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Participatory backcasting towards desirable co-produced mobility futures: A case study of MaaS in Greater Manchester

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ABSTRACT

Mobility-as-a-Service (MaaS) has emerged as a model supported by popular discourse on achieving greener, more efficient and equitable future mobility. While technological change is a primary driver for models of development, the policy pathways, implementation and implications of MaaS are complex and unclear. In this paper, we explore the implications and limitations of a participatory approach to co-produced MaaS futures in Greater Manchester (GM). We adapt a backcasting methodology involving two stakeholder workshops to develop shared future visions and action pathways. Our methodology includes a participatory approach to pluralistic vision development and the use of a Three Horizons method for backcasting. This approach provides the opportunity to explore multiple desirable futures and the formulation of action pathways without negating plausible future possibilities. The research identifies multiple policy and collaborative action areas while also revealing limitations in MaaS user agency and unaddressed sustainability concerns related to wider Smart City criticisms. Findings also suggest a lack of adequate theory within current MaaS frameworks to engage with uncertainty, change and adaptive capacity. Future areas of research include the expansion of current frameworks to incorporate alternative framings from planning and complexity theories already attempting to address these dimensions of futures.

1. Introduction

Within the context of futures research, it is important to think about uncertainty due to unpredictable changes and disruptions for long term planning (Banister & Hickman, 2013). Mobility-as-a-service (MaaS) has emerged recently, promising to disrupt current mobility systems with long term consequences. MaaS broadly refers to digitally enabled transport services that enable users to access, pay for, and obtain real-time information across a comprehensive range of public and on-demand transport service options (Enoch, 2018). MaaS core characteristics include the integration of transport modes, tariff options, a combined platform, multiple actors, use of technologies, demand orientation, registration requirement, personalisation and customisation (Jittrapirom et al., 2017). With the increasing collection of travel data and digitalisation of the mobility sector, new customer facing service models are emerging based on multi-modal platforms (usually an app) combining previously disparate services to make planning, accessing, and paying for travel easier.

MaaS, as a digitally enabled service sits within a broader Smart City discourse suggesting potential economic and benefits of higher

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personal and societal mobility through seamless access to multi-modal and more environmentally sustainable transport options (Utriainen & Pöllänen, 2018). The drivers of change and related practical challenges for MaaS range across technological (data, IoT, sensors, communications), political (climate ambitions, tax, funding), institutional (business models, leasing, sharing), social (attitudes towards ownership, aging) and economic (demand, cost, employment) concerns (Sengupta, 2017; Enoch, 2018). Building on these, there are two known challenges to successful MaaS implementation. The first, as in other smart city initiatives, is the development of a location and condition specific MaaS model to provide a broad range of beneficial outcomes for multiple local stakeholders ranging across local government, through to service providers, and to local residents (Jonas et al., 2014; Capdevila & Zarlenga, 2015). A primary reason for the failure of technology driven initiatives continues to be the lack of consideration for undesirable outcomes and differences in local conditions (Pangbourne et al., 2020; Sengupta & Sengupta, 2020), which we will refer to here as the 'smart city trap'.

The second challenge is the temporal and unpredictable nature of urban infrastructure planning and exacerbated further by the co-evolutionary nature of MaaS with constantly evolving digital and related technologies (Stone et al., 2018). While the first challenge is addressed practically through our participatory process, the second contributes to the positioning of our theoretical framework. We are aware of the growing body of transitions literature around urban transport but consider this to be more suitable for historical analysis (Fenton et al., 2020; Pangbourne et al., 2020) than action orientated research involving the development of future scenarios and pathways to desirable futures. Given the overlapping systemic roots in Futures research, we consciously choose to explore a higher-level complexity theory approach anchored in Complexity Theories for Cities (CTC) (Portugali, 2006; Batty et al., 2012) Complex Adaptive Systems (CAS) (Holland, 1992; Allen, 1997; Batty, 2005) and Adaptive Planning (AP) (de Roo, 2012; Rauws & de Roo, 2016). This systemic framework supports analysis of multiple perspectives, temporal change, development of future scenarios and implementation pathways in the midst of unclear and plural future outcomes (Sengupta et al., 2016).

The research question posed in this paper is, *What are the limitations revealed by co-producing MaaS futures using a participatory backcasting approach in Greater Manchester (GM)?* To answer this question, we utilise a customised participatory futures process to compare values, benefits, barriers and undesirable outcomes of two overtly contradictory future MaaS scenarios positioned at opposing ends of the systemic framework. The complexity perspective frames adaptive approaches to planning and implementation pathways within a centralised and decentralised future MaaS model implementation. Future scenarios based on centralised and decentralised development of digitally enabled urban services link back to multiple socio-techno-politico-economic contestations in the Smart City discourse and provide potential insight into action pathways towards desirable and sustainable MaaS futures in GM through co-design.

This paper is structured as follows: Section two reviews the relevant literature related to MaaS models, wider Smart City perspectives on centralised and decentralised system implementation, and selected future planning approaches. Section three describes the methodological approach developed and used to conduct the analysis. Section four presents and analyses the results of each step of the methodology using the Three Horizons method for participatory backcasting. Section five discusses the main findings within the context of relevant literature. Finally, section six concludes the main findings, research limitations and future work recommendations.

2. Relevant literature

It has been suggested in the literature that MaaS is the next step in integrated multimodal mobility, especially because of its focus on digitalisation and 'business dimension' (Jittrapirom et al., 2018). Therefore, as a new potential disrupter to current mobility and transport systems, consideration into the planning of MaaS and the various long-term possibilities is needed (Banister & Hickman, 2013). MaaS has been defined through various models in different studies, with different potential future implications. Sarasini et al. (2017) identified mechanisms for value capture with the focus on generating sustainable value. Polydoropoulou et al. (2020a) developed a generic MaaS frameworks for specific case studies by identifying enablers and barriers through systems innovation framework. Kamargianni and Matyas (2017) developed a MaaS ecosystem model alongside a holistic MaaS definition.

To achieve sustainable and equitable mobility services, an understanding of the societal and governance implication of MaaS, is required in which considerations and needs of decision makers and the public are met (Wong et al., 2020). MaaS requires an ecosystem including policy makers, investors, enterprise operators, customers, etc. with different needs and roles (Kamargianni & Matyas, 2017). The focus of the literature often revolves around the MaaS provider as the core of the model, often technologically driven, with less consideration given to the wider ecosystems. Furthermore, questions arising around deception, promises of freedom, and private business control over products and services are key concerns raised with examples from four European cities including the United Kingdom (Pangbourne et al., 2020). Therefore, a successful and sustainable MaaS solution must address the needs of both decision makers and users in the planning of future transport systems (Banister & Hickman, 2013). Ho et al. (2020) emphasise the need to engage the public to understand demand and preferences. In their research, stated choice analysis was used to explore the role of everyday travel and socio-economic setting. Understanding user needs is necessary for a more sustainable and integrated mobility system.

A successful MaaS model would need to encourage users away from private vehicles by addressing their needs and reducing friction for better cognitive, operational, informational and transactional integration (Lyons et al., 2019). With an in-depth understanding of the specific local needs of the different users, uptake of such models is likely to be more successful. A futures research approach is suggested to be most suitable, as the methodology addresses the 'implementation gap' by engaging stakeholders to identify policy measures, evaluate scenarios and pathways (Soria-Lara & Banister, 2018). The process of negotiation is key to a transition as technical changes can often outpace systems of governance, which can pose longer-term risk (Docherty et al., 2018).

