

Exploring future sustainable urban transport through scenarios: a critical review of contemporary practice

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ABSTRACT

Under deep uncertainty, long-range transport forecasts are prone to inaccuracy. Scenario planning – a foresight approach from futures studies – offers a means to explore different long-range transport possibilities while also engaging transport stakeholders. Transport scenario narratives constitute a rich dataset of qualitative insights to draw upon concerning contemporary transport foresight. In this paper, thematic analysis and synthesis were utilised both to identify key ideas being explored through transport scenario planning and to evaluate sampled published transport scenario narratives critically. Through standardized keyword queries of Google Scholar, published documentation from 40 scenario planning projects were identified that met the study criteria. Sampled published transport scenario narratives ($n = 173$) from 40 scenario planning projects, across 25 countries, were analysed; 95% of projects were published in peer-reviewed academic journals. This study's results provide a thematic map exploring the principal concerns captured by sampled published transport scenario narratives and opportunities for improvement are discussed as a set of recommendations for enhancing transport scenario narrative quality.

1. Introduction

The importance of long-range forecasting and prediction is only realised in the far future, long after the original forecasts or predictions were made (Zegras et al. 2004). This is highly relevant to transport sustainability and decarbonisation, where current transport planning decisions have substantial future consequences (Batty et al. 2015; Sultana et al. 2019). Unfortunately, in transportation, this long-term forecasting is often inaccurate to a problematic extent (Cruz and Sarmiento 2020). One source of uncertainty can be linked with the choice of parameters for the forecast model: even when chosen to be most probable, these remain uncertain (Rasouli and Timmermans 2012). Uncertainty in complex systems is implicated in forecast failures (Schoemaker 2004). Such uncertainty is not *predictable* unpredictability, because this is variation and is amenable to understanding through statistics. It is, instead,

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unpredictable unpredictability, deeper uncertainty of unknown and/or misunderstood variation (Goodwin and Wright 2010).

For example, using current data to forecast future transport systems is comparable to using historical data to explain current ones (see also: Bradfield et al. 2016): references classes will differ (e.g., roads are wider, cars faster and more numerous, etc.), rendering available data inadequate, misleading, or absent (Goodwin and Wright 2010). We also have more information in the second task than the first, because historical trends are known (Schoemaker 2004), e.g., that people more often travel by car than by horse, making historical car data more relevant to current events than horse data, whereas futures trends can only be explored using one's foresight, e.g., by presuming/supposing that car data will continue to be relevant in the future (or that nascent autonomous vehicle data might be more relevant).

Stochastic modelling provides one avenue for forecasting uncertain and complex futures; while this has advantages, it is esoteric and often necessitates considerable expertise, data and computational processing (Profillidis and Botzoris 2019). Another approach is to supplement deterministic (statistical) forecast models with parameters derived from judgement and opinion research with experts, which can make these models more robust to uncertainty to the limits of the experts' foresight (Goodwin and Wright 2010; Profillidis and Botzoris 2019). Of these two approaches, with respect to deep uncertainty, only stochastic approaches are appropriate, and these only to a limited extent (Walker et al. 2010). In this article, we focus primarily upon a third approach: the use of multiple scenarios.

When complex systems are uncertain it can be prudent to ask not what is most probable, but what is plausible or possible at the extremes, as "scenarios". For example, one might compare an autonomous vehicle future scenario to a scenario in which they fail to diffuse, as two extreme possibilities. In the deterministic modelling approach, this means utilising a comparative technique such as sensitivity analysis (Bishop et al. 2007), but another scenario approach (scenario planning) is more speculative and qualitative, that of utilising human judgement to assess available evidence, identify key trends, and use these to describe contrasting future scenarios through narratives (Wright et al. 2013).

The conceptual framework of scenario planning is captured by the futures cone (Gall et al. 2022), which is shown in Fig. 1. The horizontal axis shows both time (flowing left-to-right) and foresight (flowing right-to-left). The cone represents the increase in uncertainty (what is possible) with time. In the present (far left), possibilities are few – the present is certain. Circular cross-sections are possibility spaces; beyond them are disregarded or unanticipated futures. Within each possibility space, shaded areas represent scenarios. These are reached through trajectories (lines) marked by events (nodes). Trajectories can branch leading to event-contingent scenarios. Scenarios at different degrees from the centre of the possibilities space are labelled by scenario types, becoming more speculative moving away from the centre.

