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European Transport Research Review (2023) 15:27
https://doi.org/10.1186/s12544-023-00604-2

European Transport Research Review

REVIEW

Open Access

Mobility as a Service (MaaS) in the Global South: research findings, gaps, and directions

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Abstract

Background Mobility as a Service (MaaS) – bundled mobility and transport services accessible on-demand and on a single platform – has been a popular research topic in recent years. Most MaaS studies, however, are embedded in the context of cities in the Global North, where most of the existing MaaS schemes are operational.

Purpose The purpose of this paper is to give an overview of first findings of studies in the Global South. We aim to answer the following questions: Is MaaS likely to gain traction in the Global South? How does MaaS in the Global South differ from the known model? Can MaaS mitigate transport problems in the Global South?

Methodology We conducted a systematic literature review with a thematic analysis and narrative synthesis. In total, we identified 23 relevant papers that were included for full-text analysis.

Findings A qualitative synthesis of the analyzed papers suggests that: (i) there is a considerable demand and preference for integrated, app-based mobility services and that both public and private actors are likely to push the MaaS concept; (ii) however, different regulatory frameworks, available infrastructures, and user preferences, among others, require an adjusted MaaS model; and (iii) there is initial evidence that MaaS can indeed promote more sustainable mobility behavior in the developing world, although these findings require further validation from MaaS pilots and comprehensive simulation studies.

Keywords Mobility as a Service (MaaS), Urban mobility, Sustainable transport, Systematic literature review, Developing countries

1 Introduction

Transport plays an important part in modern societies and is a pivotal factor for economic growth. At the same time, however, it is inextricably linked to negative externalities such as traffic congestion, accidents, and air and noise pollution. Public authorities and policymakers thus frequently account transport-related problems as one of their key responsibilities [42]. Consequently, they advocate for shifts towards more sustainable modes of transport, reducing dependency on private cars, and decarbonizing the transport sector, among others (e.g., [47, 52]).

These objectives are of particular relevance in the context of urban areas, which are characterized by high population size and density. Most of the world's highest and most densely populated cities and metropolitan areas are found in the Global South [1]. Opposed to many cities in

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[1] In this research, when we refer to the "Global South" (or "developing countries"), we mean countries according to a classification by the United Nations Conference on Trade and Development (UNCTD) that broadly comprises Africa, Latin America and the Caribbean, Asia without Israel, Japan, and the Republic of Korea, and Oceania without Australia and New Zealand (UNCTD, n.d.).

Table 1 MaaS integration typologies. *Source*: Expanded from Hasselwander et al. [24]

3 Integration categories [33]	4 integration levels [56]	5 integration levels [43]	Examples
	4—Integration of societal goals	5—Full integration under all conditions	
Advanced Integration with mobility packages	3—Integration of service offers (bundles)	4—Full integration under certain conditions	Whim, UbiGo
Advanced Integration	2—Integration of booking & payment	3—Partial integration	Free2Move, moovel, Jelbi
		2—Limited Integration	Uber, Grab, Bolt
Partial Integration	1—Integration of information	1—Basic Integration	Moovit, Qixxit, Google maps
	0—No integration	0—No Integration	Lyft, Hertz

the Global North, the so-called megacities (i.e., populations of 10 M and more) in developing countries often continue to experience fast population growth.

It is thus not surprising that, in many cases, developing cities are facing more drastic problems related to transport compared to cities in developed countries [6, 52], with rapidly declining accessibility being among the most severe consequences. In other words, this means that travel times are usually extremely high and increasing, while the number of accessible destinations within a given period of time is decreasing [10].

The strategy arranged by development aid agencies such as the World Bank to address these issues usually encompasses transport infrastructure projects with the intention to increase the capacities of transport systems. Recent projects being financed by the World Bank include the Quito Metro Line One Project in Ecuador and the bus rapid transit (BRT) system in Dakar, Senegal. However, even assuming that these projects would deliver remarkable outcomes, what they have in common is that they are long-term projects that may take up to several years to complete. In addition to any of such long-term infrastructure projects, complementary projects that increase overall efficiency and enable short to medium term results should be established as well.

With regard to the latter, the transport sector has recently experienced the emergence of transport innovations that draw on societal changes and the integration of new technologies. Within the course of this progress, innovative mobility solutions (e.g., carpooling, ride-hailing, and car-, bicycle-, and e-scooter sharing) have been introduced and new start-up companies have been formed, which in a relatively short time gained considerable attention and had a significant impact.

Eventually, this development has paved the way for Mobility as a Service (MaaS), a new mobility concept that is seen as a solution to support alternatives to the private car. The MaaS model intends to offer integrated mobility services that are accessible on demand and through a single interface, by combining public and private transport modes, in order to serve individual mobility needs [59]. Users can choose between pay-as-you-go options or subscription-based mobility packages. The extent of integration can vary and is one of the main differentiators among existing MaaS schemes (Table 1).

A MaaS scheme is expected to increase the efficiency of a transport network and improve the performance of the integrated services [3], while being able to offer seamless customer experience across all transport modes [32]. As a result, MaaS is often regarded as an opportunity to reduce people's dependence on private cars [32].

In the Global North, first large-scale MaaS schemes such as *Whim* in Helsinki or *UbiGo* in Stockholm showed promising results, encouraging emulation in other parts of the world. Indeed, MaaS has recently also aroused interest in the developing world and is seen as a solution to mitigate existing transport problems [46]. However, while an overview of the MaaS-Alliance shows a strong concentration of MaaS schemes in the Global North (Fig. 1), MaaS is still in its infancy in the Global South.