Different localities have different needs, and thus require tailored approaches and solutions. To understand the specifics of the local context, stakeholder involvement is necessary. Previous studies have established that "Regions, municipalities and cities exploiting

MaaS type of mobility services must ensure that they are accessible and inclusive by involving all the local stakeholders from the operators to the citizens" (Aapaoja et al., 2017). It is vital to engage wider stakeholders for public benefits (Smith et al., 2018), and to involve local governance bodies for MaaS decisions being made on local knowledge (Pagoni et al., 2020). A number of MaaS studies have demonstrated the value of engaging stakeholders through workshops (Fenton et al., 2020; Pagoni et al., 2020; Polydoropoulou et al., 2020a), surveys (König et al., 2016), and Delphi studies (Jittrapirom et al., 2020). Polydoropoulou et al. (2020) held stakeholder workshops in two different locations, finding that stakeholder views vary between locations and their mode of business, demonstrating that understanding MaaS on a local scale is crucial.

Another significant aspect of MaaS is the set-up of the ecosystem. MaaS requires a platform – usually an app – that allows users to access, book, plan, choose payment plans, and pay for their desired mobility services. Based on Aapaoja et al. (2017) and Eckhardt et al. (2017), five potential generic business models for MaaS implementation can be identified. The models are: Commercial (reseller and integrator), public, PPP (Public-Private Partnership), PPPP (Public-Private-People Partnership). PPP involves a collaboration between government and the private sector. PPPP seeks to integrate the public through bottom-up participation within the process for improving services and future planning (Ng et al., 2013). PPP and PPPP are identified as multi-sector collaborative models, while the public model refers to a local (transport) authority managed MaaS, and commercial models involve a third-party facilitator. They also identify multi-sector models as more viable for rural areas, and public as more viable for cities as they already have established public transport networks. However, creation of multi-sector models could improve services in areas with reduced coverage. Collaborative models could offer public sector savings through sharing models. The figure presented demonstrates the range of proposed MaaS business models on a centralised to decentralised scale from the literature (see Fig. 1).

In this context, the use of futures methods such as horizon scanning and backcasting for planning transport and mobility systems is critical to achieve desired policy outcomes (Government Office for Science, 2007). A backcasting methodology, in contrast to forecasting which is grounded in the principles of causality determinism, is centred around solution finding, design of strategies and action pathways for an identified desired future (Banister & Hickman, 2013). Participatory backcasting is a generalised methodology that can incorporate a variety of different futures methods for the development of transition pathways and strategies involving key stakeholders in strategic decision making and policy (Vergragt & Quist, 2011; Tuominen et al., 2014; Li et al., 2019). In this framework, the emphasis is on stakeholders' and citizens' participation to co-design desired scenarios considering current, past and future contexts for identifying and developing unique and tailored action pathways. Backcasting approaches can be developed through a pluralistic or single vision approach depending on the purpose (Tuominen et al., 2014). While the former focuses on a single scenario and pathways to successfully reach the desired goals, pluralistic backcasting considers multiple visions with key stakeholders to better understand how different plausible scenarios compare, opening up a discussion on policy and action pathways, and on how stakeholder actors can adapt to potential disruptions (Tuominen et al., 2014).

Debates on MaaS systems futures extend beyond the provision of mobility and into the merits of centralised vs decentralised future scenarios. These discussions often occur in the context of Information Technology Governance (ITG), smart cities and complexity. In a smart city context, centralised systems are considered essential for managing mobility while decentralised systems are more related to personal preferences (i.e., choice of transport) (Lebrument & de La Robertie, 2019). Furthermore, the literature points to centralised approaches leading to increased data traffic and resource usage, while also facing challenges in handling many IoT devices and user demands (Mocnej, Seah, Pekar, & Zolotova, 2018). In contrast, decentralised systems are more bottom-up, distributing decision-making capabilities throughout the entire network, leading to reduced data transfer and communication delay. However, decentralised systems create a trade-off between the complexity of management and efficient resource utilisation (Mocnej, Seah, Pekar, & Zolotova, 2018). Moreover, due to these trade-offs of different systems and complexity, local authorities have been called upon to act as 'system integrators' (Rode & da Cruz, 2018). Furthermore, there has been an increasing emphasis on the importance of collaboration and interests of diverse ecosystem players in the development and delivery of smart city elements (Stone et al., 2018), including MaaS. The debate surrounding the use of Connected Autonomous Vehicles, both centralised and decentralised systems of control are considered to improved traffic flow with different merits (Beaver et al., 2020). The pluralistic future possibilities of centralised and decentralised systems have led to emerging conversations about adaptive governance in the public sector (Maccani et al., 2020) to help manage system complexity and adapt to future disruptions (technological or otherwise). As such, Janssen and Voort (2016) propose and outline a range of different approaches to adaptive governance. The approaches to adaptive governance offer good insights from a strategic perspective (Maccani et al., 2020) because it enables a system to combine both centralised and decentralised elements depending on the benefits they possess in each situation.

In navigating the complexities future transport and mobility planning, the convergence of complexity theories, cities as complex adaptive systems, and relational perspectives provides a complimentary theoretical framework (Portugali, 2006; Batty & Marshall,

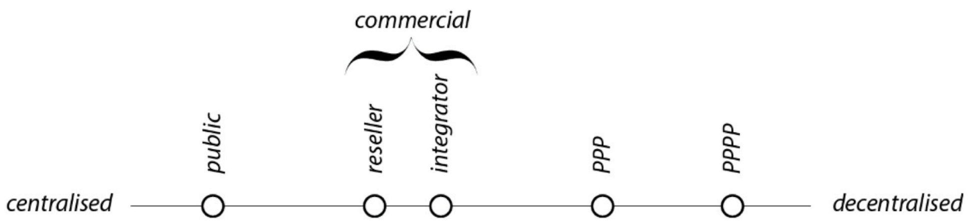

Fig. 1. MaaS business models on centralised to decentralised scale - adapted from Eckhardt et al. (2017).

2012). Within this, cities' dualistic nature of robustness and flexibility, rooted in historical path dependencies, situates their role as dynamic, ever-evolving entities likened to Complex Adaptive Systems (CAS) (Allen, 1997; Portugali, 2004, 2006; Batty, 2005). Similar to CAS, cities undergo simultaneous multilevel interactions and share three characteristics: evolution, aggregate behaviour, and anticipation (Holland, 1992). In this context, urban change is viewed as a result of chaotic interactions and emergent patterns driven by bottom-up, self-organising processes (Sengupta, 2017) responding to top-down and external pressures/influences. Thus, this perspective in planning recognises the multitude of stakeholders, technologies, and scenarios, fostering a need for a collaborative and pluralistic approach. Complexity planning, influenced by 'post-normal' science, underscores the need for an adaptive governance approach (de Roo, 2012). As cities constantly undergo anticipatory processes within the complexity of their adaptive systems, addressing uncertainties becomes paramount for effective planning and sustainable urban development. Scenario planning is rooted in negotiating object-oriented perspectives and intersubjective perspectives as cities maintain high levels of both certainty and uncertainty with change over time being perhaps the only constant factor necessitating the need for adaptive policies (de Roo, 2012). As such, this research paper looks to explore two opposing MaaS implantation futures (centralised vs decentralised) considering uncertainty and their adaptive capacity.

3. Methodological approach

This research uses stakeholder workshops within a participatory backcasting methodology. This paper situates the research and findings towards a digitally enhanced MaaS aimed at future sustainability within literature and policy on 'centralised' and 'decentralised' mobility systems. This section introduces the case study of GM and the methodology developed embedding the Three Horizons method within a participatory backcasting methodology.