The present article examines how (sampled published transport) scenario narratives and their generation (scenario planning) can

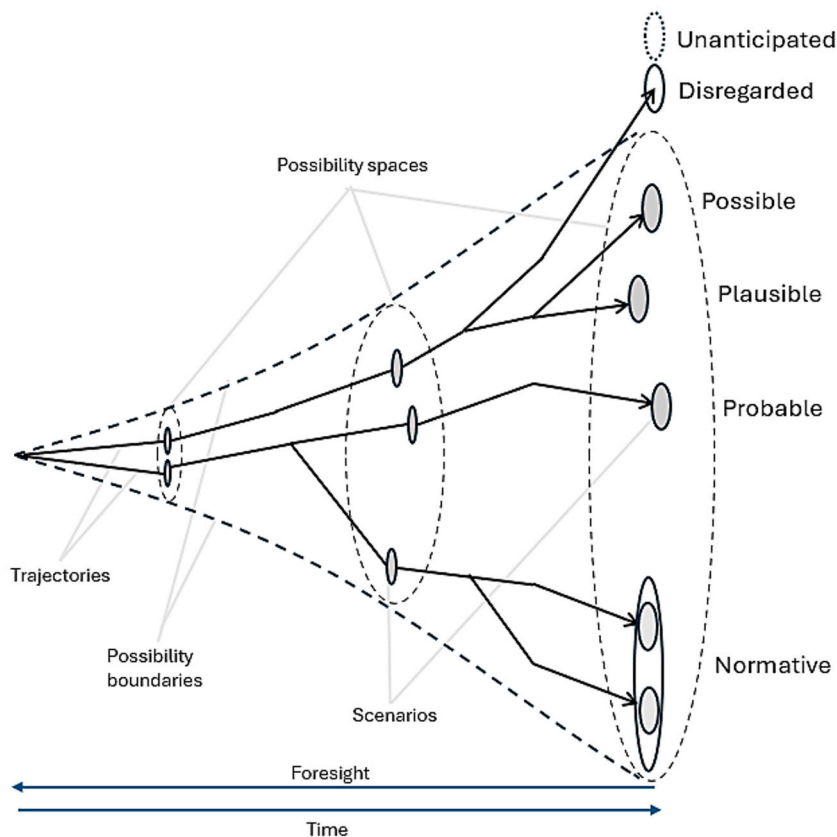


Fig. 1. Futures cone (Adapted from: Gall et al. 2022).

be linked between fields of transport and foresight/futures. Evidence synthesis for scenario planning is scarce (Abou Jaoude et al. 2022) and as scenario planning approaches come under increasing academic scrutiny (Wright et al. 2013) it is timely to synthesise transport scenario narratives critically, with respect to their quality, scope, and variation. Comparing and contrasting ideas captured across a range of sampled published transport scenario narratives provides accumulated foresight and breadth of insight into the prevalent ideas that inform this scenario planning. This also indicates the extent to which such ideas reflect decarbonisation of transport systems and the mitigation of global climate change. The purpose of this research is to explore existing sampled published transport scenario narratives, and not to explore scenario planning methods or report the results of scenario planning, or the creation of original scenarios. This article reports the results of qualitative thematic analysis and synthesis of a sample of contemporary published transport scenario narratives, guided by three focal questions.

1. What is the role of scenario planning in transport analysis?
2. How are foresight and scenario planning reflected in sampled published transport scenario narratives?
3. What are the key ideas that current sampled published transport scenario narratives explore?

In the next section (§2), literature and concepts in scenario planning in both foresight/futures and transport fields are reviewed. Then, in Section 3, the methods used for qualitative thematic analysis and synthesis of current transport scenario narratives are reported, before reporting the results of these methods in Section 4. Section 5 discusses these results, addressing the questions listed above, and offering recommendations (an agenda) for future research.

2. Review of background literature

2.1. Scenario planning in futures and foresight

Scenario planning is an approach with wide usage beyond transport. It is conceptually and methodologically diverse, echoing a more fragmented or self-reflective period in futures and foresight (Kristóf and Novák 2023). The purpose of this section is to bring together concepts from this field to understand their more specific applications in sustainable transportation. Hence, this is intended as an introduction rather than a comprehensive overview.

Table 1 provides definitions of basic terminology used in this article. “Scenario planning” is any process for generating scenarios (alternative futures), often within a broader planning process (Bishop et al. 2007). Causal factors (“trends”) are implicated in scenarios, often described through a textual description (“narrative”). Scenario planning is sequential, applying techniques at each procedural stage according to both the guidance of a school (tradition, perspective) and/or the style of the practitioner or group (Huss and Honton 1987; MacKay and Stoyanova 2017).

