2 entrances	n/a	Link with more than 2 entrances
	4. Park and ride	0.04 m^2	n/a	n/a	0.04 m^2	n/a	0.05 m^2
	5. Staircases/elevators/ escalators	Availability of staircases/ elevators/escalators	No elevator	Availability of staircases/ elevators/escalators	Availability of staircases/elevators/escalators	Availability of staircases/ elevators/escalators	Availability of staircases/ elevators/escalators
	6. Flooring	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete
	7. Sky walkway	n/a	n/a	Available	n/a	n/a	n/a
	8. Luggage trolleys	n/a	n/a	n/a	n/a	n/a	n/a
	9. Facilities in use for announcing arrivals/ departures/giving time	Available	Available	Available	Available	Available	Available
Facilities for disadvantaged groups access	10. Doorways to the public access for disabled users	Poor	n/a	Poor	Poor	Poor	Poor
	11. Information point/desk at station						
	–For disabled users	n/a	n/a	n/a	n/a	n/a	n/a
	–For elderly	n/a	n/a	n/a	n/a	n/a	n/a
	12. Ticket machines accessible to all disabled	Available	n/a	Available	Available	Available	Available
	13. Adequate signage for the blind at station	Poor	n/a	Poor	Poor	Poor	Poor
	14. Elevators for disabled/ elderly	Available	n/a	Available	Available	Available	Available
Fares and parking fees	15. Fare rates	Single journey: 15–40 THB[b] Disabilities: free	Single journey: 15–40 THB	Single journey: 15–40 THB Disabilities: free	Adults: 16–41 THB Youth/elderly: 8–21 THB Disabilities: free	Adults: 16–41 THB Youth/elderly: 8–21 THB Disabilities: free	Adults: 16–41 THB Youth/elderly: 8–21 THB Disabilities: free
	16. Parking fees	n/a	n/a	n/a	30 THB/h or 10 THB/2 h if presenting smart card	n/a	40 THB/h or 10 THB/2 h if presenting smart card
Incentives	17. Discounting card	Available	Available	Available	Available	Available	Available
	18. Others	n/a	n/a	n/a	Free ride for children (≤14 years old) and disabilities The discount rate given to elderly	n/a	n/a
Feeder connectivity	19. Bus lines	40 lines	11 lines	1 line	40 lines	19 lines	13 lines
	20. Paratransits	Available	Available	Available	Available	Available	Available
	21. Boat	n/a	–Crossing-river ferry –Express boat	n/a	n/a	n/a	n/a
	22. Train	n/a	n/a	n/a	n/a	Hua Lumphong railway station	n/a
	23. Bus rapid transit (BRT)	n/a	n/a	BRT Sathorn–Ratchaphruek	n/a	n/a	n/a
	24. Suvarnabhumi Airport Rail Link (SRT)	n/a	n/a	n/a	n/a	n/a	Link with SRT — Asok station

[a] n/a = not available.
[b] 31 THB ≈ 1 USD (as of February 1, 2011).

Table 2
Indicators selected by factor analysis and reliability test.

Indicator interpretation	Predictors included in the indicator	Measurement
Psychosocial (Y1)	Safety	Sufficient level of commitment of safety operation and strategies of managers/ staff
	Social usefulness	The extent to which attitudes on positive feelings of users on metro services on perceived support (respect, recognition, approval)
	Trust	The extent to which attitudes of willingness to rely on metro services
	Comfort	Satisfaction level of people on cleanliness, lighting, weather, ventilation, shade, etc.
Temporal (Y2)	Activity period	Time period of target activities
	Trip purpose	The characteristics of trip purposes
	Duration	The comparison of duration preference of metro trip e.g., trips on daytime, on-peak, off-peak
Affordability (Y3)	Income	Personal income per month (THB per month)
	Occupation	Occupation of respondents
Basic needs and market-based (Y4)	Basic needs	Attitude level on how metro services respond to their needs and desires
	Market-based	Attitude level in response to "Do you get what you pay for?"
Connectivity and mixed use (Y5)	Potential connectivity	The calculation of average connectivity and average integration by space syntax technique
	Mixed use	$1-\left\{\frac{\left\lvert\frac{r}{T}-\frac{1}{4}\right\rvert+\left\lvert\frac{c}{T}-\frac{1}{4}\right\rvert+\left\lvert\frac{i}{T}-\frac{1}{4}\right\rvert+\left\lvert\frac{o}{T}-\frac{1}{4}\right\rvert}{\frac{3}{2}}\right\}$ Where : r = acres in residential use (single and multi-family housing), c = acres in commercial use, i = acres in industrial use, o = acres in other land uses, and $T = r + c + i + o$. A value of 1 indicates perfect mixing of the four land uses
Design attractiveness (Y6)	Attractiveness of metro utilities	Percentage of weighted attractiveness summations of utility design (built-environment around stations) adopted to optimize the use of metro services
Equity (Y7)	Equality to access	The extent of attitude to which respondents think that they receive equal benefit from services
	Opportunity to access	The extent of attitude to which respondents think that they have equal opportunity to access metro services and are taken into account in an equal manner
Time and activity obligation (Y8)	Time obtaining	Total time (min)
	Activity location	The distance of activity locations from stations (km)
Urban environment/ compact (Y9)	Compact	Percentage of residential, commercial, employment and other activities near the station within a 5 km radius
	Reducing sprawl	Level of attitudes related to spatial knowledge and settlement, modal experiences, paths and behavior to reducing sprawl

quantify accuracy according to '*Cronbach's coefficient alpha*' [23] and item-total correlation score.