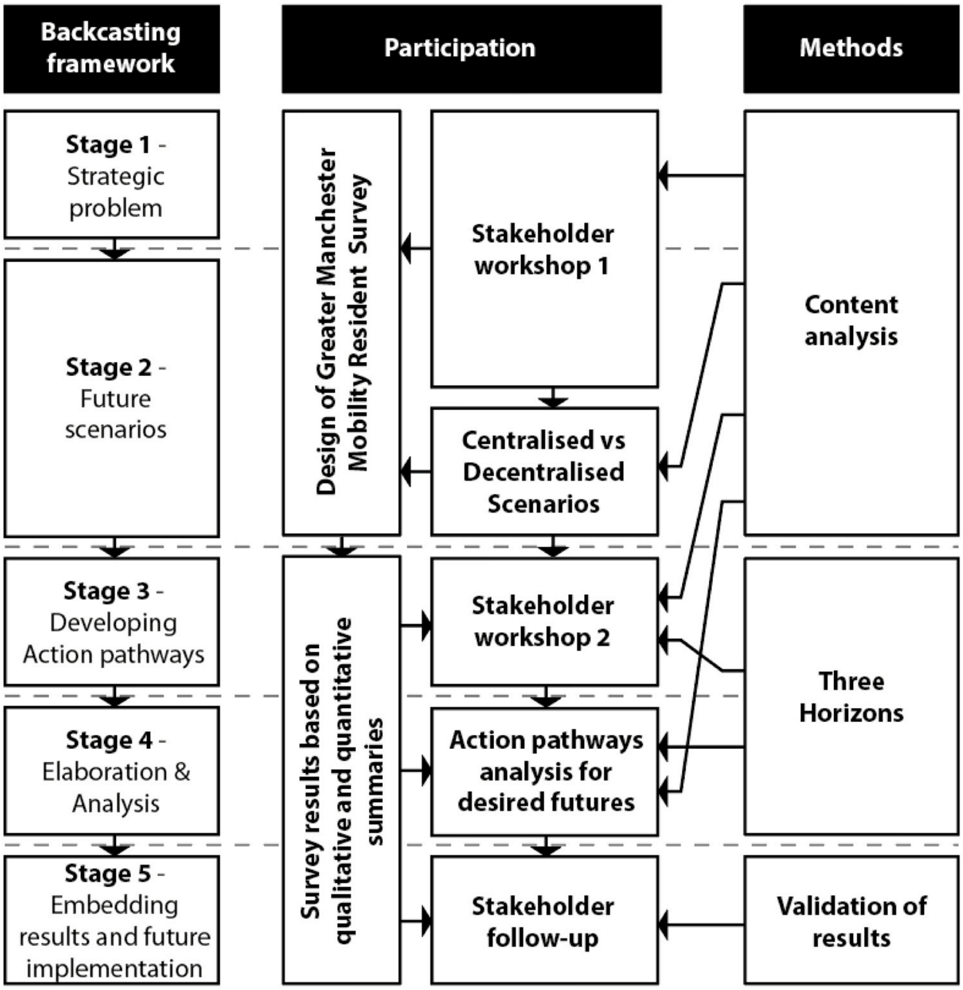

Fig. 2. Methodological approach, with methods adapted for pluralistic participatory backcasting.

3.1. Description of the Case Study

GM is a metropolitan region which combines ten local councils: Bolton, Bury, Oldham, Rochdale, Stockport, Tameside, Trafford, Wigan, Salford, and Manchester. GM's population is estimated to be 2.8 million according to the latest census information from the Office of National Statistics (GMCA, 2021). The Greater Manchester Combined Authority (GMCA) is run jointly by the councils, and elected mayor, with strategic powers related to transportation, housing, planning, etc. Transport for Greater Manchester (TfGM) is the executive arm of GMCA in charge of coordinating transport services. TfGM owns the Metrolink Trams and their infrastructure, bike hire schemes and bus stops. However, buses are mostly deregulated and owned privately, but there are plans in place to return bus services to public control (TfGM, 2021).

The main focus areas of the UK government set out in the Future of Transport programme can be identified as innovation, markets, and decarbonisation (Department of Transport, 2020). Some decisions (taxes, subsidies, funding, policies, frameworks) are made at a national level and in turn guide principles for local MaaS models. Local transport authorities have an irreplaceable role to play in identifying and implementing desirable MaaS outcomes in city regions through planning, policy, and negotiation with local service providers and other stakeholders. Furthermore, the UK government's devolution agenda has given cities and regions greater powers resulting in them leading on major transport investments (Marsden & Docherty, 2019).

In GM, this has allowed TfGM to develop the GM Transport Strategy 2040 that sets out the vision for the region to have 'World-class connections that support long-term sustainable economic growth and access to opportunity for all' (TfGM, 2021). The Delivery Plan sets several tangible outcomes including a minimum of 50% of all daily trips to be made by foot, bike, or public transport. For this to be achieved, the mobility modes of a further million daily journeys will need to be shifted away from private motorised transport. 70% of journeys in GM are currently made by car, and a third of all journeys of one kilometre or less are driven (TfGM, 2021). TfGM's approach to delivering its ambitious public transport strategy in GM relies on smarter digital integration of city transport journeys following a 'digital-first' approach, with digital solutions allowing services that are tailored to the needs of individual customers.

Due to these conditions, GM provides an interesting case study to explore through the lens of MaaS due to the political and ownership considerations unique to it. As a metropolitan region combining various stakeholders across different political boundaries, participation of stakeholders is necessary to overcome potential obstacles towards more resilient and sustainable mobility systems.

3.2. Developing a pluralistic participatory backcasting methodology

While backcasting approaches are commonly seen as expert-led, the need to involve stakeholders in scenario building or visioning stages from the beginning is recognised (Staricco et al., 2019). To conduct our research, we adapt the five-stage participatory backcasting methodology proposed by Quist and Vergragt (2006) with pluralistic backcasting (see Fig. 2). The flexible framework is customised for this paper by incorporating different stages and methods tailored to the context and problem at hand. Although stage three in the original methodological framework is named 'Backcasting', we adapted this stage to include the Three Horizons method and renamed it 'Developing action pathways' for clarity within the broader process.

This framework consists of five distinct, iterative, and interrelated stages. The adaptation of this methodology and stages are taken in the general order of concerns, futures, and actions pathways, which was deemed appropriate for this problem context to situate stakeholder discussions and thinking on MaaS futures for the region. Other research has approached the order of stages differently – such as futures, concerns and action pathways - according to their unique case studies and area of application (Curry & Hodgson, 2008; Sharpe et al., 2016). The methodology developed in this paper integrates the Three Horizons method as a way for stakeholders to negotiate action pathways informed by a resident survey for context. Although the Three Horizons method was originally developed for forecasting, the value of it lies in its systems approach and consideration of pathways towards one or more identified desired future. The value of using the Three Horizons method as a backcasting (working back from identified scenarios) tool has been previously demonstrated (Schaal et al., 2023). Our methodology incorporates two online stakeholder workshops conducted through Miro collaboration boards and Microsoft Teams due to the COVID-19 pandemic. For our case study, we adapt the five stages of the participatory backcasting methodology in the following manner:

3.2.1. Stage 1) Strategic problem orientation

by organizing and facilitating an initial stakeholder workshop (workshop 1), this stage draws parallels to the first two stages of the preparation and critique phase in the futures workshop methodology (Jungk & Müllert, 1987). Participants were asked to critique the current state of mobility in GM by identifying mobility related concerns unique to GM as a starting point.

Workshop 1 included sixteen local experts and professionals in the transport sector representing city councils, the local transport authority, academics, transport operators, and infrastructure and transport consultants across GM. Stage one of the workshop lasted 50 mins, where participants were asked to discuss and identify current issues with the current state of mobility. Participants were given access to preset Miro collaborative boards to co-produce a visual brainstorm map for each scenario.

3.2.2. Stage 2) Construction of sustainable future visions or scenarios

The second stage of the initial workshop (workshop 1) was organised around the development of desired MaaS future scenarios for GM. This stage is akin to the fantasy phase stage of a futures workshop methodology (Jungk & Müllert, 1987). Participants were asked to engage in 'fantasy' thinking and illustrate multiple future scenarios suitable for GM, and not to limit their visioning exercise by current technologies and norms. This co-production stage of the workshop lasted for 60 mins, and was conducted on a new Miro collaborative board. The recorded workshop material was then structured and analysed using directed content analysis (Hsieh &

Shannon, 2005) by the research team to categories and cluster workshop notes into defined future scenarios using a centralised versus decentralised (bottom-up versus top-down) theoretical perspective. This classification enables stakeholders to explore both extremes of the systems in the subsequent workshop and the adaptive capacity between them (Sengupta et al., 2016; Tuominen, et al., 2014).