Although our understanding of MaaS has substantially grown over the past years due to important scholarly contributions with respect to MaaS adoption (e.g., [16, 60]), the design of mobility packages (e.g., [5, 20]), permissive MaaS policies (e.g., [30, 39]), and quantifications of MaaS effects (e.g., [3, 14]), these findings are likely not directly transferable to the Global South context (or only to a certain extent). Among the most significant differences between transport in developed and developing countries are differences in available (mass) transport infrastructure, institutional arrangements, and modal splits [21]. Consider that while in many cities in developed countries citizens have access to dense urban rail networks, road-based transport is shouldering most of the transport demand in cities of developing countries. Public transport services in developed countries are often based on service contracting and operated by large, in many cases government-owned companies. In contrast, public transport services in developing countries are mostly rather informal, depending on private sector initiatives, and often operated without official endorsement [7]. Also, travel behavior and mode choices are very diverging. In developed countries, the

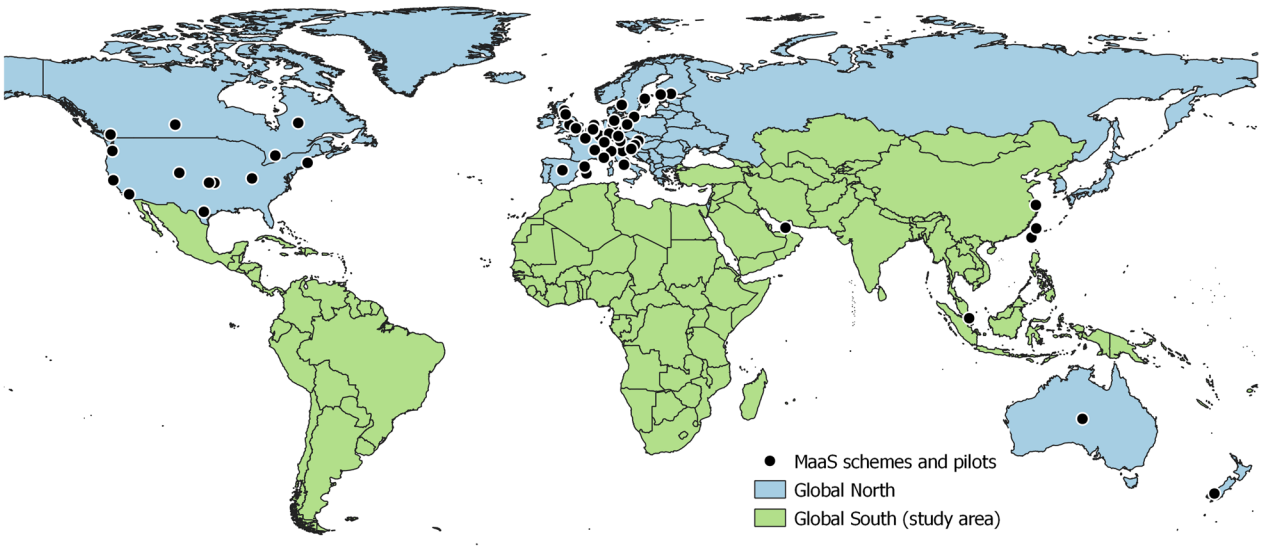

Fig. 1 Worldwide MaaS penetration: Map of existing MaaS schemes and pilots as of 2019. (*Data source*: MaaS-Alliance)

private car has been the most dominant transport mode for many decades, although car ownership is declining (especially in urban areas) and travelers increasingly rely on alternative modes due to environmental- and health-related motivations [27, 44]. In developing countries, in contrast, car ownership is still relatively low although increasing motorization rates are observed. Especially in fast-growing economies, more and more people can and do afford private cars, which are often still seen as status symbols. Altogether, we therefore argue that the Global South requires a separate investigation with regard to the implementation and analysis of MaaS. Existing findings from the Global North need to be validated and additional studies carried out, specific to the characteristics of developing countries.

Hence, the objective of this literature review is to provide an overview of the state of the art of MaaS with an explicit focus on the Global South. We argue that this will help transport planners and policymakers to recognize recent research findings and, accordingly, plan and support the implementation of MaaS schemes. Considering that this is an incipient field of research, we also aim to provide guidelines for a future research agenda.

In this context, the following research questions have been defined to guide our review study.

- (RQ1) Is MaaS likely to gain traction in the Global South?
- (RQ2) How does MaaS in the Global South differ from the known model?
- (RQ3) Can MaaS mitigate existing (and foreseeable) transport problems in the Global South?

The remainder of the article is structured as follows. Material and methods for this study are detailed in the next section. Section 3 contains the results and discussion. Finally, concluding remarks and future research directions are provided in Sect. 4.

2 Material and methods

2.1 Related work

Below we give an overview of previous literature reviews that have addressed MaaS and describe how the present work differs/complements these studies.

- An early review has been conducted by Jittrapirom et al. [32]. It mainly discusses existing definitions and core characteristics of MaaS, and identifies existing MaaS schemes.
- Utriainen and Pöllänen [59] reviewed 31 articles and categorized them according to three identified main research areas in the MaaS literature: the role of different transport modes and services, findings of MaaS pilots and trials, and expected effects of MaaS.
- Arias-Molinares and García-Palomares [1] reviewed 57 MaaS-focused publications and synthesized the findings against five major questions (What? When and where? Who? How? Why?).
- Butler et al. [4] analyzed 91 articles with a focus on outcomes, risks, and barriers for MaaS.
- Kriswardhana and Esztergár-Kiss [38] reviewed 29 articles that focus on the adoption of MaaS and the creation of mobility packages. Their analysis identifies common research approaches used in these

studies and compares findings across different contexts.

While the review by Jittrapirom et al. [32] – considering that the MaaS literature was still in its infancy at that point – is rather narrative and also covered grey literature, conference papers, and articles that only addressed certain core characteristics of MaaS (without mentioning MaaS as such), the later reviews are increasingly systematic. Indeed, the number of MaaS publications has grown significantly in recent years so that it became inevitable to systematically identify relevant studies, but also sharpen research questions, and narrow the analysis framework. In this context, our review contributes with another new and timely perspective as we focus on less studied geographical regions (i.e., the Global South [2]).

2.2 Literature search and synthesis

We conducted a systematic literature review with a thematic analysis and narrative synthesis [19]. We followed recommendations of the PRISMA guidelines [45] – a widely acknowledged framework for conducting transparent and complete reporting of systematic reviews and meta-analyses. Among others, it contains recommendations for a full electronic search strategy, the process of screening and selecting eligible studies, and the methods for handling data and combining results of the identified studies (Fig. 2).