3.2.3. Questionnaire survey

A total of 600 questionnaires were completed by interviewing metro passengers at the six BTS Skytrain and MRT Subway station sites in the BMR for the assessment process. Data collection was administered at various times of day and on different days of week. The questionnaire structure consisted of three parts related to individual travel information (e.g. where they live/origin and destination, feeders, time and costs of whole trip) and other crucial dimensions, such as built-environment, connectivity, socioeconomic and psychosocial aspects, comfort/safety, time opportunity and the opinions related to needs and equity. To test the reliability of the questionnaire structure, 50 passengers were chosen to be pilots. The data were disaggregated by different social groups including men, women, the elderly (age > 60 years old) and disabled people (physical disabilities such as blind/visual impairment and wheel chairs/physical impairment).

3.2.4. Assessment of metro accessibility

The evaluation process made use of the fitting indicator set based on factor analysis and reliability test (Table 2). The performance results were transformed to a standard scale, with a score between 0 and 1 assigned for each predictor, and then mean scores of each indicator were calculated. Accessibility score of 0.00 indicates very poor accessibility performance, while 1.00 indicates very good accessibility performance. A high score elicits better metro accessibility performance.

4. Results

4.1. User's characteristics

Table 3 illustrates the characteristics of the users at the selected stations. Among 600 respondents, almost half (49%) were male, and only 10% were over 60 years old (elderly group). Disabled people (blind or physically impaired) accounted for about 4.5%. The majority of respondents (around 60%) were working groups in commercial business (34%), government positions (5%), entrepreneurship (18%), and international organizations (3%). The statistics show that 40% of the respondents are non-working commuters, including students and an unemployed group. The average income of respondents falls in the range of 10,000–20,000 THB/month (USD325–645), albeit the average total expenditures of metro traveling (fares + parking costs (if any) + feeder costs) is about 2400–4000 THB/month (USD75–130). Pearson's chi-square test at 95% confidence level shows that there is no difference between the user's characteristics at the selected stations.

In addition, the respondents were given an open-ended question asking them to indicate their current residential location/origin and destination. The majority (almost 80%) of respondents live far (more than a 500 m radius) from the site stations where the results are classified by 3 categories including *Location type A* — live within a 500 m radius from station enabling users to reach the station with 5–10 min walk (23.5%), *Location type B* — live beyond a 500 m radius from station within the same station district (74.5%), and *Location type C* — live outside station district within BMR areas (2%).

Regarding feeder modes, bus transit is the major feeder of the metro systems representing 40%, followed by van (around 23%). Paratransits such as hired motorcycles and taxis are important feeders for the elderly and disabled people who have few other satisfactory options. Boat travel is another feeder type at some stations connected to a river, such as the Saphan Taksin station. Based on the surveys, access to such stations always involves a mixed-access pattern mode, such as, walk + bus + boat, walk + van + boat, and hired motorcycle + bus + boat (except for the elderly and the handicapped). At the other stations, people used multi-modes, such as walk + paratransit, walk + bus, walk + bus + paratransit, bicycle or car only. This phenomenon influences access costs and behavioral responses across user groups.

4.2. Overall metro accessibility performance

Overall, mean values of metro accessibility performance indicated a fair level of accessibility ranging from 0.544 to 0.630. However, more explanation concerning different dimensions of accessibility in Table 4 emphasizes the need for a basic policy to improve built-

Table 3
User's characteristics.

User's characteristics		BTS — Mo Chit	BTS — Chong Nonsri	BTS — Saphan Taksin	MRT — Chatuchak Park	MRT — Petchaburi	MRT — Hua Lumphong	Total	(%)	Pearson chi-square	Sig.*
1.	Gender										
1.1	Male	53	47	51	48	44	50	293	48.833	2.034	0.844
1.2	Female	47	53	49	52	56	50	307	51.167		
Total		100	100	100	100	100	100	600	100.000		
2.	Age										
2.1	<20 years old	10	10	10	7	6	8	51	8.500	31.331	0.178
2.2	21–30 years old	44	30	37	32	42	34	219	36.500		
2.3	31–40 years old	24	24	36	24	23	26	157	26.167		
2.4	41–50 years old	7	16	10	14	16	9	72	12.000		
2.5	51–60 years old	9	8	3	9	4	9	42	7.000		
2.6	>60 years old (elderly)	6	12	4	14	9	14	59	9.833		
Total		100	100	100	100	100	100	600	100.000		
3.	Non-disabled or disabled people										
3.1	Non-disabled	91	97	98	96	94	97	573	95.500	7.795	0.168
3.2	Disabled	9	3	2	4	6	3	27	4.500		
3.2.1	Blind	6	2	1	3	3	2	17	2.833		
3.2.2	Other physical impairment	3	1	1	1	3	1	10	1.667		
Total		100	100	100	100	100	100	600	100.000		
4.	Income										
4.1	<10,000 THB/month	11	11	21	14	15	10	82	13.667	35.607	0.078
4.2	10,001–15,000 THB/month	41	39	37	46	36	43	242	40.333		
4.3	15,001–20,000 THB/month	23	27	12	13	21	33	129	21.500		
4.4	20,001–25,000 THB/month	8	6	11	11	10	3	49	8.167		
4.5	25,001–30,000 THB/month	13	11	12	7	11	7	61	10.167		
4.6	>30,000 THB/month	4	6	7	9	7	4	37	6.167		
Total		100	100	100	100	100	100	600	100.000		
5.	Occupation										
5.1	Non-work group	31	36	47	46	40	40	240	40.000	26.656	0.145
5.2	Work group	69	64	53	54	60	60	360	60.000		
5.2.1	Hired employee	35	42	27	31	36	32	203	33.833		
5.2.2	Government officer	4	3	5	2	7	10	31	5.167		
5.2.3	Entrepreneur	23	17	20	17	15	15	107	17.833		
5.2.4	International organization officer	7	2	1	4	2	3	19	3.167		
Total		100	100	100	100	100	100	600	100.000		
6.	Education										
6.1	Less than bachelor degree	18	15	22	18	17	16	106	17.667	14.555	0.149
6.2	Bachelor degree	67	67	63	63	78	74	412	68.667		
6.3	More than bachelor degree	15	18	15	19	5	10	82	13.667		
Total		100	100	100	100	100	100	600	100.000		
7.	Vehicle in household (car, pick up or motorbike)										
7.1	No vehicle	53	43	59	41	40	39	275	45.833	16.613	0.083
7.2	1–2 vehicles	42	53	39	54	56	53	297	49.500		
7.3	>2 vehicles	5	4	2	5	4	8	28	4.667		
Total		100	100	100	100	100	100	600	100.000		
8.	Trip per week										
8.1	<5 trips/week	28	29	23	30	40	29	179	29.833	17.369	0.067
8.2	5–8 trips/week	42	34	31	41	36	41	225	37.500		
8.3	9–15 trips/week	30	37	46	29	24	30	196	32.667		
Total		100	100	100	100	100	100	600	100.00		