Following workshop 1, an anonymous online survey was conducted with residents of GM, which was circulated through social media, aimed at gathering public opinion on current and future mobility in the region. The survey gathered 138 responses and provided insights into various themes relevant to industry, academic, and government stakeholders. These contextual themes included current travel patterns, pre-COVID-19 travel behaviour, satisfaction with current transport, impact of COVID-19 on travel, integration and payment preferences, data sharing and privacy concerns, real-time information and journey planning, future mobility preferences, incentives, etc. These themes collectively provided context regarding public opinion on GM mobility, offering valuable insights for stakeholders involved in workshop 2.

3.2.3. Stage 3) Developing action pathways

Through a second stakeholder workshop (workshop 2), we use the 'Three Horizons' method (Curry & Hodgson, 2008) to involve stakeholders in the backcasting exercise. This aimed at articulating action pathways back from the desired co-designed future scenarios considering existing conditions. The structured future scenarios created from the results of the previous workshop, were presented to the stakeholders to work from. The stakeholders were then introduced to our adapted Three Horizons method as a participatory backcasting tool, and the results of the GM resident survey to provide context on the themes identified. The backcasting exercise was explained, and participants were asked to negotiate action pathways back from the identified future scenarios. Eighteen stakeholders participated in this workshop using the Miro collaborative board, most of whom participated in workshop 1. Participants spent around 30 mins brainstorming and documenting each horizon and discussed collectively at the end of the workshop. This allowed participants to reflect and digest the different discussions and think pluralistically.

This Three Horizons method adapted here takes into consideration the long-term, mid-term and short-term goals, and capacity of systems to adapt, change or to persist considering future disruptions through a pluralistic perspective. In addition, this method offers a clear framework to work with the complexity of thinking and dialogue about phases of change (Sharpe et al., 2016). Although originally conceived as a forecasting tool, the value of this method as a backcasting tool is significant (Schaal et al., 2023). The term Three Horizons is based on three futures phases for transformative change (see Fig. 3). the 1st Horizon places emphasis on the current prevailing system that loses fit over time; the 3rd Horizon includes the systems and technologies that may be marginal at present, but overtime becomes more effective by displacing systems and technologies from the 1st Horizon; the 2nd Horizon presents an unstable intermediate phase of transition between the two phases (Curry & Hodgson, 2008).

3.2.4. Stage 4) Elaboration, analysis and (action) agenda

following the backcasting workshop, we analyse the workshop collaboration notes and workshop narratives. At this stage, the workshops provided researchers with output data from the stakeholders as co-designed action pathways considering technological disruptions. The data generated was analysed by the researchers against the two distinct scenarios (centralised and decentralised systems) in Section 5 of this paper.

3.2.5. Stage 5) Embedding of results and generating follow-up and implementation

The final stage our backcasting methodology includes a follow up with our main stakeholder collaborator, TfGM, to validate the visions and pathways designed. Since, the focus of this project was the design of a MaaS prototype for GM, the follow up agenda was situated in how to best achieve this.

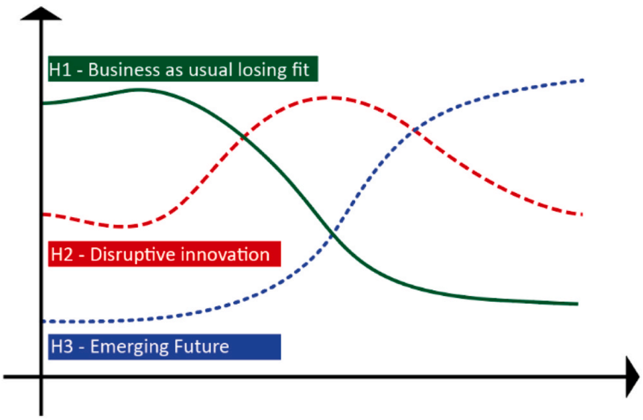

Fig. 3. Three Horizons model by Curry and Hodgson (2008).

4. Future of MaaS for Greater Manchester

This section presents the analysis of the data generated from the workshops. The sub sections correspond to the first three stages of the participatory backcasting methodology, as each section produces new and relevant analysis feeding into the following section.

4.1. Strategic problem orientation

The initial phase of the participatory backcasting methodology involves a critical examination of the current state of mobility in GM. Participants, as experts and stakeholders, were asked to summarise their insights from the workshop under clear categories. This exercise resulted in the creation of four salient topics for GM:

1) Current data generation and lack of utilisation. Stakeholder participants stated that mobility data recorded in GM was not all government owned. Private companies, some of which involved as operators for public transport, generate useful datasets but are not shared with other GM providers, resulting in lack of data integration. Some open data is available such as City Mapper, Moovit, Google and Strava but the coverage and representation of that data comes into question as it only includes users of the software. Other datasets generated by GM's local authorities include data from air quality monitoring, bus timetables and general open data for planning (National Public Transport Data Repository - NPTDR) and some information on people's locations through mobile device data.

2) Cost of service. The state of mobility cost in GM was described as not affordable for all. Participants also concluded the existence of cost barriers for Electric Vehicles (EV), as the purchase price of these vehicles are high. They also noted non-competitive pricing for multi-modal service tickets. Participants credited this lack of competitiveness to existing isolated discounts for single services such as annual train passes (these sometimes allow for central tram usage as well) discounted train tickets (for under 25 s, over 65 s, and pair travels), GM 16–18 discounted bus passes, student bus passes, rail card discount schemes as opposed to a single integrated and discounted multimodal ticket.

3) State of active travel. The stakeholder participants praised the Cycle to Work schemes and some active travel provisions, such as cycling routes in Manchester. There was, however, a consensus on the need to improve cycling infrastructure and safety which includes both cycle lanes and associated infrastructures, such as secure parking. This relates to the following point related to the general mobility infrastructure.

4) Infrastructure. Here participants raised concerns around the current schemes by GM that provide free EV charging. With an increased uptake of the technology, two problems were revealed: the increased electrical supply needed for fast charging and the lack of sufficient EV charging infrastructure. It was agreed that an incremental improvement approach would be needed based on an adaptable model responding to changing circumstances for an extensive and fully integrated EV fleet. The lack of 5 G network coverage across GM was also identified, which is critical for Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-everything (V2X), Infrastructure-to-everything (I2X) real time communication.

Analysis of insights given by participants under each salient topic revealed several drivers of change (Enoch, 2018) and barriers (Polydoropoulou et al., 2020a) in GM's mobility landscape. Addressing these aspects is vital for fostering positive transformations and a starting point for considering GM's future mobility systems.

4.2. Construction of desired MaaS future scenarios

The second part of the first workshop involved the construction of future scenarios following the identification of drivers of change and barriers. The focus in this stage was on generating pluralistic future mobility visions for GM in line with their Transport Strategy 2040 (TfGM, 2021). In this fantasy phase (Jungk & Müllert, 1987), participants brainstormed to reveal collective visions of desired urban transport future systems for GM. The two scenarios are outlined below:

Scenario 1: a decentralised mobility system as a shared economy-based provision. Here the role of technology and MaaS is to facilitate shared and personalised micro-mobility for residents. This scenario attempts to promote active travel and reduce overall carbon emissions based on bottom-up interactions and inherent system resilience. The service integration level includes peer-to-peer communication and management of mobility assets with a MaaS digital platform used to monitor and maintain these assets. It also provides personalised peer-to-peer exchange and home deliveries. Other forms of system communication include vehicle to infrastructure (V2I) and vehicle to vehicle (V2V). Data usage in this vision is purely for monitoring assets and connecting people with the mobility assets. All policy decisions in this vision strive to avoid monopoly in the mobility sector and toward incentivising behavioural change towards active travel. The overall system goals are to promote and facilitate active travel and people's interactions.

