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Hot or not? The role of cycling in ASEAN megacities: Case studies of Bangkok and Manila

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ABSTRACT

The Association of the Southeast Asian Nations (ASEAN) recognizes the role of nonmotorized transport for sustainable urban development in its policy framework. National and local policymakers in Thailand and The Philippines, two tropical countries without a tradition of urban cycling, are increasingly paying attention to cycling as well. This article aims to assess the current situation and progress in cycling, using Bangkok and Metropolitan Manila as case study cities, and to describe the necessary conditions for advancing the significance of cycling in tropical megacities. This is done by operationalizing the so-called Technological Innovation Systems (TIS) framework, which has been used in transition studies since 2008, however, never for cycling. As such this article also "tests" this framework for its application in sustainable transportation. The two case studies are characterized with regards to the current role of cycling in the mobility system, its infrastructure, governance system, and existing research on the potential and barriers. We find that TIS can readily be applied to our cases, with the analysis showing that elements such as knowledge development, actor networks, e-bike adoption, infrastructure, resource mobilization and legitimation are not well developed; on the other hand, flat terrain, attention for cycling for health and environment, heavy congestion, expansion of public transport, growing bike industry, active university communities, and the emergence of advocacy coalitions, could open up opportunities for increasing its modal share.

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1. Introduction

Within the policy framework of the Association of South-East Asian Nations (ASEAN), nonmotorized transport (NMT) such as walking and cycling is recognized as an important component in the context of sustainable urban mobility and health. In the road safety/physical activity programme of work, the Regional Action Plan on Healthy ASEAN Lifestyles (ASEAN, 2012) aims to "incorporate healthy lifestyles issues into public planning systems, especially with regard to transport and land use, safe transportation, [and] provision for pedestrian and nonmotorized traffic." The ASEAN Kuala Lumpur Transport Strategic Plan 2016–2025 includes NMT in the chapter on sustainable transport with action ST 1.1: "Institute coordinated approach to further promote non-motorized and public transport in ASEAN cities" (ASEAN, 2016: 32).

At the national level, the importance of NMT is also appreciated. In their comprehensive modelling study on low-carbon transport in Thailand, Selvakkuram and Limmeechokchai (2015) include modal shift from motorcycles to NMT as an important climate mitigation option. The national sustainable transport strategy of the Philippines (UP-NCTS, 2011) also sees a role for NMT. Similarly, for Metropolitan (Metro) Manila, NMT including cycling has been recognized as an element of sustainable transport solutions (Gozun & Guillen, 2008) and a 1.42% reduction in air pollutants from developing "bikeways" was estimated (Vergel & Tiglao, 2013). Harnessing such potentials in cities and regions may not be an easy task in general, given that traditionally the public and policymakers in South-East Asia associate cycling with poverty and the motorcycle seen as "the modern substitution of the bicycle" (Khuat, 2006: 41). Although there are some studies for countries outside Southeast Asia (e.g., Nkurunziza, Zuidgeest, Brussel, & van Maarseveen, 2012; Rahul & Verma, 2014), not much has been published about the requirements, or even the possibility, to have a substantial role for cycling in tropical megacities in this region. This is an important research gap given the potential contribution to sustainable urban transport, the current interest

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of policymakers and the significant effort required to establish cycling as a normal practice.

Though detailed data are not always available due to lack of adequate monitoring of cycling trips (Rios, Taddia, Pardo, & Lleras, 2015), it is evident that cities in developed countries have widely diverging shares of cycling, roughly between 0 and 60% of all daily trips. Vietnamese cities for example have significant, though decreasing, modal shares of cycling (in the order of 10–30%, Dematera et al., 2015), as opposed to Singapore with around 1% cycling for work trips. Kumar, Nguyen, and Teo (2014) assume a potential of 10% for cycling in public transport access trips up to 3 km and for door-to-door trips up to 5 km in Singapore, which could be realized through adding infrastructure aimed at utility cycling to the currently available bike paths that are mainly targeting leisure cycling. Koh and Wong (2012) find a lower catchment radius of 1.5 km, and that about 30% of pedestrian and bus feeder commuters would "very likely" or "maybe" shift to cycling when there is better infrastructure. Most other ASEAN cities start from a lower base and do not have dedicated cycling infrastructure; however, attention for transport and recreational cycling in politics, media, and the public is picking up throughout the region, as discussed in this study. The drivers of this positive image of cycling appear to be diverse, from green image to health, and from sustainable transport to recreation and fun. Given the potential benefits of transport cycling (see Section 2.1)—as well as the challenges and uncertainties of increasing daily ridership and thereby reap these benefits—it is useful to put the current developments into a comprehensive picture of necessary and sufficient conditions, and draw lessons for the future.

This article aims to assess the current situation for urban cycling for transportation (also called "utility cycling"), and the progress made therein in the ASEAN region using two megacities in The Philippines and Thailand as case studies, following the Technological Innovation Systems (TIS) framework. As TIS has not yet been applied to cycling this article also aims to investigate the suitability of the framework to a relatively mature practice such as cycling and thereby add to the literature on TIS analysis in the context of sustainable transport. In addition, it aims to highlight key enabling and blocking factors to future cycling policy development and implementation.

2. Framework and methodology

2.1 *Cycling in the context of sustainable transport and transitions*

It is widely recognized that cycling can play a key role in a sustainable transport system and therefore should be promoted by policymakers. In his "green transport hierarchy" for multimodal transport planning that emphasizes choice between modes, Litman (2008), concurring with Banister (2008), states walking and cycling are the first two modes to consider, followed by public transport, service and freight vehicles, taxis, multioccupant vehicles and finally single-occupant vehicles. Wang (2011) shows that cycling in Chinese cities has a lower full cost per kilometer travelled compared to all other modes for short radial trips, only to be overtaken by bus systems for other types of trips. Meschik (2012) adds to this that every person-kilometer cycled has external benefits for society versus significant cost for car travel. This is based on the notion that walking and cycling are "active" transport modes that provide substantial health benefits to individuals and therefore reduce costs to society. CTC (2015) provides an extensive overview of studies related to costs and benefits of cycling and infrastructure investments for the economy and society. Cycling also provides a mode choice to those who choose to use, or cannot afford other modes, or are physically impaired. In countries with a high bicycle share by choice, the key reasons to choose cycling as a mode of transport relate to personal benefits, for example, lower cost, time savings, higher reliability, greater comfort, ad better personal health) rather than environmental or societal benefits (e.g., City of Copenhagen, 2015). Personal benefits (utility gains) are therefore a strong predictor of first or continuing bicycle use (Pardo, 2013a).

In the context of climate change, cycling, being a zero-emission mode, can play a role too (Massink, Zuidgeest, Rijnsburger, Samiento, & van Maarseveen, 2011; Selvakkuram & Limmeechokchai, 2015). However, it may not be easy and straightforward to assess the impacts of cycling on greenhouse gas emissions, especially in isolated contexts. Fishman, Washington, and Haworth (2014) for example find that in two cities bike-sharing led to reduced vehicle-kilometers, while in one city these increased due to truck use for rebalancing the bicycles, thereby also increasing emissions. Probably in the short term impacts are rather limited, but it can play a more important role as part of system changes that help low-carbon transport, as shown in an example from The Netherlands (Brons, Givoni, & Rietveld, 2009) where the bicycle is the most popular access mode to train stations.