The literature search was performed in November 2022 using the following Boolean search strings to identify suitable publications in the Scopus (1) and Web of Science (2) database, respectively.

$$\begin{aligned} &TITLE-ABS\left(\text{"Mobility as a Service" OR "MaaS"}\right)\\ &AND\ TITLE-ABS\left(\text{"developing countr} * \text{" OR "Global South" OR "emerging econom} * \text{" OR "Africa" OR "Asia" OR "South America" OR "Latin America"}\right) \end{aligned} \tag{1}$$

$$\begin{aligned} &TS=\left(\text{"Mobility as a Service" OR "MaaS"}\right)\\ &AND\ TS=\left(\text{"developing countr" } * \text{ OR "Global South" OR "emerging econom} * \text{" OR "Africa" OR "Asia" OR "South America" OR "Latin America"}\right) \end{aligned} \tag{2}$$

Acknowledging that these search strings are unlikely to exhaust the entirety of relevant studies, we identified additional publications based on hand searching and snowballing techniques. That is, we hand searched established transportation journals for recent publications (including those in press) that might not yet appear in the mentioned databases and for MaaS-focused papers that do not have the searched keywords in the title or abstract. Also, we checked both cited and citing references for all identified records ("snowballing"). Overall, a total of 80 publications (excluding duplicates) were identified.

We only included English written scientific studies with a clear focus on MaaS and a geographic focus in the Global South for the full-text analysis (n = 36).

Studies that mention MaaS but rather deal with different concepts (e.g., carpooling or ride-hailing) as well as the few studies we could not access were excluded (n = 13).

The remaining records (n = 23) have then all been analyzed regarding their geographic focus, research methods and data, and main topic. For the categorization of the latter, we checked for the main MaaS stakeholders that the papers have focused on or are relevant to: end-users ('MaaS demand'), public and private transport operators, MaaS operators, data providers, ticketing and payment service providers ('MaaS supply'), or public authorities and regulatory authorities (ministries) ('MaaS governance') [53]. Finally, we developed a qualitative synthesis by drawing conclusions regarding the collective meaning of these studies [2]. Note that due to the paucity of empirical studies and available quantitative results, conducting a meta-analysis (quantitative synthesis) was not possible.

3 Results and discussion

Based on our systematic search, 23 relevant studies focusing on MaaS in the Global South have been identified (Table 2). Among them, 21 are published in international scientific journals and one as conference paper. We also included a preprint [29] due to its strong thematic

[2] We are aware that following our definition of the Global South (see above), we look at a very diverse set of countries with respect to income levels, modal splits, available transport infrastructure, among many other factors relevant for the implementation of MaaS. However, this definition allows us to basically include and analyze all MaaS papers that focus on countries other than the MaaS pioneers (such as Finland, Sweden, the Netherlands, Germany, Australia, Japan, etc.).

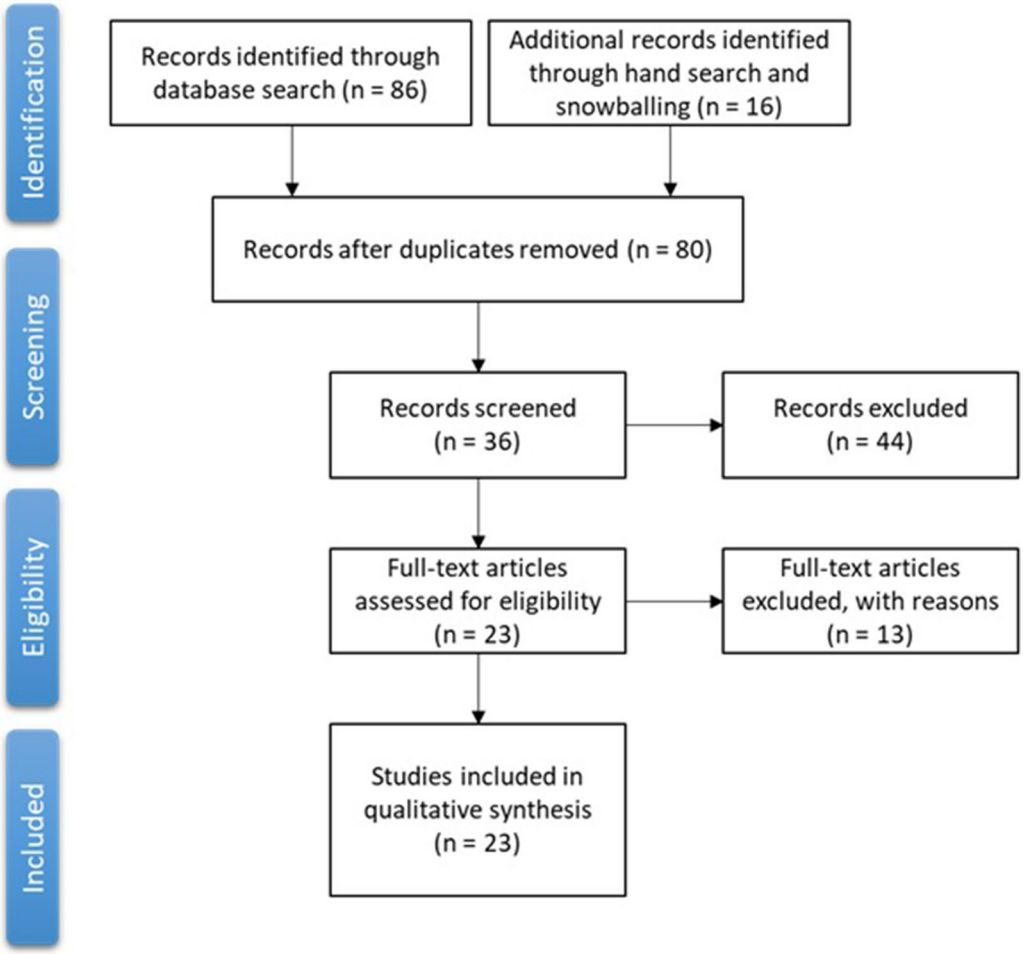

Fig. 2 PRISMA flow diagram of the literature review

relevance and because the authors have a proven track record in the MaaS literature. The small number of relevant studies highlights the emerging and timely nature of MaaS in the Global South. It is noteworthy that out of the identified studies, 18 – or roughly 4 out of 5 – have been published in 2020 or later. In terms of geographic focus, Asia is by far the most studied context, with the 15 Asia focused papers spanning across only three subregions: East Asia, South Asia, and Southeast Asia. Among the remaining publications, one has a focus in the Latin America and the Caribbean (LAC) region, four in Africa, and three have a general focus on developing countries. Finally, MaaS governance is the most studied topic (9 publications), followed by demand (8) and supply focused papers (6).