Scenario 2: a centralised and connected mobility system and government operated public transport. In contrast with the first scenario, the role of technology in this vision is to optimise and increase system efficiency through AI algorithms, balancing the system in terms of demand, cost and energy usage. This aims to have health and sustainability benefits, such as improved air quality through efficient transport management, resulting in reduced traffic. In this scenario, public service integration exists on all levels such as interchangeability of modes (tram, bus, train, etc.) and integrated timetabling. The existence of a MaaS digital platform in the vision serves to relay real-time information on services, payment provisions, data collection and analysis, both long-term and near real-time, personalise service offers and simplifying ticketing with frictionless travel. Data collected from this platform helps in managing public transport assets through real-time data feedback via a central control system. To facilitate all this, system communication includes vehicle to infrastructure communication, infrastructure-to-cloud/central control communication and infrastructure to user communication. Policy decisions in this vision are data-driven towards a responsive governance system with a more demand driven approach. The overall system goals in this future vision are to achieve seamless journeys, shorter travel time, flexible, reliable service (timing) and real-time identification of problems (no need for reporting) for greater maintenance of assets.

The two scenarios emerge as desirable and suitable future options for GM through this Fantasy stage (Jungk & Müllert, 1987). The stakeholders agreed that GM is well positioned to facilitate either (or a combination of both) desirable scenarios. The existing public transport network is well positioned to facilitate the centralised scenario. Simultaneously the region is well situated to attract new emergent businesses and innovation, which could enable the decentralised scenario. The trade-offs between Scenario 1 and Scenario 2 in future mobility planning for GM reflect fundamental choices in the design and governance of urban transportation systems. Scenario 1, with its emphasis on decentralisation and shared economy, prioritises community-driven initiatives and active travel. It encourages diverse, bottom-up interactions and aims to reduce carbon emissions by fostering a collaborative approach. However, the potential drawback lies in the challenge of maintaining system resilience and avoiding monopolies in a decentralised structure.

On the other hand, Scenario 2 opts for a centralised, data-driven model with government operation, aiming for optimised efficiency through AI algorithms. This approach promises seamless journeys, shorter travel times, and responsive governance based on real-time data. Nevertheless, the trade-off involves the potential for a more top-down, less participatory approach, as well as concerns about data privacy and the concentration of power in the hands of either government entities or private companies. Both scenarios present two distinct futures, with adaptive capacity potential requiring different transitions and negotiations (Docherty et al., 2018). The choice between these scenarios represents a balancing act between community empowerment and centralised control, highlighting the complexity of aligning diverse goals and values in urban mobility planning.

4.3. Developing action pathways

The third stage of our participatory backcasting methodology deals with scenario backcasting using the Three Horizons method. The structured futures were presented to the stakeholders at the beginning of the workshop to work from. The resident survey was used

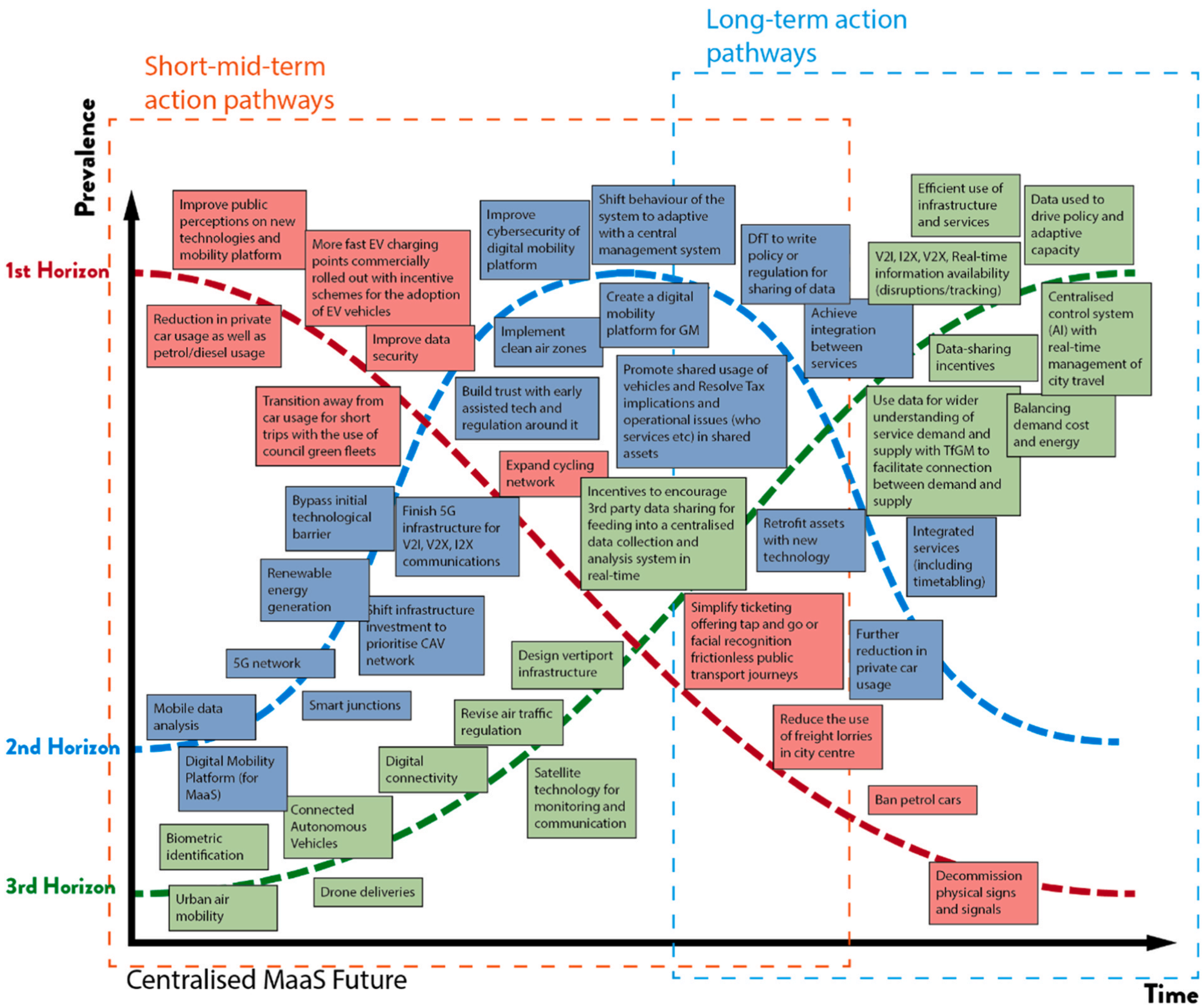

Fig. 4. The action pathway outcomes of the participatory Three Horizons backcasting workshop for the centralised MaaS future scenario.

to provide context to stakeholders for this workshop. Following the workshop, the research team structured the two Three Horizon outputs produced by the participants to more clearly showcase the action pathways identified in the exercise. The resulting Three Horizons map (see Figs. 4 and 5) indicates action pathways for the two distinct futures. Using the Three Horizons method allows for the examination of present concerns and the identification of future aspirations (Curry & Hodgson, 2008; Sharpe et al., 2016). These diagrams include the adoption of currently available and future technologies, alongside action for reducing and phasing out current system features.

1) **3rd Horizon Pathway.** Achieving long-term goals depends on identifying specific technologies that stakeholders want to use to replace current ones. To understand how to turn these desired innovations into future realities, it's essential to map the 3rd Horizon.

