Exploring eco-friendly travel towards sustainable water transport in Bangkok

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Abstract. While traffic congestion issues has not be solved in Bangkok, Thailand, an intervention in order to improve air quality and reduce greenhouse gas emissions is required for sustaining the continuation of this urban problematic. Greening mobility in term of “Eco-Friendly Travel” is therefore the ultimate transport challenge towards sustainability that will significantly reduce greenhouse gas emissions of existing unsolved land transport. Facing this global sustainability challenge arises the need to adopt an environmental friendly mobility culture by using participatory approach to integrate with technologies and fuel options for water transport system. This study was conducted based on a concise analysis of the current geography of canal network in Bangkok along with an introduction of “canal transit” to ask respondent of 1,200 sets from residents around the Lat Phrao canal which is one of the most potential canal in Bangkok. The results revealed its feasible option for local transport in terms of urban connectivity improvement and community-owned resources. However, it needs various improvements such as accessibility, transit services, urban activities spaces, and community activities and value-added transportation services which would be the keys to success to increase local economic competencies and sustaining water transport in Bangkok.

1. Introduction
Transit on road based development has become a major trend, however Bangkok Metropolitan Area (BMA) had been established since AD 2310 with water based development. It has continuously expanded into the surrounding area which canal transit system was considered as a backbone of transportation due to its urban morphology evolved. This potential allocation has brought multi benefit on water based utilization for transporting both goods and people [1]. With this potential, it demonstrated several benefits and potential compared to other urban modes of transportation choices. It is more economy in term of operation cost, there are less construction costs, and many low-to-middle income class people can afford the transportation costs, especially low emission for water transit. With this alternative mode, it can be considered as part of the future vision for global mobility. Since its direct and indirect benefit can reflect not only for the reduction of CO2 emissions and elimination of greenhouse gas but also for their potential adaptation to urban resilience, especially flooding [2]. Furthermore, water transport could be developed to accommodate seamless, efficient, personalized and user friendly travel services and to raise awareness for sustainable travel options and lifestyle of Bangkokians. Boat engine can be replaced with renewable energy solution to reduce oil dependency and decarbonize and play a vital role on the development of a Greening Mobility era of
transport towards sustainability [3]. However, the importance of the canal transit system seems to be decreasing nowadays since road based transportation has become a main mode of transportation instead of waterway transportation, particularly inland waterway (Hossain and Iamtrakul (2007). This situation caused an expansion of land development to sprawling situation of suburban areas with severe traffic congestion and degrading quality of life of people (Iamtrakul et al., 2018). Therefore, the governments must step back and reconsider about how to utilize the urban water network system efficient and more linkage with environmental sustainability [4].

Presently, urban growth tends to complicate transport operations. In order to in-depth understanding, Lat Phrao Canal was selected as a study area which represents one of the remarkable canals of Bangkok as showed in figure 1. It provided an alternative transport service to serve existing congested transport network by connecting people to available mass transit. Thus, understanding mobility patterns plays a significant role in providing an efficient water-based transportation system for Lat Phrao Canal. Particularly, community-owned transport stakeholders have been engaged in this wider transport policy and planning process [5]. This offers an alternative way of considering about transport systems that seek to supplement existing urban transport systems. Therefore, with the existing mobility patterns of Lat Phrao Canal, it is possible to develop a transportation network based on community-owned transport, the objectives of this study are: 1) To investigate the current mobility patterns of Lat Phrao Canal from the commuters’ perspectives; 2) To analyze mobility performance and factors contributing to water-based transport development of Lat Phrao Canal; and 3) To promote and recommend a boat service by focusing on community-owned transport development connecting with the existing public transportation.

Figure 1. Lat Phrao Canal and mass transit network in Bangkok.

2. Theoretical background of mobility development
Mobility is an enabler of economic growth and prosperity both for developed and developing countries. It enables access for people and goods to markets, schools, medical services, and family and friends. In order to truly attain sustainable mobility, solutions to problems need to be found across the whole spectrum of transport options. Cities need a data-driven, holistic approach that delivers a comprehensive and integrated set of mobility options. To archive sustainable mobility, there are eleven parameters as demonstrated in figure 2 [5].

| Sustainable Mobility | Indicators                                      |
|---------------------|------------------------------------------------|
| Time                | Less lost time, active time use                |
| Security            | Control and personal safety                   |
| Safety              | Safety and zero accidents                     |
| Business performance| Financial self-sufficiency                    |
| Reliability         | Certainly and guarantee travel                |
| Equity              | Fairness of access for all social groups      |
| Accessibility       | Usability, easiness, and immediate access     |
| Use of resources    | Accuracy of the use of energy land and raw materials resources |
| Environmental impact| Minimize transport impact on ecosystem        |
| Price               | Fair price based on the type of transport used|
| Emission            | Reduction of emission harmful to the environment and health |

Figure 2. Eleven parameters of sustainable mobility

Mobility has many dimensions, such as intellectual, social, professional and spatial mobility [6]. Spatial mobility comprises temporary relocations, such as trips, as well as permanent relocations, such as change of job or migration [7]. Previous research projects of mobility pattern analysis in Bangkok have been explored to identify factors of mobility as shown in table 1.