3.1 MaaS demand: potential users, reasons for adoption, and alternative use cases

Loubser et al. [41] argues that there is a lack of knowledge regarding the characteristics of a typical MaaS user, especially in the context of the Global South. Thus, its aim was to develop a framework to determine the potential MaaS userbase in a developing country. For this purpose, it reviewed the travel behavior literature and included factors such as travel purpose, travel mode, socio-demographics, subjective attitudes and perceptions, and environmental considerations in the framework to determine the MaaS userbase. Applied to the context of South Africa, it concludes that potential MaaS users are younger segments (in the 20–34 age range) with high income, while the integrated services should include bus, ride-hailing, taxi, and train.

Table 2 Overview of MaaS studies in the Global South

Publication	Geographical focus	Category			Methods and data	Main findings
		MaaS demand	MaaS supply	MaaS governance		
Chang et al., [8]	Yilan and Kaohsiung, Taiwan			●	Analysis of policy framework and lessons learned from two MaaS-pilots	MaaS in Taiwan is pushed by public actors and implemented through public–private partnership (PPP). Financially sustainable business models are yet to be developed
Chen and Chen, [9]	Kaohsiung, Taiwan	●			Confirmatory factor analysis and structural equation modelling (SEM) to assess adoption decision of existing MaaS users (n = 435)	Transport integration (enabling seamless trips) rather than ticket, payment, and travel information integration is the most important factor explaining the adoption of MaaS
Dzisi et al., [11]	Ghana	●			Modified Service Performance (SERVPERF) tool to assess MaaS features based on survey data (n = 910)	MaaS features that could improve the quality of existing transport services identified as (i) ticket booking, (ii) driver misbehavior reporting, (iii) cashless payments, and (iv) vehicle tracking
Dzisi et al., [12]	Sub-Saharan Africa			●	Identification of opportunities and challenges of MaaS based on a literature review	Opportunities include optimization of transport resources, as well as reduced congestion and car dependence. However, re-envisioning of the known MaaS model is required
Dzisi et al., [13]	Ghana		●		Modeling of operators' adoption intention using SEM and content analysis based on interview data (n = 186)	Operator show strong interest in MaaS; however, opposition from operator unions is expected
Gandia et al., [17]	Lavras, Brazil	●			Analysis of willingness to use MaaS among university students (n = 307) using descriptive statistics and classification algorithms	MaaS is likely to attract young, price-sensitive segments. It is also seen as a suitable strategy to promote alternative modes (e.g., cycling or carpooling)
Hasselwander and Bigotte, [23]	Global South			●	Barriers identification and assessment based on two-round expert survey (n = 29; n = 21)	Relevant developing countries specific barriers concern auto-centric developments and the integration of informal transport. Overall, data related issues have been identified as the most critical barrier
Hasselwander et al., [24]	Metro Manila, Philippines	●			Binary probit model of stated interest to adopt MaaS based on online survey data (n = 238)	Users show strong interest in MaaS, especially due to anticipated cost savings and increased reliability
Hasselwander et al., [25]	Global South		●		Expected diffusion of MaaS into developing countries based on multiple case analysis	MaaS platforms show great interest in the large markets of the Global South. Yet, rather slow expansion activities are expected due to the low replicability of the business model
Hasselwander et al., [26]	Metro Manila, Philippines			●	Accessibility calculation of MaaS-scenario using micro-simulation with open data (e.g., satellite imagery, OSM)	Transport integration under MaaS (i.e., informal transport services and micro-mobility) can significantly improve the access to the transit network

Table 2 (continued)

Publication	Geographical focus	Category			Methods and data	Main findings
		MaaS demand	MaaS supply	MaaS governance		
Ho and Tirachini, [29]	Developing countries (and case study of Santiago, Chile)			●	Literature review to identify needs and challenges of MaaS in developing countries	Institutional and financial constraints pose major challenges for MaaS to scale in developing countries
Ho and Tirachini, [31]	Yilan, Taiwan		●		Optimization modeling of MaaS package design to maximize profit for MaaS operator using travel survey data (n = 1,276)	MaaS packages are expected to unlock benefits to both operators (more cost-effective services) and users (cost savings)
Hu et al., [34]	Dhaka, Bangladesh		●		Micro-simulation and real-world pilot of a demand-responsive MaaS(-like) scheme	MaaS is an ideal setting to optimize vehicle scheduling of public transport (that currently run without timetables) to reduce passenger waiting times
Kamau et al., [35]	Istanbul, Turkey			●	Analysis of barriers' contextual relationships using TISM and MICMAC methods based on literature review and expert survey (n = 13)	The most significant barrier relates to existing regulatory frameworks, while barriers related to users and operators are found to be less relevant
Khaimook et al., [36]	Phuket, Thailand	●			User survey (n = 181) and trial experiment to analyze MaaS' potential to build safety awareness and enhance road safety	Usability and useful information on the MaaS app could influence and change in travel behavior
Li et al., [40]	China	●			Analysis of mode choice preference of tourists for MaaS using stated preference experiments (n = 1,945)	Mode characteristics only influence mode choices of travelers with weak mode preferences. Preferences for MaaS are influenced by changes in tour experience and daily travel habits
Loubser et al., [41]	South Africa	●			Development of user framework for MaaS based on literature review	The potential userbase for MaaS can be evaluated from the population perspective and the travel mode perspective
Narupiti, [48]	Bangkok, Thailand		●		Scenario analysis based on literature review and stakeholder interviews	Three possible options for the MaaS provider are identified: public transport service provider, private transport service provider and third party, and PPP
Pickford and Chung, [51]	Hongkong (and Brisbane)			●	Proposal of a new MaaS model ("MaaS Lite") based on a simpler organizational arrangement; applied to two case studies	The MaaS Lite model facilitates the application of MaaS to different environments with different regulatory regimes, population densities, and car ownership levels
Qiuchen et al., [54]	Shenzhen, China			●	Actor analysis of the integration of self-driving mini-buses into MaaS using data from literature review and expert and stakeholder interviews	Understanding of system structures and stakeholder perceptions – e.g., by using AFG (Action, Factor and Goal) checklist – is essential for transport integration under MaaS

Table 2 (continued)