* Significant at 95% confidence level.

environment at almost all stations, except for MRT — Hua Lumphong where the performance regarding this aspect is comparatively high in scores of connectivity and mixed use and urban environment. In the results regarding questions related to urban environment, the survey indicates the actions of concern for metro accessibility include the behavior related to spatial and travel experiences. According to the results, a much greater proportion of metro users at MRT — Hua Lumphong have the positive opinion and view of walking access to public transit (45.7% agreed) and some have characteristics of the active traveler (37.1% agreed). Those who do not own a car or motorbike are much more likely to use the metro transit systems.

4.3. Metro accessibility performance disaggregated by user groups (men, women, the elderly and the disabled)

4.3.1. Temporal variability and affordability

Fig. 1 depicts the findings relating to multi-dimensional assessment of the access performance to metro services for selected stations across user groups. The tabulation along with detailed examination shows that women, the elderly and disabled were found to have difficulty accessing services in various aspects. The elderly would be expected to be affected by the impacts of accessibility regarding temporal dimension over the other groups in almost all stations. In this case, 85% of aging passengers usually engage in the trip at off-peak periods or weekends with social purposes (e.g., visit relatives/friends or go shopping) times which possibly seem to have irregular and limited feeder services resulting in the lower accessibility scores. Not only the elderly but also the disabled likely prefer to commute during off-peak hours, together with having short activity duration that is outstandingly manifested in BTS — Chong Nonsri, BTS — Saphan Taksin and MRT — Petchaburi stations.

Interestingly, based on the interviews, at peak-hours, the working disabled are likely to commute by other transit modes instead of using metros as the reason of the inconvenient access conditions, especially comfort and safety. It would be clearly seen at BTS — Saphan Taksin station where the lower accessibility score regarding psychosocial

Table 4
Metro accessibility performance based on fitting a set of indicators to the selected stations.

Stations	Y1–psychosocial	Y2–temporal	Y3–affordability	Y4–needs and market-based	Y5–connectivity and mixed use	Y6–design attractiveness	Y7–equity	Y8–Time and activity obligation	Y9–urban environment	Mean values of metro accessibility performance (Y)[a]
BTS – Mo Chit	0.767	0.623	0.480	0.674	0.375	0.385	0.811	0.680	0.415	0.583
BTS – Chong Nonsri	0.703	0.583	0.471	0.508	0.250	0.553	0.679	0.776	0.555	0.564
BTS – Saphan Taksin	0.663	0.827	0.309	0.628	0.500	0.513	0.705	0.498	0.465	0.567
MRT – Chatuchak Park	0.665	0.700	0.542	0.595	0.375	0.438	0.653	0.618	0.310	0.544
MRT – Petchaburi	0.694	0.570	0.524	0.605	0.375	0.480	0.655	0.760	0.394	0.561
MRT – Hua Lumphong	0.704	0.447	0.474	0.599	0.750	0.543	0.645	0.659	0.848	0.630
Average[b]	0.699	0.625	0.466*	0.601	0.438*	0.485*	0.691	0.665	0.497*	0.574

[a] There was no significant difference of performance scores among stations based on *t*-test significant at 95% confidence level.
[b] The overall average scores for metro accessibility performance by each indicator were ranged from 0.000 to 0.249 (very low accessibility), 0.250–0.499 (low accessibility)*, 0.500–0.749 (fair accessibility), and 0.750–1.000 (very good accessibility).

dimension is illustrated. Furthermore, the consideration of this prospect for the disabled is noticeably seen by all BTS stations and MRT — Chatuchak Park station.

In addition, Fig. 1 points out gender differences (*t*-test significant at 95% confidence level) in terms of an affordability aspect measured by income and occupation. Most females (about 70%) earn less than 20,000 THB/month, indicated as low accessibility, whereas males earn much more. The elderly at many stations, such as BTS — Mo Chit, BTS — Chong Nonsri, MRT — Chatuchak Park and MRT — Hua Lumphong also have to be taken into consideration with this aspect. On the other hand, disabled people were found to have fair accessibility according to affordability criterion.