Table 1. Summary of mobility pattern indicators.

| Researchers    | Year | Area                        | Indicators                                                                 |
|----------------|------|-----------------------------|---------------------------------------------------------------------------|
| Punpuing       | 1993 | Bangkok                     | demographic, socio-economic, social environment, and commuting pattern    |
| Watchanarat    | 2000 | Khlong Saen Saeb, Bangkok   | characteristics of passengers focusing on land use and trip purpose       |
| Vichiensan     | 2007 | Bangkok                     | urban mobility, job accessibility, and travel pattern                     |

3. Potential of the Lat Phrao Canal for local transit improvement

Based on observations by boat, there are 29 suitable points for establishing local piers alongside the Lat Phrao canal. Mostly the suitable points are located in small vacant areas which are accessible by foot. For emphasis on the number of passengers, however, the research team selected four locations to construct piers as an initial phase of development: Wat Lat Phrao, Lotus Wang Hin Pier, Wat Bang Bua Pier, and the CODI Housing Project site. It took approximately seventy-five minutes from Wat Lat Phrao (first pier) to the CODI Housing Project Site (last pier). Those four sites share a common characteristic; buildings in the surrounding area are mostly residential units. However, some areas have specific facilities nearby (e.g., airport, universities and mass transit stations). The potential of pier establishments alongside the Lat Phrao canal are on the east side rather than the west side. Results
from network analysis was applied to analyze the potential of the Lat Phrao canal for supporting urban mobility and future connectivity between the Lat Phrao canal and MRT stations.

3.1. Network analysis and estimation of future demand
The catchment of five-kilometer network service areas of the piers located on the Lat Phrao canal was considered as a target area of analysis as demonstrated in table 2. The detail of different characteristics of pier in term of accessibility and building use could be shown along the canal from Lat Phrao pier, Lotus Wang Hin pier, Bang bao pier and CODI housing pier. It should be noted that if governments or local communities’ members who are interested in revitalizing the Lat Phrao canal for navigating passengers or goods, other local modes of transportation such as local motorcycles services, small vans or pick-up, or taxis are needed as feeder systems from the canal to other destinations such as shopping centers, institutional places, medical service centers, living units, workplaces or other transit stations such as Mass Rapid Transit stations [8]. The results of the analysis showed that if the Lat Phrao canal were fully operated for community-owned canal transit and could be connected to other modes of public transportation, it could reduce approximate travel distance from the eastern side of the Lat Phrao canal to the existing mass rapid transit lines.

3.2. Procedure and analytical method
For the questionnaire survey, the sampling size was 1,200 people, categorized into three areas near Lat Phrao Canal, namely a group of people who live near the nodes (within 500 m. and 2 km. along the Khlong respectively). A random sampling technique was applied for questionnaire distribution. The questionnaire consisted of 8 parts: 1) travel behavior and attitudes, 2) usage of water-based transport, 3) transportation mode alternative factors, 4) attitudes towards Lat Phrao Canal’s boat service, 5) expectations on Lat Phrao Canal development, 6) respondent profile, 7) housing satisfaction, and 8) housing conditions. Each part aimed to identify respondents’ experiences towards different aspects of boat services. A five-point Likert Scale (1-5) was applied for rating answers of questionnaire on particular sections. The respondents were asked to rate the scale of attitudes: (1) very lowly satisfied, (2) lowly satisfied, (3) fairly satisfied, (4) satisfied, (5) very satisfied.

Table 2. Estimated passengers classified by pier location

| Pier no. | Station           | Number of Building surround (Units) | Average household size | Estimated populations | Intention to use the Lat Phrao canal |
|----------|-------------------|-------------------------------------|------------------------|-----------------------|-------------------------------------|
|          |                   |                                     |                        |                       | 5% use | 10% use |
| 1        | Wat Lat Phrao     | 106,848                             | 4.29                   | 458,214               | 22,911 | 45,821  |
| 2        | Lotus Wang Hin    | 93,938                              | 4.29                   | 402,850               | 20,143 | 40,285  |
| 3        | Wat Bang Bua      | 63,462                              | 4.29                   | 272,155               | 13,608 | 27,215  |
| 4        | CODI Housing project | 58,196                              | 4.29                   | 249,572               | 12,479 | 24,957  |
|          | Total             |                                     |                        |                       | 69,140 | 138,279 |

4. Results of analysis

4.1. Current mobility pattern and community-owned canal transit system
The current mobility patterns from 1,200 residents were analyzed and found that the respondents’ travel purposes were working 58.8%(, studying 16.8%, visiting 11.8%, shopping 6.8%, transport mode 3.6%, business 1.3% and leisure 0.9%). This result is similar to the study of Khlong Saen Saep that the characteristics of passengers at 16 major piers were working trips and the second were educational trips [9]. The results of origin-destination analysis can be listed below:
Focusing on the 7 nodes of surrounding area (Lat Phrao Canal), it was found that the main transport types were private car and rapid transit;

Considering the origin-destination within 2 Km., it was revealed that the origins of travel mostly take place around residential areas. Meanwhile, the destinations were nearby main transportation routes including Phahonyothin Rd and Kaset-nawamin Rd.;

Classifying the origin within 500 m. along the Lat Phrao Canal, it was found that regular trips were high in residential areas. Presently, there are a number of real estate project developments including apartments and condominiums, rapidly expanding within this area. Locations on Pradit Manutham Rd. and the area where Lat Phrao Canal connects with Khlong Saen Saep are considered target areas for property development due to a large number of office buildings.