In order to give policymakers options to reduce greenhouse gas emissions from the transport sector, the "avoid-shift-improve" approach to transport policy was developed (Dalkmann & Branningan, 2007). To make this approach fully compatible with the wider notion of sustainable transport, (Bakker, Zuidgeest, de Coninck, & Huizenga, 2014) added components of "access," lifestyle aspects and transition thinking to this approach. Cycling fits well in this framework: it provides accessibility to opportunities (Pettinga et al., 2009) and an alternative to other modes especially for trips up to 5–7 km, with larger distances in case of electric bikes. If a cyclist used another mode before, the policy or measure inducing the change is a "shift" measure (Gilbert & Dajani, 1974). In addition, if trip lengths can be reduced by means of "avoid" measures, that is, through spatial planning measures, and air pollution reduced through "improve" measures, cycling becomes more attractive.

In order to further analyses how cycling can be looked at from a transitions perspective, we consider three broad frameworks. First, in the Multilevel Perspectives Framework for Socio-technical Transitions (Geels, 2012), large changes in a system may occur when pressures from the socio-political-economical "landscape" result in opening of spaces in the "regime" (e.g., car/motorcycle-dominated transport) so that niches (e.g., cycling) are able to increase their role and change the regime. In the traditional transport system, Geels (2012) sees "cracks" in the current private car-dominated system, but also observes that major transitions may still fail, especially in terms of inducing a modal shift.

The second transitions approach is related to Practice Theory (e.g., Watson, 2012), which studies routinized types of behavior in relation to social order and change. Large-scale cycling as a "normal" mode of travel can be seen as a socio-technical transition from the current paradigm (see, e.g., Gössling, 2013). Sengers (2016) notes that present day cycling in tropical megacities can be considered to be at risk, due to the very low modal shares, hence lack of critical mass, fast rise in incomes, hence private vehicle ownership and use, as well as the current regime of car-oriented planning. Shove (2012) discusses the re-emergence of cycling in the United Kingdom, currently a niche and predominantly associated with leisure. She argues that "in theory, the stages of an innovation journey (from niche, through to alignment, diffusion, and breakthrough) are the same whether the sociotechnical configuration in question is being introduced for the first time, or reintroduced at a later stage." As cycling is not a new technology but rather an "old" technology that has been "reinvented," development of cycling could start not by "niches of innovation but for pockets of persistence," that is, the reactivation of past configurations, rather than it being a fully new regime. Similarly, in the context of "stories of innovation," Oldenziel and De la Bruheze (2012) note that "the bicycle has gone through many incarnations, from serving as symbols of modern mobility and pride to the sure signs of poverty and nostalgia" (p. 22).

Elements of technological innovation can be found with the emergence of full electric or pedal-assisted bikes (pedelecs) and public bike sharing systems. As to the latter, third-generation systems have fixed docking stations, tracking technology and dedicated smart cards, while fourth generation may feature dockless systems, electric bicycles, and better integration with public transport (Fishman, 2016; Shaheen, Guzman, & Zhang, 2010). In Section 2.3, we further discuss this third transitions approach of Technological Innovation Systems.

To be successful in (re)capturing a significant modal share, cycling requires innovation in the technological system, economics (shops/manufacturing, repair workshops) (Gausemeier, Seidel, Riedelsheimer, & Seliger, 2015), the transport policy and planning framework (e.g., avoid-shift-improve; see also Section 2.2), and social realm (a lifestyle where daily cycling is acceptable to most or all segments of society), apart from merely transport policy-related measures (i.e., transport demand management and NMT-related improvements on infrastructure, regulation, and education). Currently in many countries and cities, for example in the United Kingdom, there are "emerging" rather than "established" cycling cultures (Aldred and Jungnickel, 2014; 85), and cycling being related to subcultural choices (i.e., distinct identity from the broader culture). A recent surge in the "fashion" or "cycle-chic" connotation of this mode of transport is also observed (see Pardo, 2013a).

2.2 *Literature on development of cycling as a transport mode*

A growing body of literature deals with factors that attract individuals to or deter them from cycling; the so-called "necessary conditions," or barriers that need to be taken away. However, these factors are not necessarily sufficient to make people cycle more (Gatersleben and Appleton, 2007). The "sufficient conditions," that is those that, when met, will effect a real change, will depend on each country's context. This section discusses conditions related to infrastructure, socio-economic factors, natural environment, and policy.

Separate cycling facilities, traffic calming measures, integration with public transport, and transport demand management are identified as important measures in Pucher and Buehler (2008). Pettinga et al., 2009,, define five criteria as necessary conditions for "cycling-inclusive" transport planning: (1) coherence: most or all destinations can be reached by bicycle and there is integration with public transport, (2) directness: minimization of detours and U-turns, (3) safety, for example, through dedicated infrastructure and speed limits), (4) comfort: smooth road surface and protection from sun and rain, and (5) attractiveness, that is, a pleasant environment. Rios et al. (2015) include these conditions into a broader framework that includes four necessary components of cycling policy. The first deals with the infrastructure and services, which are focused on the physical characteristics of the network and any other physical implementation (bicycle parking, on-the-road services, etc.). The second component focuses on regulations and institutions which relates to laws, decrees or general regulation of cycling and the institutions that exist to manage cycling in a city. The third relates to citizen participation, which includes not only active participation (e.g., user groups and activists), but also education and promotion activities of cycling. The fourth is monitoring and operation, which is focusing on the operation of systems (e.g., public bicycles and high-end parking systems) and monitoring of all data related to cycling and its effects.

Other important factors that are relevant when discussing cycling development are given in Gatersleben and Appleton (2007), who discuss the process of intentional behavior change for cycling to work trips, including stages of precontemplation, contemplation, prepared for action, action, maintenance, and potentially relapse. This was then used to study the need for different policy interventions for people in different stages of change for cycling in the tropical city of Dar-es-Salaam, Tanzania (Nkurunziza et al., 2012). Targeting specific user-groups has also been discussed in Park, Lee, Shin, and Sohn (2011) who, interestingly, observe that in Singapore 57% of commuter cyclists were leisure cyclists before, and suggest that "young white-collar workers who live in high-rise apartments and enjoy intensive leisure-cycling in groups, are a good target" for cycling promotional campaigns. Aldred and Jungnickel (2014) for the UK, as do Jones and Novo de Azevedo (2013) for Brazil, discuss the cultural dimension and how the meanings of cycling, including its association with other social identities by groups in society are connected to the materials and competences seen as necessary for cycling. In comprehensive review of studies, Heinen, van Wee, and Maat (2010) conclude however that the relationship between socio-economic factors, such as age, gender, income, household structure, and cycling remains unclear, both in terms of direction and causality. Travel cost and safety are more important for cycling than for other modes.

Handy, van Wee, and Kroesen (2014) discuss urban densities, infrastructure, distance, costs, social-demographic factors, individual perceptions, bicycle availability (including e-bikes/

pedelecs), and bicycle access, similar to Brons et al. (2009) who look at the role of cycling in increasing the propensity of people travelling by train. Weather, and its perception, is also a key factor, even though most literature discusses weather in the context of Western countries and cold and moderate climates (Böcker, Dijst, & Prillwitz, 2013), rather than tropical climates. Meng, Zhang, Wong, and Au (2016), being one of the exceptions to this, finds that rainfall is the most important weather factor for cyclists in Singapore, secondly humidity and thirdly temperature (with a preference for 29.5–31.1°C).