Regarding time consumed and activity obligation (measured by the distance from the end station to the destination), the majority of metro users (>70%) have less egress distance at the end of the trip (<0.5 km), especially the elderly. The respondents considered the route before traveling by metro. However, some users have a long egress journey, so they used multi-modes to access their activity location as aforementioned. Although walk egress distance is quite low, it does not mean that people are provided with good accessibility. From the performance results of time consumed (Table 5), the estimation data indicated that the average total travel time from origin to destination is about 40–60 min, reported as a poor to fair accessibility level. Users wasted time in waiting to catch various transit modes, and walking to stations. As such, a double impact exists for the vulnerable groups (women, the elderly and disabled people).

Table 5 illustrates that most disabled people spent the greatest amount of time on metro accessibility compared with the other groups, with the average total time of about an hour, followed by the elderly (about 41–50 min). Regarding gender, men and women show little difference in time taken, by which the percentage of respondents of both groups were equally distributed at all range. Nevertheless, for cost consideration, most of the elderly spent more than the other groups because of costlier feeders. It is interesting that disabled people, even with being exempted from paying metro fares (Table 1), still pay high for the metro trip owing to the feeder expenses. Based on survey, taxis seem only a popular feeder choice for them in the case of indirect routes.

4.3.2. Psychosocial consideration on accessibility

The individual accessibility scores regarding psychosocial perspective, obtained from the assessment obviously illustrate access differences across user groups as shown in Fig. 1. Except MRT — Hua Lumphong and MRT — Petchaburi stations, the disabled potentially remark the service provision in the condition of comfort, safety, social usefulness/supports and trust, regarded as the psychosocial parameters. With this respect, the disabled at MRT — Chatuchak Park were found to have the lowest accessibility scores (0.2). Data from structuring interview emphasize the substantial consideration of safety management and effective communication for such vulnerable group. Through detailed investigation as demonstrated by the satisfaction test in Table 6, a majority of disabled people (66.7%) showed a very low perception of the provision of travel information, and in the available support in understanding route links and transfers.

About 50% of disabled groups were strongly dissatisfied with the safety operation of services that should be much considered as the key area of the accessibility attention. More than half of the elderly also agreed on this latter concern. They face difficulties due to indirect routes, wasting time on transferring as well as creating additional costs for themselves. Contrary to the hypothesis, the opinions related to psychosocial aspect between men and women have no significant differences.

4.3.3. Design attractiveness

The illustration in Fig. 1 also provides the essential evidence of unsuitable conditions of facility design supporting metro access of