   Stakeholders engaging with the centralised mobility system future identified a series of emergent technologies that would facilitate the identified future. Considerations included urban air mobility options (i.e., drones for deliveries) and Connected Autonomous Vehicles (CAV). The stakeholders further proposed use of AI to optimise the system with data collected and analysed from mobile devices, vehicles, and infrastructure; satellite technology for monitoring; MaaS digital mobility platforms (demand-side); and smart junctions. Facilitating this type of data exchange is based on a high-speed internet network (5G as current technology) and satellite technology.

   In the decentralised mobility system future, drones and connected EVs also feature, however, they exist as part of a sharing economy system of micro-mobility with open collaboration between the private and public sector. Subscribing to services becomes easier with biometric payment technology. Swappable solid-state batteries allow for easy system upkeep. A 5G network facilitates connectivity and features AI and edge computing towards edge utilities.

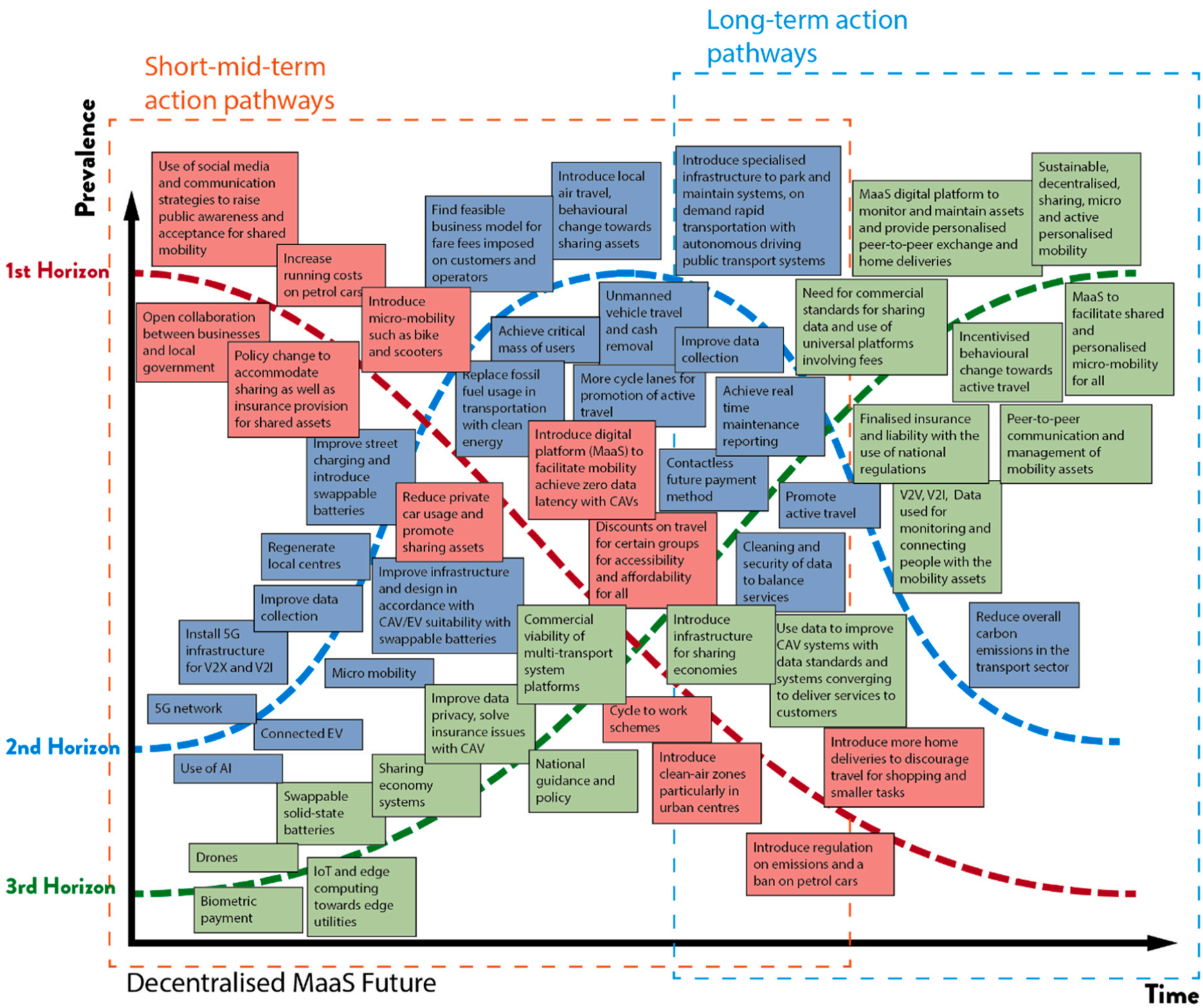

Fig. 5. The action pathway outcomes of the participatory Three Horizons backcasting workshop for the decentralised MaaS future scenario.

2) **Short-mid-term action pathways.** While the 3rd Horizon is crucial, short- and mid-term actions are also needed for steady progress towards the desired future. This involves addressing immediate concerns, implementing mid-term innovations to bridge current and future technologies, and taking initial steps to lay the foundation for future advancements.

   In the centralised mobility system future, proposed change within the 1st Horizon sees private and fossil fuel car usage reduced with EV adoption increasing through incentivised schemes. For the short-term innovations in play (2nd Horizon), commercially rolled out charging points would facilitate the uptake of EV technology, with the government committing to more renewable energy generation for reducing the overall transport CO2 emissions. Infrastructure would require substantial investment to prepare for the CAV networks, vertiports, and communication capacity (V2I, V2X and I2X). Public engagement is required to raise trust in autonomous technology and uptake of a newly created MaaS digital mobility platform. Policies and regulations would see a revision in the areas of air traffic and facilitate the creation of clean air zones around the city centres, assisted by the expansion of cycling networks.

   In a decentralised mobility system, short- and mid-term changes for present concerns sees private car usage reduced, with the promotion of shared assets and addition of shared micro-mobility options such as bikes and scooters. Changes in regulation and policy at local and national level facilitate this shift from fossil fuels to cleaner energy by increasing the running cost of petrol transportation. For innovations in play, social media and communication strategies help achieve a critical mass of users by encouraging a cultural and behavioural shift towards shared mobility, cash payment replacement, unmanned vehicle travel and active travel. The promotion of active travel would accompany a regeneration of local centres and the creation of more cycle lanes. Improvements in infrastructure such as 5G installation will enable V2X and V2I communication, improving data collection and creating a suitable environment for the deployment of CAV/EV with swappable batteries, more street charging and the introduction of local air travel. Issues surrounding such technologies, including data privacy, insurance issues and business model suitability, would see resolution at this period. This new mobility system would be accessible through the introduction of a digital platform (MaaS), allowing for commercially viable multi-transport systems.
3) **Long-term action pathways.** In long-term planning, the final actions are taken to achieve the desired future state. This involves implementing new technologies while retaining some essential features of the original system. Identifying these key elements is crucial for framing the last steps toward the desired future.

Long-term actions and changes in the centralised mobility future included the introduction of an adaptive central management system capable of achieving integration between services. This involves assets retrofitting assets with new connected autonomous technology and biometrics for frictionless public transport journeys. TfGM would facilitate this connection between demand and supply for the central management system with data fed through incentivised third-party data sharing, facilitated by Department for Transport (DfT) data sharing policy and regulations. With a ban on outdated fossil fuel dependent cars and a reduction in private car usage, physical signs and traffic signals will gradually be decommissioned as shared CAVs are promoted. Tax implications and operational issues regarding shared assets would be resolved at this point, and improvements to the digital mobility platform will see increased cybersecurity and real time-data feeding into the central control for adaptive demand and supply management.