Other literature discusses problems of (upfront monetary and non-monetary) investments in cycling infrastructure and the delay in realizing the benefits through the so-called valley of death analogy (Gatersleben & Appleton, 2007). Deffner, Hefter, Rudolph, and Ziel (2012), argue that investments into cycling infrastructure can be justified based on the argument that it gives choice to people to choose the transport mode they prefer, that is, it facilitates a diversity of lifestyles and promotes equity and a multimodal transport system. The role of specific facilities, awareness (car-free days, bike fairs, etc.), social media and different user-groups (particularly university students) as enablers is discussed in various articles (e.g., Gozun & Guillen, 2008; Rimano et al., 2015; Rose & Marfurt, 2007).

From this brief review it follows there is a lot of literature on factors influencing bicycle use and how to improve conditions for cycling (i.e., the "necessary conditions"), however, not on the actual impact of these conditions on real levels of bike use (i.e., the "sufficient conditions"), particularly in developing countries. In Latin America, Rios et al. (2013) did an effort to systematize current status of cycling policies, but it is far from a thorough long-term review; in Africa, Pendakur (2005) did a review, but with only scarce information available. No ex-post assessments that cover bike transport development over several decades in tropical countries have been found. Experience of Western-European countries, and new infrastructure evaluation in US cities and Tokyo, cannot easily be transferred to other cultures, climates, and urban contexts, which highlights a research gap, as confirmed by Handy et al. (2014).

2.3 *Analysis framework: Technological innovation systems*

In order to analyses the current situation and potential for a transition toward a more urban transport cycling in ASEAN megacities we adopt the Technological Innovation Systems (TIS) framework of Bergek, Jacobsson, Carlsson, Lindmark, and Rickne (2008), which is based on theoretical school of Innovation Systems (e.g., Lundvall, 1992). TIS is defined as "socio-technical systems that are focused on the development, diffusion, and use of a particular technology (in terms of knowledge, product or both)" (Bergek et al., 2008; 408) and is used to characterize what key functions in an innovation system are fulfilled for specific technologies in a country or a region. Its advantage over analysis based on other, more conceptual analysis systems, such as the Multi-Level Perspective (Geels, 2002), is that it is intended to answer policymakers' questions on what interventions to make, which provides a good fit with our research objective.

TIS is usually applied to hardware technologies, such as energy efficient air conditions, biodigestion systems (Tigabu, Berkhout, & van Beukering, 2015) and CO_2 capture and storage in a country (Alphen, Ruijven, Kasa, Hekkert, & Turkenburg, 2009). However, as a technology or a practice is always subject to some combination of knowledge, institutions, markets, actors, public, and political factors and resources, a well-established practice such as cycling could also be examined in such a functional way (with electric bikes and bike sharing system as technologically innovative elements). To our knowledge, however, this has not been done earlier. Shove (2012) analyzed cycling in the context of innovation journeys, which has a related yet different approach, as discussed above. Therefore, this article is also a test for applying TIS to an established practice such as cycling.

The TIS framework (Bergek et al., 2008) follows a staged approach of analysis in six steps, (1) define the innovation system, (2) identify the components (actors, networks and institutions), (3) describe the seven functions of the system, (4) assess the functionality, (5) analyses blocking and inducement mechanisms based on the functional patterns, and (6) identify policy issues and recommendations.

The seven functions in step three are: (I) knowledge development and diffusion, which looks at the breadth and depth of the knowledge base, its development over time, and how it is diffused, including scientific, technological, design, and market knowledge; (II) influence on the direction of search, looking at factors that support development and use of the technology, such as belief in its growth potential, incentives, regulatory pressure, and support, and the articulation of interest by customers/users; (III) entrepreneurial experimentation, that is, the breadth and number of experiments, projects and (pilot) applications, etc. taking place; (IV) market formation, including the progression of phases such as nursing, bridging, and mature market and may include indicators such as the size of the market as well as types of users and the demand profile; (V) legitimation, dealing with the technology needs to be considered appropriate and desirable by relevant actors in order for resources being mobilized, demand formed, and political momentum built up; (VI) resource mobilization, which looks at human capacity in technical skills and financial resources, for example, for infrastructure and products; and (VII) development of positive externalities for different actors in the TIS, for example, through labor markets, emergence of specialized intermediate goods and service providers and information flows. Figure 1 schematically presents the six TIS steps and seven functions as applied in this article.

2.4 *Methodology*

The current situation of cycling, with a focus on Metro Manila and Bangkok, two megacities that are relatively comparable in several respects (see Table 1), will be assessed following the TIS steps and functions as introduced previously. The definition of the system of innovation, or the "unit of analysis," is the use of bicycles, including e-bikes/pedelecs, bike sharing, and pedicabs, as a means of transport in ASEAN megacities. The two cities can be considered representative for other megacities in the Southeast Asia region in terms of size and climate, are in

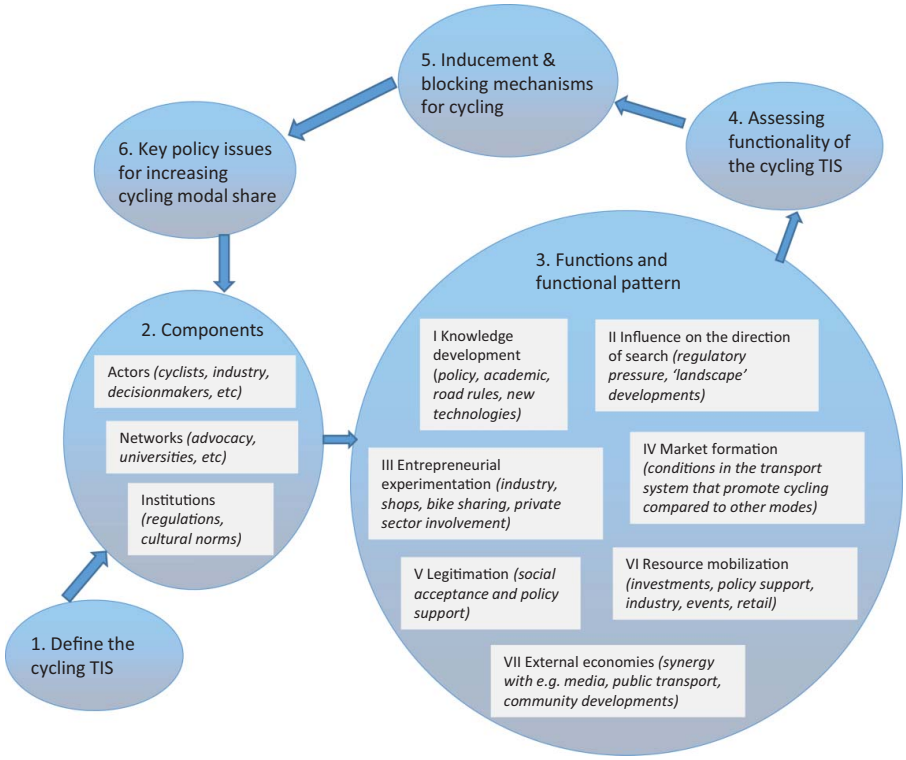

Figure 1. TIS steps, applied to cycling (adapted from Bergek et al., 2008).

middle-income countries, and are chosen based on their progress in cycling policy compared to other cities in the region; Singapore, which has progressed as well, will be discussed briefly as well.