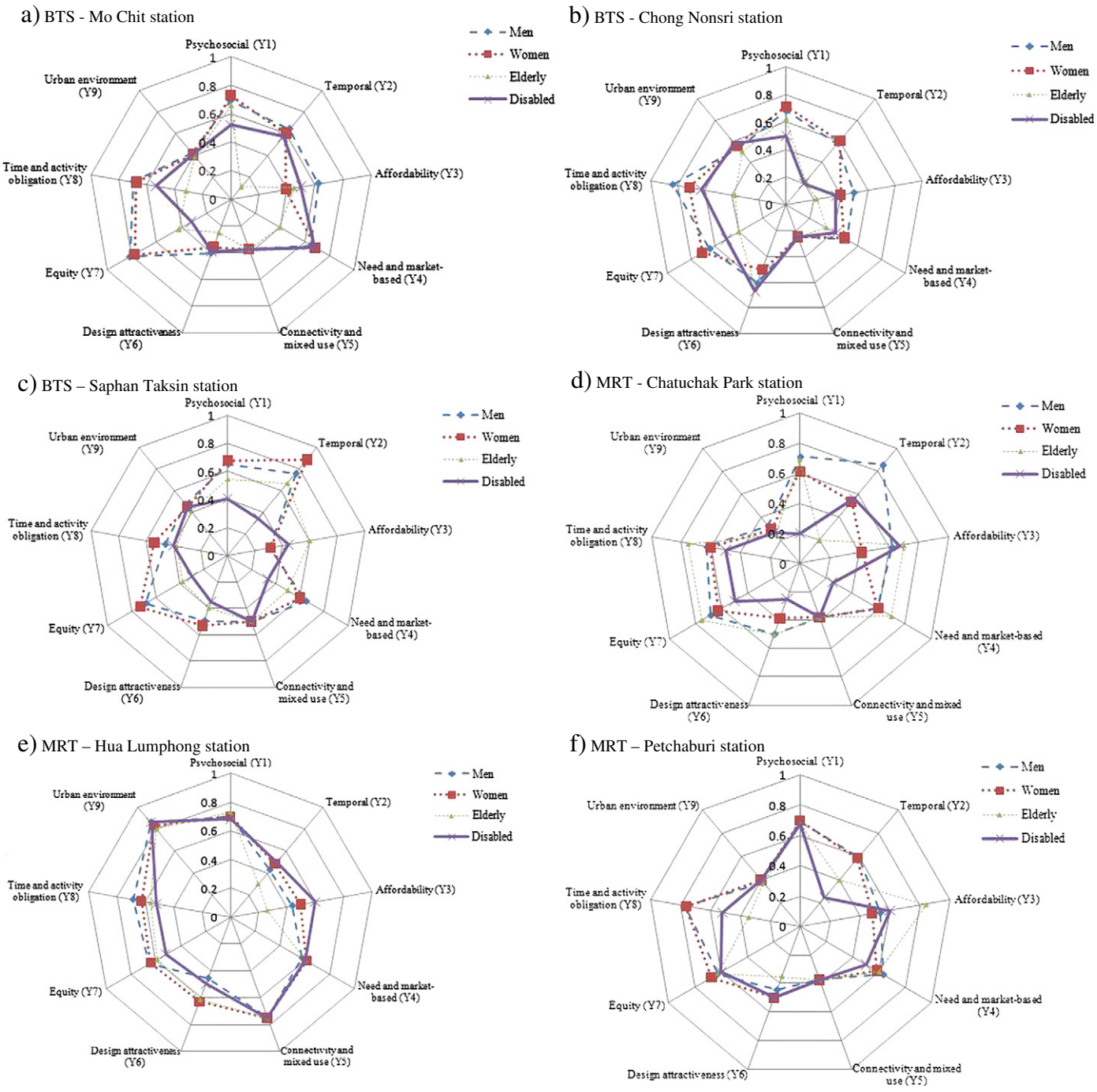

Fig. 1. Metro multi-dimensional accessibility performance of selected stations disaggregated by different user groups. Note: (1) Accessibility scores range from 0.00 which indicates very poor accessibility performance, to 1.00 which indicates very good accessibility performance; (2) *T*-test sig. at 95% confidence level for male and female accessibility = 0.042 (*t*-values 2.638), for typical and disabled users = 0.027 (*t*-values 2.215), and for typical and elderly people = 0.363 (*t*-values 0.910).

vulnerable groups in some stations. Women, the elderly and disabled at MRT — Chatuchak Park station seem to have a poor performance with this prospect; while BTS — Mo Chit, located next to it, failed to serve the appropriate access facilities to the elderly group. Also, BTS — Saphan Taksin, without the elevator and special services to accommodate the needs of the elderly and disabled (see Table 1) found poor performance for such groups in similar concern.

The results in Table 7 show that the majority of the elderly and the disabled feel dissatisfied with the availabilty of access facilities, and the convenience and the quality of access facilities. For the design arrangements related to connectivity, significant differences among user groups are found. The elderly and the disabled feel inconvenienced by the access facilities. During the interview, these groups showed their interest in improving design arrangements and access facilities, especially with the sidewalks. This phenomenon raises the notion of a universal design concept.

4.3.4. The attitudes related to equity aspect

The study also asked the respondents about their attitudes to opportunity and equality to metro access. The results show that the performance are parallel to the pre-investigation of access practices where disadvantaged groups (70% elderly, 65% disabled, 50% women) expressed that they receive a lack of opportunity and unequal benefits on their perceived access needs. There are significant

Table 5
Total time and total costs of commuting by metro commuting.

User groups	Total time (minutes)[a]					Total (%)
	≤30	31–40	41–50	51–60	>60	
Male	12.3	20.1	24.9	28.7	14.0	100
Female	13.4	17.3	28.7	20.5	20.2	100
Elderly	2.5	15.0	37.5	22.5	22.5	100
Disabled	0.0	3.7	14.8	59.3	22.2	100
	Total costs (THB)[b]					Total (%)
	≤40	40–60	61–80	81–100	>100	
Male	45.1	31.4	11.6	9.2	2.7	100
Female	41.4	32.2	14.7	7.2	4.6	100
Elderly	12.5	22.5	32.5	10.0	22.5	100
Disabled	14.8	40.7	18.5	18.5	7.4	100
	Very good accessibility → Very poor accessibility					

[a] Total time = access time + waiting time + time used of metro commuting.
[b] Total costs = feeder costs + metro fares + parking fees (if access to station is by car).

differences between the BTS and the MRT according to equity concerns (Fig. 1). In this case, the performance related access equity of the MRT seems better than that of the BTS. In terms of opportunity to access the BTS, route information and transferring, remain the great barriers for BTS, especially for people with disabilities and the elderly. In addition, in the equality assessment, the most important access difference between the BTS and the MRT is seen to be the differences in unequal access benefits, especially high percentage of accidents for disadvantaged groups concerning walking access at the BTS.

5. Discussions

Based on the framework of this research, it is intended that a better understanding of equitable access be reached. As such, the existing metro accessibility performance based on the BMR empirical case induces an accusation of unfairness in metro accessibility along with various aspects across user groups. Support was found for the hypothesis based on a statistical *t*-test at 95% confidence level (note (2) Fig. 1). The mean scores of overall accessibility performance identify significant differences between female and male, and also disabled and typical user groups. Despite the fact that the assessment model does not statistically distinguish the mean scores between the elderly and typical users, the data of some aspects such as psychosocial, facility design and temporal dimensions showed poor accessibility levels as aforementioned in details examination. These pertain to the consideration of transport planning and policy of cities.

5.1. Implication of the results

Even though the rationale behind the traditional accessibility approach has yielded improving mass rapid transport and more accessibility of other public transport for people in the cities, it might fail to explicitly show the details examination of the effects of individuals across socioeconomic segments under accessibility attention. Also, their responses on needs, abilities, and opportunities relating access might be overlooked, as comprehended by the study. To balance priorities of individual access to services based on BMR empirical case, policy actions differentially targeting the vulnerable groups regarding different dimensions of accessibility should be geared for consideration.

Considering *psychosocial*, *comfort* and *safety dimensions*, these entities have impacts on access needs and abilities. Regardless of user disaggregation (Table 4), accessibility level indicated by psychosocial parameter across stations seems high; albeit it does not truly reflect whether all user groups properly and satisfactorily access the metro systems as the chief target of equitable access compared to disaggregated version in Fig. 1. It can be implied from the study that the lower the feelings of uncomfortability and unsafety associated with accessing metro services, the greater equitable access to services will be. The example of this assumption could be seen in the MRT — Hua Lumphong and MRT — Petchaburi stations, where accessibility scores regarding psychosocial dimension (Y1) across user groups seem equal and high, with the attitudes to equity (Y7) reports following in the same direction — in contrast to the results from other stations. With regard to premium fair service accessibility, it is important to integrate a safe environment program into the policy that addresses the existing possible risks to vulnerable groups on using and accessing services and substantially identifies acceptable safe condition of the groups.