Publication	Geographical focus	Category			Methods and data	Main findings
		MaaS demand	MaaS supply	MaaS governance		
Singh, [55]	Kochi, India		●		Case study of a MaaS pilot	The feasibility of an adjusted MaaS model that augments governance and service provision specifically to the developing country context is highlighted
Ye at el., [61]	Anting New Town (in the suburbs of Shanghai), China	●			Acceptance analysis with UTAUT model based on survey data (n = 600)	Success factors for MaaS include effective promotion campaigns, improved user experience, protection of user data, and customized mobility packages
Zhang and Zhang, [62]	China			●	Comparative analysis of MaaS development based on literature review and case studies	Proposal of an alliance-based model for MaaS implementation and highlighting the importance of stakeholder cooperation, government support, and data sharing

Table 3 MaaS demand studies in the Global South based on stated preference/intention data

Study	Focus area	Sample size	Adoption rate	Profile of adopters	Motivation for adoption
Ye et al. [61]	Anting New Town (in the suburbs of Shanghai), China	600	more than 70%	Younger segments, high education, membership experience	Convenience, time savings, curiosity, recommendations by others
Hasselwander et al. [24]	Metro Manila, Philippines	238	84%	Female, all ages, living within the Metropolitan area (opposed to those living in the adjacent provinces), membership experience	Reliability, cost savings
Gandia et al. [17]	Lavras, Brazil	307	Car owners: 69% Non-car owners: 69%	Car owners: middle income; occasional drivers Non-car owners: male, high travel expenses, short travel distances	Convenience, cost savings

Other studies have used stated preference data to analyze the demand for MaaS, and all found a high overall willingness to use MaaS (Table 3).

The case study of Ye et al. [61] is Anting New Town in the suburbs of Shanghai, where inadequate public transport and high car dependence are observed. It collected 600 responses through household surveys. The data was analyzed under the framework of the Unified Theory of Acceptance and Use of Technology (UTAUT). The theory holds that there are four key constructs that explain usage intentions of new technologies and subsequent usage behavior: performance expectation, effort expectation, social impact, and facilitating conditions. Ye et al. [61] adds three additional latent variables to the basic framework: perceived risk, individual innovation, and usage attitude (i.e., the stated intention to use MaaS once it is available). The results of the study show that expectations of increased convenience and time savings (performance expectation), recommendations by others (social impact), and curiosity (individual innovation) are the most influencing factors. It was also found that there are disparities among different population segments. Young people with high education level and membership experience (i.e., having used membership-based transportation services such as public carpooling or ridesharing) are identified as the most likely potential users. To also account for the needs of other segments (e.g., the elderly), Ye et al. [61] therefore recommends the introduction of customized mobility packages.

Similarly, Hasselwander et al. [24] analyzed the demand for MaaS in Metro Manila, one of the most crowded and dense urban areas in the world. Using data from an online survey (n = 238), it estimated binary probit models to analyze the overall intention to adopt MaaS as well as the intention to increase the usage of public transport if MaaS is available. For both, strong willingness was observed (84% and 61%, respectively). The study found that potential MaaS users expect a cheaper and more reliable service. The statistical models further indicate that MaaS can leverage existing multimodal travel behavior and the increasing usage of transport apps. The study argues that especially digital natives prefer to book, plan, and pay transport services via smartphones. Hasselwander et al. [24] therefore conclude that MaaS is a suitable strategy to induce a modal shift and promote green mobility behavior.

Gandia et al. [17] surveyed 307 university students in Lavras, Brazil. Classification and Regression Trees (CART) were used to identify favorable responses related to MaaS use among car owners and non-car owners. While the stated willingness to use MaaS was high for both groups (69% in both cases), different motivations to adopt MaaS were identified. Unsurprisingly, non-car owners were found to be more price sensitive, and willing to accept travel alternatives that offer less flexibility if offered at lower costs. The integration of different transport and mobility services as well as the provision of travel information under MaaS therefore likely adds value to these kinds of travelers. In contrast, avid car users (i.e., who drive daily) are less likely to adopt MaaS – which is also a consistent finding from case studies in developed context (e.g., [16, 28]). In conclusion, Gandia et al. [17] claims that MaaS ingredients such as cashless payment, transport integration, mobility packages, and customization especially create value for commuters. Also, MaaS was found to be an ideal setting to promote alternative transport modes such as cycling or carpooling.

Dzisi et al. [11] examined the potential value of various MaaS features to users of informal transport (i.e., *trotro*, a local minibus service) in Ghana. Using a Modified Service Performance (SERVPERF) tool, it has been noted that these users expect reliable and cost-effective services above all. This is consistent with findings from other parts of the developing world, and it is argued that MaaS

indeed could improve both aspects (see above, [24]). In particular, Dzisi et al. [11] found that the ability to make cashless payments, book tickets online, track vehicles, and report driver misbehavior would improve perceptions of MaaS compared to existing services.

First insights into the demand for MaaS from a real-world MaaS application are reported from the MenGo project in the Kaohsiung metropolitan region, Taiwan. Using data from existing MaaS users (n = 435), Chen and Chen [9] assessed the factors that led to the adoption decision. The study found that transport integration (enabling seamless trips) rather than ticket, payment, and travel information integration is the most important factor explaining the adoption of MaaS.

Two of the identified studies on the end user side propose alternative use cases for MaaS in developing countries. Khaimook et al. [36] includes a case study in Phuket, Thailand, where a high use of motorcycles and associated road safety concerns are prevalent. It thus introduces Mobility as a Service in a local context (MaaS-LC), which aims to build safety awareness and enhance road traffic safety. The study first uses traffic accident, traffic volume, points of interest, and public transport data to build safety and walkability indices. Both indices as well as map, trip planning, and payment functions were integrated into a MaaS app (*GoTH app*). A survey (n = 181) and a trial experiment with the *GoTH app* have then been conducted. Among those that tried out the app, 59% stated that they would continue using the app. Note that this percentage is considerably lower compared to the stated preference studies in which the MaaS concept was only explained to respondents in theory (Table 3). One possible reason could be that the passenger information provided by the app was not accurate, as pointed out by 39% of the respondents. Nonetheless, a significant impact of app use on mode choices and safety awareness was found. 39% of respondents confirm that they have used a different route and/or travel mode due to information provided by the app. Especially the perception of bus use has improved (by 51% of respondents). Interestingly, the safety and walkability indices have been well received, as the vast majority of users (78% and 80%, respectively) indicated that this information was relevant when choosing among travel options.