To identify the seven functions in step 3 of the TIS approach we first conduct a systematic review of international and local literature about Thailand and the Philippines to identify and characterize the key contextual factors for cycling as well as qualitative research including field visits in Bangkok and Metro Manila. The public discourse is analyzed using printed and social media published between 2013 and 2015 for Thailand (40 articles[1]) and the Philippines (20 articles[1]) respectively, following, for example, Gössling (2013), who carried out a similar content and discourse analysis for Copenhagen, and Rimano et al. (2015), who investigate the mass media image of bicycles by performing a cluster analysis on "risk and danger," "sustainable mobility," "wellness and leisure" for Italy.

The governance structure and relevant policies are reviewed through policy documents in both countries, insights of members of the Firefly Brigade, which is one of the biggest association of cyclist in the Philippines, the Inclusive Mobility Network and the University of the Philippines, as well as three key informant interviews in the context of urban transport policy from Thailand, including representatives of the Ministry of Transport and the Thailand Cycling Club. A rapid survey of advocacy groups involved in mainstreaming of cycling was also done through interviews and a review of their printed and online media.

[1] Available upon request.

We then compare the results of the two cities, and discuss these in the context of international experience from European Latin American cities as well as Singapore, from which possible futures for the role of cycling in tropical megacities in the ASEAN are derived.

3. Current situation in Bangkok and Metro Manila

This section describes the status-quo of cycling in Bangkok and Metro Manila and the context within which this is happening. This information will subsequently be used in the TIS analysis in the next section. The data are summarized from (Bakker, Guillen, & Nanthachatchavankul, 2016), which includes all detailed documentation and references to the relevant media, policy documents, and additional literature.

3.1 *General city statistics and information*

Table 1 gives general indicators with relevance to cycling (see Heinen et al., 2010) for Thailand and the Philippines and their respective capitals, including general information on the cities' economy, demographics, vehicle ownership, and natural environment. For other indicators, for example, trip patterns, we have not been able to find recent and reliable statistics.

3.2 *Thailand: Bangkok metropolitan region*

Bangkok is the capital and economic powerhouse of Thailand, producing more than 50% of the countries' GDP. The city has been sprawling into many directions and has developed into a metropolitan area comprising Bangkok and five other provinces, together referred to as the Bangkok Metropolitan Region

Table 1. General indicators relevant to transport in Metro Manila and Bangkok.

Aspect	Thailand/Bangkok	Philippines/Metro Manila
GDP/cap ($, 2014)[a]	5977	2872
GDP growth (av. 2010–2014)	3.2%	5.9%
Urban population (million)	8 (14)[b]	12 (24)[c]
Urban density (cap/km^2)	4361[d]	19,000
tCO_2/cap (transport sector, national, 2010)	0.88[e]	0.25[f]
Motorisation (city proper) # cars / # motorcycles per 1000 cap	198/303[g]	86 / up to 432[h] (entire country)
Climate	Tropical, monsoon[i]	Tropical, monsoon
Urban topography	Flat	Flat

[a]World Bank Indicators, http://data.worldbank.org/indicator/NY.GDP.PCAP.CD
[b]Based on the 2010 census (http://popcensus.nso.go.th/upload/popcensus-08-08-55-E.pdf).
[c]2010 Census of Population and Housing: National Capital Region. National Statistics Office of the Republic of the Philippines.
[d]Calculated from Sintusingha (2012): 6842 population, 1569 km^2 in 2007
[e]Narupiti et al., 2014
[f]Mejia et al. (2017). It is noted that this is likely to be an underestimation
[g]Department of Land Transport (2015). http://apps.dlt.go.th/statistics_web/vehicle.html; includes pickups
[h]total vehicle registration, 2013; Land Transportation Office Annual Reports, quoted in Mejia et al. (2017)
[i]30–35 C mean high throughout the year; four months monsoon, mostly short heavy showers late afternoon

(BMR). As of March 2017, there are five urban rail lines in operation, with another seven being constructed or planned, and several suburban rail lines. Buses stop on the side of the road, implying conflict with other road users including cyclists. Motorcycle taxis, motorized three-wheelers (tuk-tuks), and *songthaews* (local paratransit) are a common sight across the city, providing a key public transport feeder service, as most destinations can only be accessed via long narrow side roads (*sois*), which emerged without any central planning (Sengers & Raven, 2014). Khuat (2006), developed a "motorcycle-dependency" rating, in which Bangkok would be qualified as "medium" motorcycle dependency. Nonmotorized three-wheelers (*samlors*) have been banned in the city of Bangkok since 1964, however, remain common in urban areas in the surrounding provinces i.e. the outskirt of the BMR. Other aspects of transport in Bangkok include prevalence of dead-ends, U-turns, long traffic signal cycle times, and lack of or low quality zebra crossings and footpaths.

Bangkok's urban development from 1960 to the early 1990s was laissez-faire, and there was no official urban plan until 1992 (Sintusingha, 2010). Furthermore, urban transport policy and planning is characterized by car-oriented planning, responsibilities split across more than twenty agencies, political influence, and lack of standards and regulations. Charoentrakulpeeti, Sajor, and Zimmermann (2006) highlight the significance of the "modern lifestyle and forms of consumption that logically bear heavily on the transport situation in Thailand," that is, the "middle-class propensity for peripheral and suburban type of single detached home ownership, private car ownership, and associated car dependence for travel." Ownership and use of private cars are seen as "a necessity and desirable" including for enhancement of social status, safety, and a reduction of one's exposure to pollution.

Although no cycling modal share data for the entire city or region of Bangkok appear to be available, several studies indicate bicycle ownership and use is significant, and in the order of 1% of the modal split of trips (Raha & Taweesin, 2013), including feeder trips to public transport (OTP, 2014). Many poor people are using bicycles, which are also called "maid bikes." In addition, the Pun bike sharing system (third generation like most contemporary systems) started in 2013, and as of 2016 consists of 50 stations and over 500 bikes, with expansion planned. A more or less increasing trend in 2013–2014 to 5–10 trips per day per station was observed. Most Pun trips are between 0.5 and 2 km, with approximately 10% over 2 km (Raha, 2015). Household bicycle ownership, in Thailand country-wide, is approximately 60% (Oke, Bhalla, Love, & Siddiqui, 2015)

Since 2008, the Bangkok Metropolitan Administration (BMA) has been improving bike infrastructure with approximately 200 km of bike lanes as of 2016. However, these are often built primarily for sport and recreation purposes (e.g., the cycling track around the airport) and are sometimes disconnected from the main transport network; other stretches are on

Figure 2a. Examples of shared paths, bicycle lanes on the road and exclusive bike lanes (photos: Stefan Bakker).

Figure 2b. (Continued).

sidewalks and along main roads (see Figure 2). Many urban rail stations have small bicycle parking racks and at some stations these are being used, by public transport users and street vendors. In terms of the five criteria for cycling-inclusive planning by Pettinga et al. (2009) (see Section 2.2), we can summarize the current situation as follows:

1. Low directness: cycling from origin to destination requires large detours rather than the shortest possible route, as bicycles must follow car infrastructure including U-turns and due to the many cul-de-sacs; in addition, there are long waiting times at traffic lights.
2. No coherence: the few bike lanes are scattered, not connected, and of different typologies (see Figure 2), therefore only a small share of possible destinations can be reached.
3. Low safety due to many crossings and mixing with motorized traffic, unexpected situations, little priority to bicycles by other users, few protected bike lanes.