Table 6
Satisfaction test in attitudes related to psychosocial aspect of metro accessibility.

Satisfaction	User groups	Strong dissatisfaction	Dissatisfaction	Partial satisfaction	Satisfaction	Strong satisfaction	Total (%)
Perception of travel information provision, or supports in understanding route links and transferring	Men	0.0	2.0	44.7	45.7	7.5	100
	Women	0.3	2.9	34.9	53.4	8.5	100
	Elderly	0.0	57.5	10.0	32.5	0.0	100
	Disabled	3.7	66.7	29.6	3.7	0.0	100
Directness of routes that does not make passenger facing waste of time travel or creating opportunity costs	Men	0.7	3.8	42.7	47.4	5.5	100
	Women	0.3	5.5	52.4	35.8	5.9	100
	Elderly	0.0	20.0	52.5	27.5	0.0	100
	Disabled	0.5	4.9	48.5	40.3	5.8	100
Satisfaction of service quality related to indoor environment e.g., cleanliness, lighting, etc.	Men	0.0	3.8	40.6	42.3	13.3	100
	Women	0.3	2.0	36.8	50.2	10.7	100
	Elderly	0.0	5.0	72.5	22.5	0.0	100
	Disabled	0.2	3.0	38.7	45.9	12.2	100
The extent to which attitudes of willingness to rely on perceived control and quality of management of services	Men	0.0	2.4	42.7	39.9	15.0	100
	Women	0.0	2.9	33.6	52.1	11.4	100
	Elderly	0.0	0.0	32.5	62.5	5.0	100
	Disabled	8.6	2.8	30.6	45.4	13.3	100
The extent to which attitudes on positive feelings of users on metro services on perceived support	Men	0.0	3.8	32.4	41.6	22.2	100
	Women	0.0	2.9	30.0	47.6	19.5	100
	Elderly	0.0	0.0	22.5	60.0	17.5	100
	Disabled	3.5	0.0	31.8	44.9	19.9	100
Sufficient level of commitment of safety operation and strategies of managers/staff	Men	0.3	5.5	44.4	44.0	5.8	100
	Women	0.7	6.2	48.2	37.1	7.8	100
	Elderly	5.0	52.5	20.0	15.0	7.5	100
	Disabled	11.1	37.0	40.7	11.1	0.0	100

Note: Ratings range from strong dissatisfaction (accessibility scores 0.00) which indicates very poor accessibility performance, to strong satisfaction (accessibility scores 1.00) which indicates very good accessibility performance.

Table 7
Attitudes to design attractiveness.

Attitudes to design attractiveness	User groups	Strong dissatisfaction	Dissatisfaction	Partial satisfaction	Satisfaction	Strong satisfaction	Total (%)
The availability of access facilities e.g., ticketing machines, signage and elevators	Men	0.0	12.3	35.5	40.6	11.6	100
	Women	0.0	10.1	34.2	44.6	11.1	100
	Elderly	0.0	25.0	32.5	42.5	0.0	100
	Disabled	22.0	51.9	22.2	3.7	0.0	100
The convenience of access facilities	Men	14.0	22.2	51.9	3.7	0.0	100
	Women	10.1	24.6	24.2	30.0	7.2	100
	Elderly	22.5	37.5	15.6	28.0	8.8	100
	Disabled	14.8	35.0	27.5	10.0	5.0	100
The quality of side walk	Men	3.8	29.6	44.7	21.6	0.3	100
	Women	3.3	36.7	45.6	13.8	0.7	100
	Elderly	0.0	62.2	21.6	21.6	0.0	100
	Disabled	14.8	48.1	18.5	18.5	0.0	100
The design arrangement related to connectivity within station areas	Men	2.0	19.1	32.1	33.4	13.3	100
	Women	3.9	25.7	32.9	30.0	7.5	100
	Elderly	27.5	50.0	15.0	7.5	0.0	100
	Disabled	22.3	48.1	22.2	7.4	0.0	100
The quality of side walk e.g., width and flooring	Men	4.1	33.4	34.8	20.1	7.5	100
	Women	4.6	32.6	33.2	23.1	6.5	100
	Elderly	2.5	50.0	17.5	25.5	5.0	100
	Disabled	3.7	51.9	14.8	11.1	18.5	100

Note: Ratings range from strong dissatisfaction (accessibility scores 0.00) which indicates very poor accessibility performance, to strong satisfaction (accessibility scores 1.00) which indicates very good accessibility performance.

Unsatisfactory comfort and safety on metro access as the result of Section 4.2 have been derived from several access processes upon types of user groups. It becomes essential that, based on findings, majority of the disabled are dissatisfied with safety operation, by which they would face accidents, especially the blind, from getting off feeders, walking to stations, and taking elevators (available only in some stations) to boarding. Despite the fact that the services have staff responsible for helping them; they would prefer to be offered special facilities/design supports for manually accessible services. Also, senior passengers significantly have an effect on this prospect, but they greatly posed the possibly unsafe conditions where excessive crowds are using the services, especially on queuing and boarding. It is a result of lack of identifying priority areas for them, unlike the disabled; without ticket buying and queuing, they were less faced with the confines at boarding stations.