Li et al. [40] investigates the potential role of MaaS for tourism transport, arguing that this topic has rarely received attention in the literature. For this purpose, a dummy MaaS app for tourists has been developed and integrated into an online survey. Respondents (n = 1945) were asked for their preferred transport mode (touristic bus, ride sharing, public transport, or car sharing) to access four different tourist attractions in the suburbs of Beijing. Based on the mode choices, respondents were classified into three subgroups: strict preference (25%), no preference (3%), and weak preference for transport modes (72%). Mode characteristics such as total travel time, cost, and walking distance were found to influence the mode choice behavior of the latter group only. The mode choice behavior of the first group, in contrast, is mainly determined by previous experiences and travel habits. However, Li et al. [40] argues that mode choice behavior can gradually be influenced by setting trial periods, travel discounts, and subsidies. Making use of the data collected through the MaaS app, the importance of customized mobility packages is highlighted.

3.2 MaaS supply: role of different stakeholders and business model adaptations

Narupiti [48] suggests that there are basically three possible options as to who will take on the role of the MaaS provider. Accordingly, MaaS in the Global South can be established by private actors, by public actors, or a combination of both (PPP).

Hasselwander et al. [25] addressed the question of whether existing MaaS platform providers (such as *MaaS-Global*) will expand into developing countries and thus establish the MaaS concept in the Global South. The study concludes that mobility platforms are generally interested in the large markets of emerging economies as they seek for growth and depend on a high number of user transactions. However, MaaS platforms are expected to expand rather slowly (in contrast to rapidly expanding ride-hailing platforms such as *Uber* or *Bolt*). This is due to the need to adapt the business model for each city – taking account of existing regulatory frameworks, available transport modes and mobility solutions, etc. – and the need to cooperate with numerous actors with different interests.

However, MaaS may also be established by local players. Especially in Asia and Africa, major mobility platforms (e.g., *Grab*, *GoJek*, *SafeBoda*) aim to integrate different mobility services and modes of transport (among many other services for daily needs) as part of their "super app" strategy (e.g., [18]; see also [22]).

At the same time, first MaaS pilots in the Global South such as in Kochi [55], Yilan and Kaohsiung, both Taiwan [8, 31], Bogota [37], and Quito, Kigali, Kathmandu, Hanoi, Pasig (Metro Manila), and Nanjing as part of the EU-funded SOLUTIONSplus project [50] show that also public actors have MaaS on their agenda. While many of these projects are still in the early planning stage, Singh [55] provides insights from an operational MaaS scheme in Kochi. It explains that the MaaS project grew out of long-term multimodal integration efforts following the implementation of a mass transit system. The MaaS

platform called *Kochi One* – accessible through smartphone apps and smartcards – is operated by the government-owned public transport provider Kochi Metro Rail Limited (KMRL). It integrates public transport (metro, bus), informal transport (auto-rickshaws), boat services, and taxis. Users benefit from multimodal trip planning, cashless payment options, pre-purchase of travel credits, and different season tickets (e.g., weekday/weekend/monthly pass). The *Kochi One* project also brought significant changes for transport operators and authorities. As described in Singh [55], the MaaS approach has (i) triggered formalization of individual bus operators, (ii) harmonized informal transport services with the public transport network to serve as a feeder mode, (iii) enhanced regulation of private transport services, and (iv) initiated institutional development of transport agencies.

In line with the findings from Kochi, Kamau et al. [34] stresses that MaaS is an opportunity to digitize transport services, optimize vehicle scheduling, and improve passengers' travel experience. To address the problem of inefficient and unorganized public transport services, it proposes a demand-responsive MaaS model that leverages centralized management and vehicle ICT support. The concept was applied in a four-month pilot in Dhaka, where users' travel requests were met by either scheduled buses or ride-sharing services, depending on time and cost constraints. The results show that the actual average waiting time reduced by 75% compared to the current operation. It was further found that operating costs would decrease, the more customer use the service. At higher demand level, operating costs of the demand-responsive service would be comparable to the costs of traditional public transport.

Adding a perspective from sub-Saharan Africa, Dzisi et al. [13] argues that MaaS is a potential solution to compensate for the shortcomings of current regulatory systems and to connect passengers and operators more efficiently. The study analyzed whether informal transport operators in Ghana are willing to join a MaaS platform. This is a very crucial question for twofold reasons. First, informal transport is the most popular travel alternative in many cities of the Global South. Hence, MaaS platforms need to integrate informal transport to achieve critical mass. Second, informal transport is characterized by a highly individualized and fragmented operator landscape. It is therefore essential to understand the collective needs and intentions of this stakeholder group, in which individuals are the main drivers of change. The study found that most operators (both drivers and conductors) of minibuses are interested in joining a MaaS platform (75%). The most significant factor for the stated interest in MaaS was identified as familiarity with the MaaS concept and internet-enabled mobility services such as ride-hailing. Also, expectations of improved working conditions, efficiency, and higher earnings as well as low perceived effort levels to join the MaaS platform and social factors (e.g., if MaaS has positive connotations among friends and passengers) increase interest in MaaS. However, Dzisi et al. [13] also found that representatives from operator unions are more skeptical towards MaaS. Their main concerns are possible job losses and in particular that the MaaS model would make the profession of conductors obsolete. Considering the power dynamics in the informal transport sector, the study thus concludes that opposition from operator unions may hinder the uptake of MaaS.

In Yilan, Taiwan, the Ministry of Transportation and Communications (MOTC) and the Yilan Country Government have launched a MaaS project that also features mobility packages. Focusing on tourists, the MaaS packages bundle a wide-range of transport services (both inter-city and urban transport services) with sightseeing, tourist attractions, and accommodation. In this context, the study by Hu et al. [31] aims to develop a bundle-pricing decision model for the optimal design of MaaS packages under a profit maximization assumption of the MaaS provider. It found that bundled services increase the MaaS provider's profit because the number of user purchases increases. At the same time, users also benefit from the lower cost of bundled services compared to their accumulated costs when purchased individually.

3.3 MaaS governance: opportunities, implementation barriers, and policies required

Ho and Tirachini [29] aims to assess the potential of MaaS in developing countries. For this purpose, it conducts a literature review and outline differences between urban transport markets in developed versus developing world context. The study identifies different objectives for MaaS in developing countries. In cities where private modes are dominant (e.g., Hanoi, Jakarta), MaaS can help inducing a shift towards public modes. Where public transport use is already high (e.g., many cities in Latin America), MaaS can help replacing private trips with shared mobility solutions. In terms of implementing MaaS, however, Ho and Tirachini [29] concludes that the known Maas model – including the formulation of mobility packages – is not feasible due to the dominance of informal transport services and the lack of public subsidies to support formal public transport.