In the decentralised mobility system, long-term change includes a total ban on petrol and diesel cars, with the introduction of strict emission regulations. On-demand rapid transportation will be available through public and autonomous transport systems. The new CAV-based systems will include new data standards, data security measures, specialised parking systems and maintenance solutions. Issues surrounding insurance and liability through national regulations will also be addressed to facilitate the running of this future. Affordability and accessibility measures, such as special service discounts for certain groups, will provide access to these mobility systems for all, with added ease through the introduction of contactless payment methods. The use of universal data platforms to share real-time data from sources such as digital mobility platform, smart junctions and vehicles will allow for real time maintenance reporting. The introduction of clean-air zones in urban centres, coupled with cycle to work schemes and more home deliveries, discourages short shopping trips and smaller task-related travel needs, aiming to reduce motorised transport demand.

5. Discussion

The research findings are discussed in the context of the two challenges identified in the introduction. The first half of the discussion highlights issues related to consensus, roles and multiple local stakeholders. The second identifies some of the shortcomings of theoretical frameworks in use for the uncertainties involved in MaaS planning and explores the potential of complexity frameworks.

5.1. Enablers, barriers, consensus and roles

The use of plural future scenarios does not rely on a single best-fit consensus allowing the identification of differing roles and pluralistic views on enablers and barriers related to the alternate future visions. The primary aim of the participatory approach was to address policy and implementation issues surrounding development of generic versus specific MaaS models addressing local stakeholder values, knowledge and differences in outlook (Pagoni et al., 2020; Polydoropoulou et al., 2020). The two overlapping and divergent future visions created reflect local authority interests and multi-scale commercial service provider interests in GM are aligned on multiple aspects but diverge on areas of responsibility for regulation, infrastructural provision and models of service delivery. There is broad consensus on a need for 5G, V2X, data collection, automation and integrated services through the introduction of a digital platform (MaaS) allowing for commercially viable multi-transport systems. As with broader Smart City initiatives, the outcomes reinforce the identified need for collaboration due to interdependence between actors of the diverse ecosystem (Stone et al., 2018). Using a systems innovation framework (Polydoropoulou et al., 2020a) reveals that the GM stakeholders broadly value technology driven future MaaS models, which is unsurprising in the context of the commercial service providers seeking opportunities and the local transport authority (TfGM) taking a pro-active stance within the remit of the devolved GMCA. Technological progress was seen as an enabler, with the majority of barriers identified in terms of infrastructural development, behaviour shifts and data privacy.

The development of and subsequent use of plural – in our case two – future scenarios within the Three Horizons process provided a comparative and combinatory set of findings related to implementation pathways. The findings reflect the interest categories of business model actors identified by Aapaoja et al. (2017) and Eckhardt et al. (2017). The stakeholders converge on the existing public transport network in strong position to facilitate the centralised scenario but also suggest that the region is well situated to attract new emergent businesses and innovation actors to enable the decentralised scenario. In both scenarios, responsibility for infrastructural development is seen as an area of governance with or without a commercial partner. The lack of 5G network is repeatedly identified as a critical barrier, for multiple aspects of real-time communication. The centralised scenario (seen as more local authority controlled and led) focuses more on sustainable transport infrastructure, travel mode shift and associated emission reductions. Commercial partners are seen in roles facilitating infrastructures such as EV charging points. The decentralised scenario places greater importance on large scale government developed infrastructure to enable new and more distributed commercial services such as shared micro-mobility. Changes in local regulation and policy such as raised running costs for fossil fuel use are identified important push factors to drive users towards new and potentially less polluting travel options. There are open questions on the capacity of local authorities to facilitate and manage new end-user services and expanded digital in infrastructure Regulatory areas include taxation and bans on existing fossil fuel dependent transport. Regulation is also seen as necessary to enable CAV and other automated technologies to become viable within the ecosystem. The role of government in the pathways is seen as that of facilitator or system integrator (Rode & da Cruz, 2018) towards resolving GM data ownership, operator co-ordination and pricing anomalies creating a lack of MaaS competitiveness against existing siloed services. It is notable that the multi-sector stakeholders in GM do not bring up service standard maintenance and resident inclusion for equitable and sustainable urban accessibility (Couclelis, 2000; Rietveld & Bruinsma, 2012; Levine et al., 2019) beyond service discounts for certain groups.

5.2. Lack of people, public, citizen agency

As identified in the cited literature, the needs of the public (Smith et al., 2018; Wong et al., 2020), customers (Kamargianni & Matyas, 2017), service users (Banister & Hickman, 2013; Lyons et al., 2019) and citizens (Aapaoja et al., 2017) must be addressed and negotiated in MaaS decisions at a local scale. These further reinforce the idea of users as simply demand generators and the Smart City trap being deeply embedded in the conceptualisation of MaaS as a business model with mechanisms for value capture (Sarasini et al., 2017). The last 'people' in PPPP (Public-Private-People Partnership) models (Eckhardt et al., 2017) for MaaS identified in the literature is difficult to achieve in reality due to a lack of agency in implementation stages. Given the business framing of the scale, it is also worth questioning whether bottom-up participation within the process towards improved services and future planning (Ng et al., 2013) equates to more than volunteered geographic information (VGI) surrender. In order to address the danger of the smart City trap, the additional dimension of consideration in bottom-up systems requires public engagement (Smith et al., 2018) in both formulation and action to enable multi-level user agency. In order to address the danger of the Smart City trap, the additional dimension of consideration in bottom-up systems requires public engagement (Smith et al., 2018) in both formulation and action to enable multi-level user agency. To address this issue in development pathways, consideration of formal mechanisms such as benefit agreements are suggested as potential avenues to link to end-user agency and accountability towards equity-seeking groups (Sengupta & Sengupta, 2020).

5.3. Sustainability but not environmental sustainability

MaaS is widely discussed in terms of achieving more sustainable future mobility outcomes. This is aligned with a wider technology and information and communication technology (ICT) driven popular Smart City discourse on the potential sustainability benefits of such innovations and initiatives. The participatory process in GM demonstrates that all stakeholders believe in the potential for MaaS to provide future social, economic and environmental sustainability benefits in a similar manner to Smart City initiatives (Ismagilova et al., 2019; Raharjana, 2019). The findings and outcomes show that sustainable futures are primarily considered on the basis of value to the commercial stakeholders and successful long-term implementation for the local authorities in connection to wider economic growth agendas. These are in line with the business orientated formulation of sustainable mobility services (Wong et al., 2020), sustainable value (Sarasini et al., 2017) and in a broader sense to urban accessibility through 'access to opportunity for all' (TfGM, 2021). However, there is a lack of genuine mechanisms to address known critical understanding of environmental sustainability impacts from similar technology driven initiatives (Goel et al., 2021; Wang et al., 2021). Sustainable here does not connect to sustainability as per the Brundtland (1987) and related sustainable development goals (United Nations, 2015). The workshops also demonstrate that GM stakeholders' approach MaaS futures with techno-utopia tinted glasses when considering far-future scenarios with untested and not implemented technologies. While literature typically focusses on the MaaS provider (Pangbourne et al., 2020), a hidden potential to reconnect to environmental consideration lies in the finding that the urban environment is considered a key driver of change for MaaS in GM implementation pathways. Recognised relational dimensions of urban renewal, active travel infrastructure and air quality suggest potential areas for climate related actions related to but wider than mode shift strategies.