Travel patterns found to be concentrated in the inner city were determined by the number of trips originating from residences. Typically, the first trip of the day would start in the morning and the last trip ended at night. Accordingly, this pattern often resulted in particular traffic conditions, such as rush hour with a high amount of traffic occurring in the morning and evening, especially on the main roads as depicted in figure 3.

![Figure 3. Mobility pattern of Lat Phrao Canal area.](image)

4.2. A key promise of promoting water based transport development

Residents who live close to transit stations will use public transportation more than private. In terms of transportation alternatives, a private vehicle was mainly chosen for commuting to work. Lack of public transit accessibility was considered a significant factor affecting the selection of private vehicle. Meanwhile, walking was ranked second in commuting to work, travel, and study. Nevertheless, distance should be primarily examined where walkways conveniently and effectively connect with public transit. Respondents were less apt to choose the mass rapid transit systems, BTS, MRT, and ARL.

In addition, to understand more on trip purposes of residents, classifications of trip purposes into different periods of travel time were investigated. The results revealed that most of the respondents purposely travelled for work. Significantly, trips for work, study, or travel was found most common...
during 05.00 a.m. – 12.00 p.m. The time period of 06.00 a.m. – 8.00 a.m. was considered rush hour with a high number of respondents leaving for work, study and travel, leading to bad traffic conditions on a daily basis. Therefore, mobility within the study area, especially during the morning rush hour, is limited in traffic congestion. More alternatives or solutions regarding transportation service, especially mass transit system, should be managed and taken into consideration for the study area.

4.3. Factors of sustainable mobility and water-based transport development

According to the principles in the theoretical background on sustainable mobility development [5], nine parameters were applied for water-based transport development of Lat Phrao Canal. The results found that a degree of respondents’ attitudes on statements concerning factor development among 7 factors of 9 was high on the agreed level (3.51–4.50). Only 2 variables were found to be on the fair agreed level; shorter distance of traveling (3.47) and several attraction areas: retail shop, coffee shop, to relax during the trip (3.45) as illustrated in figure 4.

![Figure 4. Sustainable mobility of water-based transport development.](image)

Thus, the seven factors include: 1) quality satisfaction during a journey, 2) quality satisfaction of a good transport route, 3) adjustable transport modes when facing traffic congestion, 4) convenience of traveling, 5) route safety, 6) estimated time for traveling, and 7) short travel time must be taken on water-based development. Testing the relationship between two variables: respondents’ experiences (used or never used waterway transport groups) and the above 9 factors of water-based transport development found that 5 factors indicated with a significant statistic relationships with respondents’ experiences. So, a public transport system should be high accessibility and good condition and the availability of safety equipment must be ensured. Regarding respondents’ expectations in using a boat service following the development of Lat Phrao Canal, it was found that 68% of respondents expected to use a public boat service of Lat Phrao Canal if a service is made operational.

Finally, the result of this section aims to show all mobility patterns and factors for water-based transport development along Lat Phrao Canal. Better mobility based on respondents’ perception could drive demand for expanded transport. The current situation of Lat Phrao Canal needs to be managed regarding both physical areas and water transport services as well as a place of transit. It suggests that there is a potential value to utilize a boat service in a multi-model transport network with a reasonable fare rate, high accessibility and good conditions at the pier [10]. A community-owned public transport system of Lat Phrao Canal can be achieved by local stakeholders and a collaboration of interest groups that will make community-owned boat service possible.
5. Conclusions and recommendations

Waterway transportation is an important consideration in regards to supporting city logistics development schemes, urban mobility improvement, urban aesthetics value and eco-friendly travel. The Lat Phrao canal is one of the longest canals that is applicable for navigation and has much potential in terms of urban connectivity improvement and community-owned resources. However, it needs various improvements such as accessibility, transit services, urban activities spaces, and community activities. All these improvements are necessary to support a community-owned canal transit system for the Lat Phrao canal due to the existing community allocation to generate participation sense. Moreover, to expand benefits to other groups in the communities, spatial development based on Transit-Oriented Development (TOD), and value-added transportation services are two keys to success to increase local economic competencies. Moreover, there should be connectivity improvement between piers-to-places and efficiently use new technologies particularly renewable energy for boat engine remain the challenge to support the clean transportation vision of the future towards Greening Mobility.

6. References

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