Indeed, the often unstructured, informal, and poorly regulated transport markets represent a significant roadblock for the transition to MaaS [12, 23]. At the same

Table 4 Opportunities and barriers for MaaS in the Global South

Opportunities	Barriers
Digitize public transport services and optimize transport resources [12, 34]	*Difficulty to integrate informal transport services* [12, 23, 29]
Integrate fragmented services into a single and intuitive platform [29]	*Lack of financial resources* [12, 23, 29, 35]
Formalize and enhance regulation of transport services [55]	Need for stakeholder cooperation [23, 35, 51]
Increase access to public transport through the integration of first/last mile solutions [26, 51]	Data related issues [23, 29, 35, 51]
Promote alternative transport modes [8, 17, 29]	Legal concerns and conflicts [23, 35]
Institutional development of transport agencies [55]	Challenge to identify viable business model [8, 23, 35]
Induce modal shifts [8, 24, 29]	*Lack of available infrastructure* [12, 23, 35]

Italic marks opportunities and barriers that are exclusive or at least more relevant for MaaS in the Global South context

time, MaaS is seen as an opportunity to improve existing transport services. Dzisi et al. [12] argues that informal transport can benefit the most from MaaS if it comes with the integration of new technologies. Relevant technological innovations include automatic vehicle location, passenger-counting mechanisms, and electronic ticketing that all contribute to better service levels and improved utilization of transport resources. Dzisi et al. [12] also identifies local and affordable alternatives that are feasible for informal transport such as the use of mobile communication technologies for vehicle location and electronic ticketing. The study concludes that more sustainable and efficient transport systems under MaaS contribute to steady economic development, whereas poor infrastructure and financing challenges are identified as the main barriers.

While the literature describes diverse opportunities for MaaS in the Global South (Table 4), two studies explicitly focused on implementation barriers for MaaS [23, 35]. Kayikci and Kabadurmus [35] identifies and discusses barriers in the context of a developing megacity, Istanbul. Following a comprehensive literature review, eight overarching barriers were identified. In the next step, an expert survey (n=13) was conducted to assess the paired relationships of barriers. Total Interpretive Structural Modeling (TISM) and Matrix-based-Multiplication-Applied-to-a-Classification (MICMAC) methods were then used to understand contextual relationships and develop a simplified graphical representation of the complex system. Existing laws, regulations, and guidelines have been identified as the most critical barrier, also influencing other barriers such as the identification of a viable business model and financing questions. The study concludes that the first step should be to establish a proper legal framework before focusing on the deployment of MaaS.

Similarly, Hasselwander and Bigotte [23] have identified a list of 34 barriers based on a literature review. Overall, the barriers identified are consistent with those from Kayikci and Kabadurmus [35] (Table 4), with Hasselwander and Bigotte [23] providing a finer breakdown. For example, while Kayikci and Kabadurmus [35] reports 'customer acceptance' as one of the barriers, Hasselwander and Bigotte [23] distinguishes between different barriers why users would not accept MaaS (e.g., users do not perceive added value, users have concerns regarding data privacy, users refuse mobility plans, etc.). A two-round expert survey (n = 29, n = 21) has then been conducted to assess the barriers in Global South context and identify additional barriers specific to developing countries. Data related (e.g., the need for standardized open data) and transport planning related issues (e.g., difficulty of integrating different transport modes) have been identified as the most critical barriers. Highly relevant barriers that are specific to developing countries, furthermore, concern the integration of informal transport and autocentric developments. Legal concerns and conflicts – in contrast to Kayikci and Kabadurmus [35] – only received a medium score. Possibly, this indicates that in Istanbul stricter regulations are in place compared to other developing cities.

In addition, Pickford and Chung [51] stresses that not all cities – especially developing cities – would have the necessary prerequisites to enable MaaS such as open data standards, payment infrastructure, and the stakeholders' willingness to share data. MaaS is therefore not an 'one size fits all' solution, but rather depends on local needs and capabilities. Pickford and Chung [51] therefore proposes a MaaS model based on a simpler organizational arrangement that can easily be applied to different contexts: *MaaS Lite*. It aims at delivering the most common trips with a limited number of means of transport (typically mass transport complemented by feeder services) and a readily available payment option. *MaaS Lite* does not require the introduction of a third-party platform provider, and only complementary transport operators would have to share data with each other, whenever necessary. Incrementally, additional transport operators

could be integrated and more advanced data sharing could be realized. Applied to Hong Kong, Pickford and Chung [51] proposes that *MaaS Lite* would only need to integrate two modes – mass rapid transit (MRT) and bus – which would be enough to significantly improve access to the transit network and which would only require bilateral agreements between the involved operators.

Hasselwander et al. [26] examined the impact of MaaS on transit accessibility in more detail, using Metro Manila as a case study. It shows that due to the lack of integrated planning approaches, the transport systems are inefficient with disaggregated networks of different transport services (MRT, buses, and local minibuses called *jeepneys*), and that the majority of the population does not have access to these services within walking distance. Transport integration under MaaS, both the available services and shared micro-mobility (i.e., e-scooter and bicycles), which are not yet available on a greater scale, could potentially provide a remedy. According to its calculation, the integration of *jeepneys* could almost triple transit accessibility from 23.9% to 65.0%. If micromobility would be integrated as a feeder mode, almost the entire population could have convenient access to the transit network. This suggests that under MaaS, areas that are underserved by public transport could be connected to the transit network, which is a promising way to address latent demand and compensate for lacking transport infrastructure. However, both facilitating (e.g., incentives for micro-mobility ownership) and regulatory (e.g., legal framework for MaaS operation) policies are needed to fully exploit such potential, the study concludes.

Using a real-world case, the introduction of a self-driving minibus service in Shenzhen, Qiuchen et al. [54] provides further insights into the challenges of integrating new transport services into MaaS. The study highlights the crucial role of understanding system structures and stakeholder perceptions.