The findings on this issue would be of use for improving the stage of mass rapid transit and other public transport designs. As mentioned in Section 4.3.3, besides unavailable or unreliable provision of the existing metro facilities for disadvantaged groups (Table 1) that entails substantially physical improvements, psychosocial impediments to access appear to be strong to identify the problems of unsuitable design of staircases, escalators/elevators, curbs, walkways, narrow doorways, etc. of each group as discussed in the Results towards efficient improvement.

Surprisingly, the study shows no gender differences regarding psychosocial issue; nevertheless, socioeconomic discrepancy among men and women cause high impact on accessibility level in line with *affordability* and *temporal dimensions* due to affecting opportunity to access the transit services. Regarding affordability, from the findings, gender income disparity and unemployment not only limit individual metro accessibility, but also affect long-term social sustainability. With a weak economic base, women can less afford to access metro services than men. In particular, non-working elderly women and non-working disabled (NWD) women report more negative effects. In this case, public transport subsidies should be provided and justified in a reasonable and equitable manner.

According to findings, the primary reason on costly metro accessibility is aligned with feeder expenses affecting all groups, yet its effects to accessibility level depend on wide magnitudes of socioeconomic status. Influences of this factor are evidently revealed from the performance results of MRT — Petchaburi station where location exposed very low connectivity, mixed use and urban environment scores in accessibility consideration; albeit high accessibility scores according to affordability of the elderly are illustrated, they have high impacts on unbalanced access costs among user groups as the part of analysis in Table 5. Their responses relating to needs and market-based (based on the question 'Do you get what you pay for?') and the opinions on equality and opportunity to access services significantly presented positive attitudes, thus supporting the core methodology of the study which is why accessibility assessment needs to look at these various aspects together. In addition, it would affect policy actions to distribute the service subsidies along with socioeconomic basis.

However, costly metro accessibility brought by feeder expenses of vulnerable groups becomes interesting in the discussion. It is likely associated with the transport behavior to avoid using public transportation as supported by Tangphaisankun et al. [16]. Cost efficient feeder services connecting metro lines should be considered in the intervention to fulfill the approach of an efficiently integrated mass transit system. One concern is that not less than two-thirds of passengers, especially the elderly and women use the services for non-mandatory purposes at different off-peak hours and weekends, regarded as *temporal influences*. Incentive programs with appropriate time allocation could be arranged for these groups to enhance behavioral responses to access transits towards increasing propensity to use such services.

5.2. Limitations and recommendations

Assessment framework and design method proposed by this study drive the novel viewpoints of multi-dimensional aspects to the accessibility contribution along with the balanced access priorities of metro user groups based on BMR experiences; nevertheless, as one of the limitations, the comparative non-user based model is acquired to fulfill the gap of the study particularly in the behavioral and psychosocial responses, socioeconomic and other barriers of non-users on using the services. Also, the comparison of the access decisions to services between both groups should be moved toward by further research.

The endeavor may need to modify the techniques or measures when considering the part of non-users' perceptions. Hensher and Rose [24] discussed that the *stated choice model*[2] could be applied in recognition of the measurement of preferences between traveler

[2] The stated choice method can be used for predicting the behaviors or preferences of commuters or non-commuters when choosing among alternatives defined by attributes.

and non-travelers on mode choice decision underlying the behavioral economics and psychological approaches. Adjustment of model to accessibility assessment involves the determination of geographical configuration and benchmarks. On such notion, user-based and non-user-based accessibility model regarding the conditions of different urban zones across socioeconomic segments can be more clarified. Yet, detailed examination and in-depth interview of disadvantaged group on service experiences (e.g., negative feedback from potential users) as discussed in this study should not be regardless. The study recommends integrating two approaches together.

However, if considering the indirect way, the commuters who have a trip frequency of less than 3 trips/week, classified as 'non-users' [25] can remark feedback on some of the reasons why they don't use the service with a standard attitudinal survey to make comparison across stations and zones. In that case, the study would reflect some concerns. According to profile data belonging to neighborhood types in Section 4.1, vulnerable non-commuters (disadvantaged groups who have less trips) who live in Location type A, as buffer zone areas, also found similar negative feedback on psychosocial aspect on accessing services, for instance, the crossing time to pass through the metro turnstiles is too short for people, especially slow-moving seniors to pass without getting jammed, thus concentrating on the extent to which the importance of safety and comfort considerations to accessibility domains. Nonetheless, the slight number of elderly and disabled population on stations is another key barrier to significantly endorse this finding because the metro systems are still unpopular modes for them partly because of such access difficulties. So, purposive sampling and interviewed key informants are the solution of the study.

In addition, the study did not illustrate the institutional influences that are important and could be challenges in any future works. Further research should explicitly study factors affecting the accessibility performance and how to measure the policy efficiency as well as how to implement the policy or the analysis of the impacts from policy decisions.

6. Conclusions

Central to two hypotheses dissected through the holistic assessment framework of the study, the performance consequences to accessibility consideration on selected mass rapid transit stations across user groups as regards simultaneously multi-dimensional aspects based on BMR empirical case elucidate the potential effects of psychosocial, comfort and safety and other dimensions to the disabled, and the elderly, and in fact, not performing well in light of their needs and abilities on their experiences with accessibility; while socioeconomic segments influence more the rights of women in services accessible. The findings support the main objective of the study in that, accessibility assessment needs to simultaneously consider various aspects of accessibility. Despite the fact that most of the indicators are qualitative judgments from respondents, chi-square statistics show an indifference of user's characteristics of the selected stations, in that it might reduce bias and inaccuracy of the results. This supports the pattern of Bangkokians' behavioral responses to premium transit services in BMR. In the effort to maximize accessibility for all users, policy actions, as respective of the findings, might be useful not only to BMR, but also to other cities or any related public transportation services to balance priorities of access among groups. Also, the discussion that argues to integrate various dimensions to accessibility-based knowledge would be the primary contribution by which models and design methods need to be appropriately adjusted to.