Figure 2c. (Continued).

4. Little comfort: no shading in existing infrastructure, exposure to hazards, noise, and pollution.
5. Attractiveness: good in quiet alleys, near local markets and in parks, however, not attractive on bigger roads.

These days cycling is trendy, fashionable and increasingly popular among several groups. The car-free day is held annually in Bangkok since 2005, with participation increasing every year, and large bike-related events, such as fairs, are held on a regular basis, with visitors in the thousands. Dozens of smaller or larger bicycle groups or clubs regularly organize group rides in inside or outside the city, mostly on weekends. At universities there is an active bicycle community as well, linking transport and environmental issues with trendiness. Meetings at cycling-themed cafes are commonplace. In (social) media, cycling is a popular theme, both from a lifestyle as well as a policy perspective. We found over 100 Facebook pages[2] directly or indirectly related to cycling in Bangkok, which together have approximately 1.2 million followers as of March 2016. These include communities and cycling groups (mostly for fun and recreation), NGOs or campaigns for cycling as transport mode, media (e.g., sports cycling), and initiatives from academic institutions, for example, those that promote cycling on university campuses. The latter can be seen as protective spaces for innovation, where "sustainability experiments" take place (Sengers, 2016).

The bicycle market, especially for high-end models, has been growing by 15–25% and exceeds USD 200 million, and the International Bangkok Bike Fair in September 2015 branded Thailand as the hub of ASEAN cycle business.

Also in newspapers and magazines the topic has gained attention in recent years. When looking at some of these articles analyzed in Bakker et al. (2016) we can observe how cycling is framed. Prime Minister General Prayuth Chan-o-cha spoke about the "government policy to promote the use of bicycles as means of exercise or daily commute vehicle," which "helps to improve people's health and reduce air and noise pollution." Another article reports that a new cycling route is part of the government's programme "Return Happiness to Thais," and aims to promote cycling as a way to maintain health and cultivate a love of exercise. Cycling also has been associated to the idea of "liveable city" and "low-carbon society" while contributing to GHG emission reduction, and cycling has a "social value." However, there are plenty of different views in society, for example, "cyclists don't belong on the road," and motorists "who treat cyclists as a nuisance and bike lanes as an intrusion into their road space (…) and that roads are exclusively meant for motor vehicles, and not for bicycles" (Bakker et al., 2016).

Advocacy groups include, for example, Thailand Cycling Club (TCC), Thai Cycling for Health Association and the Bangkok Bicycle Campaign; their activities include campaigning, organizing events, carry out research and surveys, and initiating and influencing policy discussions. The Bike and Walk Forum, organized by several advocacy groups and government agencies, is held annually since 2013 and provides a platform for sharing research on NMT. A bicycle policy working group, convened by the BMA and joined by several groups and experts, discusses bicycle issues related to infrastructure, events,

[2]List available upon request from the first author.

safety, etc. The public can learn about the outcomes of these meetings, for example, through social media.

Significant policy activity related to cycling can be observed since a few years, even if local politicians have paid attention to it for over a decade. Through the National Health Commission Office of Thailand and initiated by TCC, the Cabinet has adopted a Resolution on "Supportive Systems and Structures for Walking and Cycling in Daily Living" in which nine Ministries are assigned tasks and responsibilities to promote NMT (National Health Commission of Thailand, 2012). The NMT feasibility Study (OTP, 2014) provides a blueprint for 140 public transport stations in Bangkok that can be upgraded to facilitate interconnectivity and NMT accessibility. BMA's "City of Happiness" policy includes various public transport and cycling measures such as 10,000 public bike sharing bikes and speed limits on shared roads. The Environmentally Sustainable Transport Master Plan (OTP, 2012) proposes measures such as the development of networks and facilities for cycling, promotion of NMT, and introduction of bike sharing. The Ministry of Transport adopted the Manual of Standards for Bikeway Design and construction, which are based on American standards and specifies which types of bike infrastructure (shared road, shared lane, bike lane, and segregated track) is to be provided on road categories based on speed and volume of motorized vehicular traffic (Thailand Cycling Club, 2016). More guidelines for infrastructure and promotional activities are being developed by other agencies. In 2015, approximately USD 39 million was invested in cycling infrastructure throughout the country, mainly by the Ministry of Tourism and a smaller share by the Ministry of Transport.

The approach currently in Thailand may be characterized by fragmentation and focus on individual stretches of infrastructure, with little attention for data and monitoring, communication and education, electric bikes, or other necessary policies such as transport demand management, traffic calming, and car taxation (Narupiti, Tippichai, Nanthachatchavankul, Sutjaritthanarak, & Bakker, 2014). To date, there appears to be limited involvement of international experts or sharing of best practices, though a nationally appropriate mitigation action is being proposed and developed that includes technical assistance for cycling as a public transport feeder mode.

There is limited literature on public acceptance of cycling in Thailand, although one article suggests it may be relatively low. Nongnuch (2015) carried out a representative survey among 15,700 respondents in 10 provinces across different regions in Thailand and found that the public image of cycling as a daily mode of travel is "moderate," and, though there are strong positive associated images as well, negative images such as "poor man bike," "dirty biker," "embarrassed to ride to work or school," and "obsolete way" also scored high.

3.3 *The Philippines: Metro Manila*

In the Philippines, Metropolitan Manila, also known as the National Capital Region, is constituted into a special development and administrative regions subject to direct supervision of the President and composed of 17 cities. The Metro Manila Development Authority (MMDA) is the agency that performs planning, monitoring and coordinative functions, and exercises regulatory and supervisory authority over the delivery of metro-wide services. Most cities or Local Government Units in Metro Manila have their distinct traffic management office or board, operating under the Office of the Mayor or adjunct to the latter with their own personnel and budgets. The Department of Public Works and Highways is the agency involved in all infrastructure related to roads, the planning of which draws heavily from US references and standards (Regidor, 2015).

Culturally and traditionally, the bicycle has never been mainstreamed nor encouraged in the country's public transport system. Only in the late 1980s to early 1990s bicycles and pedicabs (nonmotorized three-wheeler taxi) were seen, due to the oil price surge in that period. By the 1990s, they were banned on major roads due to safety and congestion issues. In the past two decades approximately 23% of households own bicycles (Oke et al., 2015). It is estimated that up to 35% of destinations are within a 15-minute walk or bicycle trip and the majority of short trips are made by paratransit and cars (Leather, Fabian, Gota, & Mejia, 2011); however, only 2% of all trips in Metro Manila are made by bicycles (Gozun & Guillen, 2008). At least two universities have initiated bike sharing initiatives. There was also a small scale Asian Development Bank demonstration project in Pasig City. In the initial mapping activity of the Ateneo School of Government's Inclusive Mobility Project supported by the Rockefeller Foundation, in four cities in Metro Manila, there are over 60 bike shops estimated. Since 2008, there is also a bike courier service, Pedala Bike Messenger, with a pool of 150 bike messengers in 2013.

Designated bike lanes are being constructed and as of 2015 add up to approximately 70 km, including one World Bank

Figure 3a. Existing bike infrastructure in Metro Manila (Source: Danielle Guillen for Figure 3a, and Regidor (2015) for Figure 3b (instead of 'left' and 'right')).