Zhang and Zhang [62] also focusses on the role of stakeholders. One of its main findings is that the cooperation among various stakeholders is essential for the success of MaaS, which requires both government support and data sharing. Arguing that the implementation of large-scale MaaS projects in China has been slow in the past – and based on lessons learned from successful projects in Europe – it proposes an alliance-based model for MaaS implementation under government intervention.

Chang et al. [8] refers to the available ICT infrastructure and comprehensive public transport systems to explain why Taiwan is one of the leading countries in Asia for MaaS. The study uses two Taiwanese pilot projects – *UMAJI* in the Taipei-Yilan corridor and *MenGo* in the Kaohsiung metropolitan region – to discuss lessons learned and policy implications. Prior to the pilots, strategic planning was conducted to identify benefits and challenges, formulate implementation strategies and performance evaluation frameworks, and develop permissive policies at national level including a nationwide travel information platform and open data policies. The MaaS model in Taiwan builds on a PPP and is financed with public funds. Consortiums partners (such as the project leader, ICT companies, transport operators, payment platforms, and research institutions) are commissioned through a tender process. The MaaS schemes offer seamless transport services, mobility packages, and leisure and touristic related value-added services. Preliminary results show that MaaS programs enjoy high customer loyalty and that shifts from private to public and shared transport modes have been observed. The study concludes that mobility packages and pricing schemes need to be regularly reviewed to increase positive outcomes and achieve profitable operation. In conjunction with disincentivizing measures for individual motorized transport, this can enable greener mobility behavior in the long term.

4 Conclusion and future research directions

This study has conducted a systematic literature review on MaaS in the Global South. It has identified an emerging body of literature that focuses on MaaS through the lens of the regions of the developing world, including Africa, Asia, and Latin America. The available studies acknowledge the multifaceted nature of MaaS and frame their analysis from different perspectives – users, transport operators, policymakers. Several studies have identified a huge interest on MaaS on both the demand and supply side. It seems that integrated transport is also a key objective for the public sector, which is expected to further push the MaaS concept in the Global South. While MaaS is a transport innovation that evolved in the context of some of the most developed cities (e.g., Helsinki and Stockholm), scholars explicitly call for re-envisioning the MaaS model and core characteristics, and align it with innovations from the developing world. Proposals and applied changes in MaaS schemes and trials in the Global South include the following:

- Access to MaaS with offline alternatives such as smartcards or basic phones [12, 51, 55];
- Incremental *MaaS Lite* approach without the need for a platform integrator [51];
- Customized MaaS packages for certain population groups [61];
- Integration of informal transport as a feeder mode [12, 13, 26, 55];

- Integration of tourist-related services [8, 31, 40];
- Integration of retail, food, entertainment, and other non-transport services [29]; and
- Provision of road-safety and walkability information [36].

Yet, the results of this study emphasize that many cities in the Global South face additional challenges in implementing MaaS due to inadequate public transport systems and insufficient availability and integration of digital technologies. Additionally, a well-defined regulatory framework and collaboration among all MaaS stakeholders is required, while financial obstacles arise when building and upgrading infrastructure to support MaaS operations. To address these challenges, it is crucial to draw upon best practices from successful MaaS pilots in other regions, as well as from other large-scale transport initiatives in the Global South (e.g., BRT and LRT). Moving forward, MaaS should be embraced as a long-lasting solution to promote sustainable mobility, requiring the alignment of political will and private sector cooperation. By doing so, we argue that MaaS can indeed become a viable and transformative solution in the Global South.

Although important contributions have been made to this incipient area of research in recent years, additional studies are needed. One important ingredient of MaaS – mobility packages – has so far only been addressed narrowly. It would be extremely important to understand customers' willingness-to-pay for different mobility packages. Stated choice experiments are needed to understand which transport and mobility services should be included, and how much (unlimited or limited, either based on time or distance) of each. In particular, the role of public transport should be studied. Are customers valuing it more when it is offered together with shared mobility in a bundle? – as found in previous research in the Global North [20], or does the introduction of other alternative modes (e.g., ride-hailing or e-scooter sharing) of the MaaS-mix make public transport less attractive?

To support decision making and public policy, scholars should also focus on quantifying potential MaaS effects. The initial evidence examined in this study suggests promising results, particularly with respect to the adoption intent of potential user groups. However, since there are only few available studies, the very positive picture could also be caused by a publication bias [57]. Simulation studies are needed to assess the overall impact on the transport systems once MaaS is fully operational. Does MaaS really enable better utilization of transport resources – and do total vehicle-km, transport emissions, and travel times decrease, while overall mobility and accessibility increase? Demand-side modeling with a long-term perspective is further needed. The most important question here is whether MaaS can reduce car-ownership.

Building on the research by Dzisi et al. [13], future research should also center around the question of how to digitize informal transport and make it ready for MaaS. As pointed out in several studies, in cities where informal transport is the most dominant travel option, integrating it into MaaS – under consideration of the needs and interests of individual driver-operators – is essential. Cost-efficient solutions to map, locate, book, and pay informal transport services with and without smartphones need to be developed and tested. A model similar as applied by ride-hailing companies in the developing world, where operators are supplied with smartphones through microfinancing [15], could be a feasible option.

Finally, the Global South context and necessary adaptations contribute to the complexity of MaaS and the subsequent discussions about what it is and what it is not. To facilitate a comparison of different MaaS schemes and help finding a common denominator for scientific studies on MaaS, a holistic typology framework that integrates the Global South context and clearly categorizes and ranks MaaS schemes based on (updated) integration levels (cf. Table 1), service features, and societal impacts needs to be developed [49].

Acknowledgements
We thank Christine Bonsu and two anonymous reviewers for insightful comments that helped to improve this study. A previous version has been presented at the 16th World Conference on Transport Research (WCTR) in Montréal, Canada.

Author contributions
MH: Conceptualization; Methodology; Formal analysis; Visualization; Writing—original draft JB: Methodology, Supervision; Validation; Writing—review & editing.

Funding
Open Access funding enabled and organized by Projekt DEAL. The research received funding from the project ÖKONVER-2 by the Helmholtz Association. The first author further received financial support by the Portuguese Foundation of Science and Technology (FCT) through research grant PD/BD/143184/2019 under the MIT Portugal Program.

Availability of data and materials
No datasets were generated or analyzed during the current study.

Declarations

Competing interests
They authors have no competing interest .

Received: 20 April 2023 Accepted: 28 August 2023
Published online: 05 September 2023

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