5.4. Uncertainty, plurality, plausibility and adaptive pathways

The diverging areas of the plural future scenarios and known and unknown uncertainties of an evolving situation highlight a need to develop adaptive pathways. Different MaaS models have not been shown to engage fully with adaptive pathways for competing desirable futures. The debate surrounding backcasting approaches and Mobility as a Service (MaaS) reflects diverse perspectives on the implementation of an adaptive approach, particularly in the context of pluralistic participatory futures methodology. Planners and urban policy-makers advocate for adaptive plans and programs to anticipate future changes, employing backcasting approaches to identify planning measures that could be beneficial and mitigate adverse outcomes (Stead & Banister, 2003; Papa & Ferreira, 2018; González-González et al., 2019). An existing approach for comparison is through the use of Dynamic Adaptive Policy (DAP) for MaaS (Jittrapirom et al., 2018). DAP's key notions include 'Vulnerabilities' and 'Opportunities', events that can respectively diminish or enhance policy impact (Jittrapirom et al., 2018). The focus for DAP is on anticipating shortcoming and creating adaptive capacity for them. In contrast, this paper is concerned with viewing alternative desired future implementations of MaaS and identifying pathways that, in the short to mid-term, enable adaptive switch between unclear futures. This is in direct response to known uncertainties surrounding MaaS implementation acknowledged across various dimensions, including external forces, the complexity of the urban transport domain, limited knowledge about overall effects, and uncertainties in decision-makers' valuations (Kölbl et al., 2008; Jittrapirom et al., 2017, 2018; Polis & Hoadley, 2017). Changing user preferences, values and actions contributing to directly to system change are desirable from a sustainable deployment perspective but contribute to the overall complexity of the system. This in turn further necessitates an adaptive approach going forward given that GM demonstrates different drivers of change within the two plausible futures (Enoch, 2018). This level of uncertainty underscores the need for an approach, considering the complexities, uncertainties, and diverse perspectives inherent in planning for the future of urban mobility that focuses on identifying short to mid-term adaptive policies that can support a multitude of competing desired future states.

An observable pattern in the plural future scenario approach is the convergence of pathways for both future scenarios in the short to mid-term and divergence in the long-term. The underlying plausibility of multiple futures (Jungk & Müllert, 1987) and uncertainties involved in technological co-evolution suggest the need to look at adaptive governance (Janssen & Voort, 2016; Maccani et al., 2020) as a strategy to address the possibility that either one or a combination of the futures may manifest. In order to comprehend the implications of the multi-scenarios approach, it is worth reiterating that the terms centralised and decentralised here primarily refer to the public to private business model scale introduced previously. The scenarios also reflect management of mobility choices towards normative goals versus degrees of personal choice (Lebrument & de La Robertie, 2019). The current MaaS framework hence limits the relationship between the scenarios by assuming bottom-up systems are limited to centralised versus bottom-up decision making, data management responsibilities and efficient resource utilisation with complexity trade-offs (Mocnej, Seah, Pekar, & Zolotova, 2018). This partial utilisation of complex systems logic contributes to the limited problematic framing of MaaS model formulation as it ignores the potential for more complex systemic behaviours such as emergence and adaptivity in the system (Sengupta, et al., 2016). The scenarios present two distinct futures, with the need for adaptive capacity to negotiate different transitions (Docherty et al., 2018). The choice between these scenarios represents a balancing act between local (commercial) stakeholder empowerment and the role of government, highlighting the complexity of aligning diverse goals and values in urban mobility planning. An adaptive approach to governance as seen in Smart City literature (Maccani et al., 2020) provides capacity to respond to complex changing circumstances and uncertainties (Janssen & Voort, 2016; Rauws & de Roo, 2016; Sengupta et al., 2016).

5.5. Complexity and framing

At a theoretical level, the findings of this paper reflect limitations in current MaaS discourse involving problem structuration, user exclusion and related adaptive implementation pathways. As demonstrated, current theoretical frameworks contribute to this gap by not engaging with the multiple known complexities of MaaS futures. Complexity theories of cities and complexity planning (Allen, 1997; Portugali, 2004, 2006; Batty, 2005) provide alternative and as yet under-utilised frameworks for engagement with technologically co-evolving futures. While MaaS has specific enablers and barriers, an acknowledgement of broader bottom-up processes in dynamic interplay with top-down actions is desirable (Sengupta, 2017; Sengupta, et at., 2016) for sustainable systemic change aligned with desirable futures and the avoidance of unintended consequences (Banister & Hickman, 2013).

6. Conclusion

This paper aimed at answering the following question: *What are the limitations revealed by co-producing MaaS futures using a participatory backcasting approach in GM?* The research findings presented have implications for stakeholders involved in shaping GM's mobility landscape. In this paper we explore the limitations exposed by this approach and contextualise the findings against existing critical literature on MaaS, Smart Cities and complexity planning.

The collaborative analysis of the current state of mobility in GM revealed four salient problem categories: data generation and utilisation, cost of service, state of active travel, and infrastructure. The Maas ambitions within GM and sustainable mobility systems are encapsulated by the dual plausible futures categorised as centralised and decentralised. One moves towards a shared economy provision, and the other towards a centralised government operated system. Stakeholders identified and negotiated action pathways considering technological infrastructure development and supporting policy over time with a focus on user needs. The findings revealed the critical need to consider adaptive action pathways due to the plurality of plausible and desirable long-term future scenarios, and the need to plan for uncertainty.

The results of the workshops are specific to GM, but the pathways, technologies and MaaS concerns highlighted by local stakeholders are not exclusive to the region. The project engaged local stakeholders from various sectors, including government, academia, business and operators fostering discussions on adaptable, integrated policy, and action pathways for MaaS implementation. This engagement addressed the need for local knowledge in MaaS decision-making. The participatory backcasting methodology was adapted to include the Three Horizons method, which provided the opportunity to explore multiple desirable futures and the formulation of action pathways without negating plausible futures. While this approach identifies multiple policy and collaborative action areas, it also reveals limitations in both the base methodology and MaaS theoretical frameworks.

The findings demonstrate that a workshop-based participatory approach and use of appropriate methods to integrate different perspectives, can indeed lead to a more nuanced understanding of locally appropriate MaaS models, as demonstrated in the literature (König et al., 2016; Fenton et al., 2020; Polydoropoulou et al., 2020a). The limitation of the method in this case is that it propagates the techno-utopian service provider perspective that is prevalent in multiple failed Smart City initiatives by treating the citizen, urban resident or service user as a customer. This issue, referred to by us as the 'smart city trap', is identified in critical mobility and MaaS discourse as the essential need to engage with users (Ho et al., 2020) to ensure public benefits (Banister & Hickman, 2013; Smith et al., 2018; Wong et al., 2020) and enable better integration of new services (Lyons et al., 2019). The findings indicate that user engagement was seen as a barrier, requiring development of mechanisms to engender trust in technologies such as autonomous vehicles and digital platforms. The use of a limited public survey to provide context for stakeholder workshops did not result in the inclusion of end-user priorities as assumed in the methodology.

A collective belief among stakeholders in the potential of MaaS to improve future social, economic, and environmental sustainability benefits appears misplaced. The sustainability discourse is limited to value for commercial stakeholders and alignment with broader economic growth agendas. The study reinforces the absence of genuine mechanisms to address well-known environmental sustainability impacts stemming from technology-driven initiatives. A more direct link to sustainability is needed to align MaaS development with holistic sustainability goals and sustainable development.

The significance of this research paper is threefold. Firstly, it reveals the limitations inherent in co-produced MaaS futures through a participatory approach. Secondly, it incorporates the elements of uncertainty and adaptive capacity when examining two contrasting MaaS futures, providing a nuanced understanding of potential outcomes. Lastly, it innovatively adapts a participatory backcasting approach by including the Three Horizons method, thereby offering a new framework for considering various action pathways.

Further work is needed to develop participatory methodologies that incorporate end-user agency within MaaS development and avoid the smart city trap. A more critical evaluation of the sustainability framing within MaaS initiatives is essential. Multiple criticisms of MaaS development relate to its specific theoretical framing. There is potential to explore alternative framings, such as planning and complexity theories, which already attempt to incorporate collaborative actions in processes involving uncertainty, change and adaptive capacity.

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CRediT authorship contribution statement

Sigita Zigure: Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis. **Ulysses Sengupta:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Solon Solomou:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mahmud Tantoush:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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