Figure 3b. (Continued).

project (MMDA, 2015; Romero, Guillen, D., Cordova, & Gatarin, 2014) is in place. As can be seen in Figure 3, some of these are fully segregated, others painted on the side of the road, and some are on the sidewalks. Quality of the infrastructure varies, and conflict with pedestrians has also been reported. On all five criteria of cycling-inclusive planning currently Metro Manila would be doing poorly, though it can also be argued that given the stage of policy and planning it is too early to meaningfully apply these criteria.

Since 2010, a range of policy documents including Administrative Orders and Senate and House Bills have been proposed and some of these are adopted at the local level, even though there is no clear national policy yet. The key policy objectives and issues highlighted in these bills include global warming, fuel consumption, environmental protection, protecting bicycle-using labor force from injuries and deaths, health of the people, cheap alternative means of transport in the light of fluctuating fuel prices, advance the right of the people to a balanced and healthful ecology in accord with the rhythm and harmony of nature, air pollution, reduction of traffic congestion, exercise and relief of stress, cheaper transport, reduced road damage, and enhance well-being (Bakker et al., 2016). Administrative Order No. 254 calls for "Reform the transport sector to reduce the consumption of fossil fuels. The new paradigm in the movement of men and things must follow a simple principle: 'Those who have less in wheels must have more in road.' For this purpose, the system shall favor nonmotorized locomotion and collective transportation system (walking, bicycling, and the man-powered mini-train)." The Nationally Environmentally Sustainable Transport Strategy (NESTS) (UP-NCTS, 2011) includes strategies and indicators related to NMT. Designation of bike lanes is called for by several proposed bills including, for example, the Sustainable Transport Act of 2013, Bicycle Lane Act of 2014 and the Bicycle Lane Act of 2015. Other policies and measures such as parking, incentives for electric bikes, establishment of Local Bikeway Office and transport demand management (TDM) is included in other bills. However, it is important to note that while the Department of Transportation has the NESTS framework in place, none of the bills in the Congress or its counterpart in the Senate has passed. In the Philippines for a national law to be enacted, it should both pass the majority of the Senate and Congress members. The pending bills reflect that for the majority of policy makers, such bills were not a priority at the time it was being deliberated.

In the Philippines, key bike advocacy organizations include the pioneering Firefly Brigade: an NGO that promotes the use of the bicycle for clean air and sustainable communities. Activities include an annual awareness raising tour, monthly critical mass biking tour, installing provisions for bike parking, engaging with government agencies promoting the cycling agenda in urban design, conducting NMT forum and providing training. The National Bicycle Organization founded in 2014 is also active in organizing bike rides, in smaller groups as well as large events such as National Bicycle Day held every year on November 4th, bicycle education, seminars, partnering with national and local government agencies, as well as related advocacy, for example, by supporting the Share the Road movement. Their main task is to encourage local government units to develop NMT policy by providing templates for local government units to utilize in the crafting of their own respected NMT policy. The Tiklop Society of the Philippines seeks to promote the use of folding bikes as a means to better oneself and achieve cleaner air to breathe and more liveable cities. It promotes multimodal transportation and has successfully lobbied for having folding bikes be allowed on the light rail system. The Share the Road Movement has been instrumental too in promoting car-free days and road-sharing exercises together with MMDA as well as in some local government units like Pasig City, Iloilo City among others. They also conduct the "Bayanihan sa Daan" Awards (Cooperative Heroism) together with the Office of the President on Environmental Protection on recognizing pioneering local governments, individuals, civil society groups, and organizations from across the country that are actively promoting walkable-bikable communities and road-sharing initiatives. There is also the Inclusive Mobility Network, a relatively new NGO and an offshoot of the Ateneo de Manila University School of Government Inclusive Mobility Project, the interviewee of which noting the need for political will to implement the plans being advocated. The network aims to provide a platform for all champions of related sustainable mobility initiatives including those working on walking, cycling and its integration with public transport system as first and last mile connectivity means. To date in the Philippines, in the absence of national policy on cycling, there are a few cities (Marikina City, Pasig City, Iloilo City, and Davao City) that initiated to have its own local policies on bicycles. Some cities and municipalities also have separated policy for three-wheelers or pedicabs for public transport use.

In a brief survey of social media pages, we found approximately 40 Facebook pages directly related to cycling, together having over 400,000 "likes" or fans. Most pages are dedicated to recreational or sport cycling; however, around 50,000 fans are for seven advocacy related pages. These organizations use these pages to report on their activities, highlight issues, organize events, and spread ideas. There is regular media coverage of cycling related policies and events. A media content analysis of online media, mostly newspapers, shows cycling is framed as supporting green living and low-carbon society, and articles normally highlight the infrastructure

and discipline problem on the streets. Examples of framing include Marikina being dubbed the "Healthy City" and cycling having many physical and mental health benefits. It is also fun, cheap and good for the environment." Other articles related cycling to "lifestyle" and a "people-oriented method of transportation." However, cyclists on the road can also be seen as a "nuisance" (Bakker et al., 2016).

One of the earliest researches on the reason why bicycle is not significant transportation/commute mode was done by Gozun (2001) and it noted the role of personal attitudes and community values which affect the potential use of cycling in the noncycling community of the University of the Philippines; even respondents who find cycling as a good recreational sport do not think of cycling as a viable transportation mode for commuting. Generally cycling may be identified with poorer sections of society, such as security guards, construction workers, pedicab drivers, etc.; however, these days it is also being looked at as something good and perhaps "cool," particularly when certain brands of bikes are used. Pedicabs in urban areas are usually for last mile connectivity and perceived to be the cheaper and safer mode while in the suburbs, they are usually found in less well-off gated communities as an alternative to tricycles as they are the noiseless modes for the public last mile connection of around 250 m to 2 km (Guillen, 2000).

4. Emerging picture: TIS analysis and discussion of cycling in Bangkok and Metro Manila

Using the case study data as introduced in Section 3, we apply the TIS framework to cycling in Bangkok and Metro Manila. The results are depicted in Table 2 and should be read in conjunction with the city contexts described in Section 3. Where aspects are relatively similar for Bangkok and Metro Manila we use merged cells.

Table 2 and Section 3 show there is a significant theoretical potential to increase the cycling modal share in both ASEAN cities. However, to harness this potential, barriers need to be addressed. Key gaps in the current TIS include limited knowledge development (including data), actor networks, advocacy coalition, e-bike adoption, infrastructure, resource mobilization, and legitimation; the latter due to issues such as car-oriented planning, competition from motorcycles and paratransit, few bike-friendly policies, and potentially limited public acceptance. These gaps, together with mechanism that (could) promote or block cycling development, lead to a set of policy recommendations as provided in Table 2.

Given the preceding overview and analysis, what can be said about the future of cycling in tropical megacities in the ASEAN? Can it become a mainstream practice with modal shares in the range of 5–30% or will it remain a niche? Obviously, both are possible. Addressing (most of) the policy issues can be seen as necessary conditions to move beyond cycling as a niche, that is, without implementing these policy recommendations with the required resources the modal share is unlikely to go up significantly.[3]

[3]The example of Tokyo, with a 16.5% modal share in 2008 (Pucher et al., 2012) despite absence of dedicated bike lanes, shows it is not impossible.