Acknowledgments

The authors appreciatively acknowledge all key informants from the Office of Transport Policy and Planning (OTP), Ministry of Transport, Thailand, Bangkok Metropolitan Administration (BMA), Mass Rapid Transit Authority (MRTA), Bangkok Mass Transit System Public Company Limited (BTSC), Bangkok Metro Public Company Limited (BMCL), and metro survey respondents for providing the valuable information. Thanks go to Farzam Garshasbi for his English language assistance. This research was partially supported by Asian Institute of Technology and Rajabhat Chandrakasem University.

References

[1] M. Kwan, J. Weber, Individual accessibility revisited: implications for geographical analysis in the 21st century, Geographical Analysis 35 (4) (2003) 341–353.
[2] M.D. Meyer, E.J. Miller, Urban Transportation Planning, 2nd ed. McGraw Hill, New York, 2000.
[3] K. Lucas, G. Marsden, M. Brooks, M. Kimble, Assessment of capabilities for examining long-term social sustainability of transport and land use strategies, Transportation Research Record 2013 (2007) 30–37.
[4] M. Kunieda, A. Gauthier, Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities, GTZ, Eschborn, 2007.
[5] X. Zhu, S. Liu, Analysis of the impact of the MRT system on accessibility in Singapore using an integrated GIS tool, Journal of Transport Geography 12 (2) (2004) 89–101.
[6] G. Vandenbulcke, T. Steenberghen, T. Thomas, Mapping accessibility in Belgium: a tool for land-use and transport planning? Journal of Transport Geography 17 (1) (2009) 39–53.
[7] J. Cheng, L. Bertolini, F. le Clercq, Measuring sustainable accessibility, Transportation Research Record 2017 (2007) 16–25.
[8] S. Chalermpong, Rail transit and residential land use in developing countries: hedonic study of residential property prices in Bangkok, Thailand, Transportation Research Record 2038 (2007) 111–119.
[9] C.H.C. Bae, M.J. Jan, H. Park, The impact of Seoul's Subway Line 5 on residential property values, Transport Policy 10 (2) (2003) 85–94.
[10] H. Du, C. Mulley, The short-term land value impacts of urban rail transit: quantitative evidence from Sunderland, UK, Land Use Policy 24 (1) (2007) 223–233.
[11] K.T. Geurs, B. van Wee, Accessibility evaluation of land-use and transportation strategies: review and research directions, Journal of Transport Geography 12 (2) (2004) 127–140.
[12] G. Giuliano, Land use impacts of transportation investments: highway and transit, in: S. Hanson, G. Giuliano (Eds.), The Geography of Urban Transportation, The Guilford Press, New York, 2004, pp. 237–273.
[13] T. Sivakumar, T. Okamura, T. Yabe, F. Nakamura, A survey design to grasp and compare user's attitudes on Bus Rapid Transit (BRT) in developing countries, Journal of International Association of Traffic and Safety Sciences (IATSS) Research 30 (2) (2006) 51–58.
[14] M. Brons, M. Givani, P. Rietveld, Access to railway stations and its potential in increasing rail use, Transport Research Part A: Policy and Practice 43 (2) (2009) 136–149.
[15] M. Givioni, P. Rietveld, The access journey to the railway station and its role in passengers' satisfaction with rail travel, Transport Policy 14 (5) (2007) 357–365.
[16] A. Tangphaisankun, T. Okamura, F. Nakamura, R. Wang, A study in integrating paratransit as a feeder system into urban transportation and its effects on mode choice behavior: a study in Bangkok, Thailand, Proceedings of 12th WCTR Conference, July 11–15, 2010, Lisbon, Portugal, 2010.
[17] N. Ohmori, N. Harata, Evaluation of space-time accessibility considering daily activity engagement of the elderly, Proceedings of TRANSED 2004, CD-ROM, 2004.
[18] R. Likert, A technique for the measurement of attitudes, Archives of Psychology 140 (1932) 1–55.
[19] T. Yigitcanlar, F. Dur, Developing a sustainability assessment model: the sustainable infrastructure, land-use, environment and transport model, Sustainability 2 (2010) 321–340.
[20] A. Tangphaisankun, F. Nakamura, T. Okamura, Influences of paratransit as a feeder of mass transit system in developing countries based on commuter satisfaction, Journal of the Eastern Asia Society for Transportation Studies 8 (2009).
[21] H.F. Kaiser, The application of electronic computers to factor analysis, Educational and Psychological Measurement 20 (1960) 141–151.
[22] D. Geourge, P. Mallery, SPSS for Windows Step by Step: A Simple Guide and Reference, Allyn & Bacon, New York, 1999.
[23] L.J. Cronbach, Coefficient alpha and the internal structure of tests, Psychometrika 16 (3) (1951) 297–334.
[24] D.A. Hensher, J.M. Rose, Development of commuter and non-commuter mode choice models for the assessment of new public transport infrastructure projects: a case study, Transportation Research Part A 41 (5) (2007) 428–443.
[25] A.J. Khattak, Y. Yim, L. Stalker, Does travel information influence commuter and noncommuter behavior?: results from the San Francisco Bay Area TravInfo Project, Transportation Research Record 1694 (1999) 48–58.