Many cities across the globe are following such a path, spearheaded by Dutch and Danish cities where in excess of 30% of urban trips are by bike, followed, for example, by German cities where significant policy efforts also resulted in modal share increases of over 2%-points between 2002 and 2008 in three cities (Lanzendorf & Busch-Geertsema, 2014). In Bogotá, there has been a substantial increase from 0.58% in 1998 to 5% modal share a few years later; however, then it stagnated due to lack of safety in crossings, reduced policy interest in cycling during 8 years of poor mayoral mandates, lack of funding, and lack of institutional follow-up (Pardo, 2013b). If we compare Bangkok and Metro Manila to these cities, it is clear the latter are in a relatively early stage—with lack of bicycle infrastructure resulting in low safety—and policy efforts will need to be sustained for years if not decades to see results. The same can be said for advocacy coalition, which are not yet well-developed in either city, as shown by the example of Santiago which had a civil society movement already since the late 1990s. The members were able to build up momentum and gain successes in the course of many years through collaborative planning processes (e.g., the Citizen-Government Roundtable for Cycle-Inclusion), and increase the modal share from 2% in 2006 to 4% in 2012 (Sagaris & Ortuzar, 2015). We did not find examples where cities invested heavily in infrastructure for more than ten years without seeing a significant increase, though it may well be that this will be found in the future, as many cities have been developing bike lanes since recent years.

Singapore may be able to provide interesting lessons in the future as well, as the city has started in 2013 expanding the bicycle network from the existing 200–700 km by 2030. The existing segregated bike lanes are mainly part of the Park Connector Network. The planned network focuses on improving footpaths to accommodate cyclists together with pedestrians, as well as dedicated cycle tracks; on-road cycling lanes are not considered. Both intra-town cycling, especially integration with public transport, and cycling between towns. The Singaporean town of Tampines was the first to develop a full network, which resulted in a significant increase in cycling levels on upgraded stretches, particularly near the metro station, even if starting from a low base with peak rates between 10 and 100 cyclists per hour (Nguyen et al., 2015). Regarding drawing lessons for other cities, it should be noted that Singapore currently has much higher quality footpaths and more space to expand these compared to most other cities in the ASEAN. Although the approach could work elsewhere—provided it is implemented well—it is recommended to monitor the results and experiences with shared pedestrian-cycling lanes in Singapore, and evaluate carefully before implementing elsewhere.

However, even if policymakers, planners, and other stakeholders follow international best practices, spend resources accordingly, and are able to make the necessary and often politically difficult choices, the future of cycling cannot be predicted: ultimately cycling as a daily practice is a human behavior change issue. At this point in time it is not known, and arguably cannot be known fully, what the conditions are in these cities, or any city with a currently low modal share, that would result

Table 2. Overview of existing situation for cycling in Metro Manila and Bangkok using the TIS framework.

TIS steps	Bangkok	Metro Manila
Components (step 2)		
-Actors	Cyclists, policy makers (local and national), advocacy groups, media, bicycle shops, recreational cycling groups, private sector, e.g., (e-)bike industry and commercial developers, pedicab drivers, traffic police	
-Networks	Groups on social media, university cycling organizations, international networks of bicycle advocacy groups Bicycle policy working group	
-Institutions	Cultural norms, with the car seen as status symbol, giving a low status to the bicycle; importance of "comfort" compared to travel time; procar policies and regulations, e.g., road guidelines, policies, including transport planning practices and strategies; initial bike lane regulations are developed	
Functions (step 3 and 4)		
Knowledge development and diffusion	• Lack of data on trip patterns and current cycling levels/modal share, showing low priority with transport planners • Knowledge and capacity to develop and implement cycling-inclusive transport plans are limited; no formal cycling education in schools or in planning and engineering curricula in universities • Limited exchange of global, regional, and local knowledge • User experience: everyone can cycle but no experience in navigating the streets and route finding • Motorized vehicle drivers do not know how to share the road safely with cyclists • E-bike knowledge limited • Annual Bike and Walk Forum since 2013	
Influence on the direction of search (high-level developments, "landscape pressures")	• Some first policy activity, though it is not possible to assess whether there is a clear believe with governments that cycling can and will play a substantial role in the future • Drivers for cycling acknowledged by policymakers and communities include congestion, air pollution, climate change, and health • Cycling caters to values such as collectivism and feeling of "community" • No important historical role of the bicycle (as compared to, e.g., Vietnam) • High-level policy and statements supportive towards cycling • Motorcycle taxi considered convenient: competes with cycling	• Bottom up policy initiatives seeking regulations on cycling-inclusive planning
Entrepreneurial experimentation	• Bicycle industry thriving • Many bicycle shops; also cafes that act as meeting places for cyclists • Private sector involvement in bike sharing and rental; however public transport companies have not yet shown interest • Various businesses including retail and restaurants want to associate themselves with bikes as a fashion symbol • Tricycle can still be seen in suburban areas • No e-bikes yet	• Pedicabs (tricycles) are still popular • Few e-bikes on the road
Market formation (i.e., conditions that promote cycling compared to other modes)	• In terms of modal share cycling is in the take-off phase or "bridging market"; however, bicycle is a mature technology • Though initial infrastructure investments are being made, assessment according to five criteria of cycling-inclusive planning shows that currently there is low coherence, directness, comfort, safety, and attractiveness • Motorcycles are a strong competitor (high ownership, more status, less physical effort, relatively cheap even at high fuel prices), especially in Thailand • Car-oriented planning: sprawl, few TDM measures, traffic management (few traffic lights, no traffic calming) • Air pollution deters potential cyclists • Gated communities: even though these create supportive cycling conditions inside the community, these also contribute to longer (thus less attractive) bike trips by forcing people to make detours • Many commuting trips are long due to the large city size; however, trips for other purposes may be below 3–5 km • High bicycle ownership among all population segments, though not everyone may know how to utilize one • Initial budget available for bike lanes • First bike lanes more for recreational cycling; inner city lanes are of low quality • Cul-de-sacs and U-turns: high detour factor • Sois (small streets): many are suitable for cycling • Crosswalks in bad shape • Few traffic lights (and long intervals) • Potential for public transport access/egress mode	• Bicycle ownership low • Initial bike lanes built (however often on sidewalk, causing conflict, and covering a relatively small area) • Marikina Bikeway Office promotes cycling • Pasig City in Metro Manila has developed bicycle policy

(*Continued on next page*)

Table 2. (*Continued*)

TIS steps	Bangkok	Metro Manila
Legitimation	• Predominantly supportive public statements from politicians, though sometimes ambiguous • No 'hard choices', such as allocating road or parking space to cyclists, made yet, and transport planning remains car-oriented • Social acceptance of bike lanes only likely when not impacting current road users • Social acceptance of the practice itself, given tropical weather and class-oriented society: probably limited in present days, however, little comprehensive literature. Association of bicycle with poor people is quite strong in general. However, it's also very trendy and associated with a healthy lifestyle. Spill-over effects from recreational to transport cycling are however unclear. • It's very media-chic at the moment, also in social media • Active advocacy groups support cycling • Universities and students embrace cycling • Likely there is low acceptance for TDM policies • Traffic management, e.g., by speed limits and traffic calming: acceptance unclear • Bicycle events very popular • Moderate social acceptance of cycling (limited literature evidence) • Strong car industry, which may influence policy	• Probably more acceptance for TDM policies (Mejia, Dematera, Guillen, Villaraza, & Bakker, 2017) compared to Thailand • No evidence found on public acceptance, cultural barriers or negative images associated with cycling
Resource mobilization	• Many people involved in various ways: groups, shops/cafes, universities • Growing bicycle industry, both domestic and international brands • Bicycle-related events are getting bigger • Knowledge development takes place through conferences, networks • Initial budget allocation, up to $40 million in 2015, mainly from Ministry of Tourism • High-level policy support • Bike sharing system is small but being expanded	• Budget allocation very limited up to now • Bottom-up policy initiatives • Philippines is significant bicycle exporter • Bike sharing system very limited and no clear plans for large scale implementation
Development of positive externalities	• Synergy with public transport (first/last mile connectivity), particularly given urban rail expansion • Cycling clubs (for recreation) and events • Media like cycling • Bicycle industry is significant and growing: employment benefits • Business benefits for local communities along cycling routes	
Inducement mechanisms (step 5). Based on existing information and current trends	• Increasing congestion could build momentum for "alternative" mode • Investments in public transport • Attention to health benefits, "healthy city" • Climate change: cycling fits into, e.g., "low-carbon society" • Other policy objectives, such as well-being, equity, air quality, noise reduction support cycling • Flat terrain • "Incremental" infrastructure improvements • Bangkok promoted as "City of Happiness"	• Pedicabs are employment opportunities
Blocking mechanisms (step 5). Based on existing information and current trends as well as potential future mechanisms	• Culture, potential unwillingness of population to cycle (though no conclusive evidence exists) • Climate: temperature, humidity, precipitation, exposure to sunlight are considered barriers • Personal benefits of cycling are not well communicated or emphasized • Air pollution and general environmental condition of the cities are not conducive • Lack of coordinated and high-quality planning, lack of budget or policy low priority • Lack of willingness to take "unpopular" measures (TDM, traffic management) • Inadequate knowledge and lack of data on the relation between investments and benefits (see also section 2.2); potentially low usage of bike lanes being built, reducing political willingness for further policies • Isolated measures, sometimes introduced for image reasons, rather than comprehensive vision and planning • Competition with motorcycles and relatively convenient paratransit, the latter a politically powerful interest group • Unclear whether the current advocacy coalitions have sufficient power to make sure progressive policies will be developed and implemented • Unclear whether majority of society considers cycling an appropriate means of transport • No e-bike policies yet • Street vendors may oppose cycling on sidewalk	• Public may not consider cycling a convenient transport mode (limited evidence)

Policy issues: options for immediate or future consideration by national and local decision makers (step 6). Based on preceding TIS steps, local and international literature and summary from Bakker et al. (2016)	• Invest in quality infrastructure based on cycling-inclusive planning; improvements can be incremental, but should be of high-quality in order to show commitment and create "status" for the cyclist and follow a plan towards a comprehensive network • Carry out comprehensive ex-ante evaluations including cost-benefit analysis for infrastructure • Analyze propensity to cycle of urban population, e.g., based on categories from Dill and McNeill (2012) • Develop supporting policies including national and urban cycling strategies, cycling-friendly road and intersection design standards, incentives for electric bikes, liability laws in favor of cyclists and education and communication promoting cycling to the public as a "normality" and convenient daily transport mode (Nongnuch, 2015), e.g., through projects such as bike to school • Implement traffic management and TDM measures, potentially including restrictions or disincentives for paratransit and motorcycles • Engage private sector in, e.g., bike sharing, rental, and bicycle parking, as well as bike industry • Ensure sufficient staff in local governments dedicated to cycling and build capacity for planning • Work with and strengthen the advocacy coalition • Support knowledge development by funding research programmes, conferences, curricula • Make use of national and international knowledge and best practices, though avoid copying without consideration or employ only foreign consultants but ensuring its appropriateness in the local application • Adopt targets related to increasing cycling modal share, gather data and develop a monitoring system • Reduce "detour factor" by improving connections between sois • Make use of shading of elevated highways • Pedicab promotion

in mass cycling as seen in Vietnamese cities in the 20th century; and whether such conditions are desirable and acceptable. Research and monitoring can only assist decision makers and reduce uncertainty, while time will tell the impact.

5. Conclusions

In recent years, cycling gained public interest in ASEAN at the regional, national and local level. This paper set out to analyses the current situation and future potential of cycling as a mode of transport in ASEAN's megacities using the Technological Innovation Systems (TIS) framework as a research method and applied to Bangkok and Metro Manila.

The two cities are relatively comparable in many aspects of cycling. Starting from a low base, both cities acknowledge cycling as a key option to achieve sustainable urban transport and public health objectives by policymakers and media. The bicycle is often used by both the poor for short trips as well as the more affluent for sports, recreation, and fun activities. As a fashion symbol, group activities, social media and events, cycling, or the bicycle is very popular. As a comfortable choice for transport purposes, cycling is still a niche and not (yet) an established culture. The TIS analysis shows that common elements not conducive to cycling include limited knowledge development, actor networks, advocacy coalition, e-bike adoption, infrastructure, resource mobilization, and legitimation; the latter due to issues such as car-oriented planning, competition from motorcycles and paratransit, few bike-friendly policies, and potentially limited public acceptance—with weather being one among several factors. On the other hand, flat terrain, attention for cycling for health and environment, heavy congestion, expansion of public transport, growing bike industry, active university communities, emergence of advocacy coalitions, and a potential to fit with cultural values, could open up opportunities.

Although initial investments in infrastructure dedicated to cycling are being made, these are fragmented and there are no integrated plans or visions. Especially in Bangkok, infrastructure appears being more for recreation and health rather than transport, and it is not clear at the moment to what extent policymakers believe cycling can play a significant role in urban transport, despite high-level supportive statements and development of policies. In Manila there is a strong bottom-up approach, both in civil society and policymakers, who are proposing regulations supporting cycling, but given the absence of a comprehensive national policy to mainstream cycling in the transport system, challenges remain.

To move cycling beyond a niche transport practice and achieve a transition to significant modal shares, incremental but consistent improvements in infrastructure focusing on a comprehensive network based on cycling-inclusive planning are required. This implies creating adequate conditions for safe cycling in as many roads as possible—which may or may not require segregation. Other policy issues include improving regulations to protect cyclists, education toward bicycle use and respect of cyclists and communication, progressive transport demand management policies, ensuring sufficient dedicated staff in relevant government institutions, promotion of e-bikes as a convenient option in a tropical climate and alternative for motorcycles, data and monitoring, working with the private sector, and enhance the advocacy coalition.

We found the TIS framework can readily be applied even to a technology that has been around for more than a century but re-emerging and gaining popularity in recent days. It provides a practical approach to investigate missing elements or functions in the current system and identify policy issues. TIS is useful as it analyses the entire "technology system" comprehensively and specifically focuses on what policymakers can do to address blocking factors; it forces the researchers to think more broadly about issues which otherwise might have been missed, for example, knowledge development, advocacy coalitions, and industry development. As TIS is often applied to and oriented toward new and complex technologies developed by the private sector, applying the functions of knowledge development and entrepreneurial experimentation is perhaps less straightforward. However, overall TIS provided a helpful framework for our analysis and policy recommendations.

Further research gaps include more detailed data on cycling trips and their characteristics, a comprehensive study into the potential for cycling in tropical megacities and the conditions under which these potentials can be achieved, especially for ASEAN megacities where motorcycles are a dominant mode of travel, and the propensity of recreational cyclists to start cycling for daily mobility.

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