Börjeson et al. (2006) differentiates three scenario types: “predictive”, “explorative”, and “normative”. These are elaborated in Table 2. Briefly, predictive scenarios concern what will happen, either one likely future (“forecast”) or different contingent futures (“‘what-if’ scenarios”). Explorative scenarios concern what could happen, varying between considering only events beyond one’s control (“external scenarios”) and only the consequences of actions (“strategic scenarios”). Normative scenarios concern desirable futures, arising from system optimisation (“preserving scenarios”) or system change (“transformative scenarios”). Hence, “scenario” is not reserved only for a particular school or tradition of scenario planning (c.f., Goodwin and Wright 2010), and different schools/styles favour different scenarios.

These schools/styles advocate diverse procedures, so it is helpful to consider a generic typology of staged procedure. This article combines those used by Ramírez and Selin (2014) and Kosow and Gaßner (2008: pp. 24–25). In Fig. 2, these are compared to more specific steps in one common procedure (MacKay and Stoyanova 2017) and figurative illustrations (Kosow and Gaßner 2008) informed by the possibilities cone (see also Fig. 1). (1) *Scenario field identification* is making important initial decisions, e.g., scenario domain and scope, often working with clients or end users. (2) *Engagement design* is clarifying the scenario planning procedure and techniques across all subsequent phases. (3) *Investigations* are the gathering of relevant information, such as concerning trends historical or

Table 1
Scenario Planning Terminology

Term	Definition	Reference
Scenario	Description of a hypothetical alternative future.	(Börjeson et al. 2006; Cordova-Pozo and Rouwette 2023)
Narrative	Textual description of a scenario, utilising a “storyline”	(Steinmüller 2018)
Scenario Planning	Any procedure or technique for generating scenarios	(Bishop et al. 2007)
Trend	A trend (or driver or force or factor or element) is a system determinant, or cause of future outcomes.	(Wack 1985a; Wright et al. 2013)
Procedure	Sequence of scenario planning tasks	(Huss and Honton 1987)
Technique	Systematic means of completing a task, generating a product.	(Bishop et al. 2007)
School	Broad traditions, perspectives or practices of scenario planning	(Bradfield et al. 2005; Amer et al. 2013)
Style	The scenario planning perspectives and practices of a particular practitioner, group or organisation.	(Huss and Honton 1987)

Table 2
Scenario Type Comparison (Börjeson et al., 2006).

Scenario Type		Horizon	System certainty	Scenarios		Some associated approaches and techniques
				Number	Type	
Predictive <i>What will happen</i>	Forecasts	Near-term	Very high	1	Quant.	Explanatory and predictive modelling
	What-if	Near-term	High	≥ 2	Quant.	Explanatory and predictive modelling, PMT
Explorative <i>What can happen</i>	External	Medium- or Long-term	Low	≥ 2	Qual.	IL, Morphological analysis
	Strategic	Medium- or Long-term	Low	≥ 2	Qual.	IL, Optimisation modelling (e.g., cost-benefit analysis, multi-criteria analysis)
Normative <i>What is desirable</i>	Preserving	Medium- or Long-term	Low	1	Quant.	Optimisation modelling (e.g., cost-benefit analysis, multi-criteria analysis)
	Transforming	Long-term	Very Low	≥ 1	Qual.	LP, Backcasting

emergent. (4) *Analysis* is the process of explaining or understanding the information gathered, often culminating in differentiating salient trends and trend interactions. (5) *Scenario generation* is the synthesis of investigations into scenarios, which may involve their progressive improvement and evaluation; scenario generation may be algorithmic, reasoned and/or intuitive. (6) *Scenario transfer* is the dissemination of completed scenarios (e.g., through a report or presentation, or within subsequent planning). It is not typically a passive transfer, however, but is more often the active use or application of the scenarios for various decisions and planning purposes (e.g., Ramírez and Selin 2014).

A technique is a means of generating a product by completing a procedural step (Bishop et al. 2007). They vary from simple heuristics to complete methods that could also stand alone. Not all phases or steps necessitate formal techniques, and techniques are not necessarily limited to different phases. A survey of techniques is beyond this article's scope (see: Gordon 1992; Bishop et al. 2007; Godet et al. 2008; Kosow and Gaßner 2008; Sustar et al. 2020). Table 3 lists and describes some common techniques.

Schools, by contrast, are broad traditions, perspectives or practices of scenario planning that inform the procedures and techniques employed. There is some consensus concerning three principal schools of scenario planning (Bradfield et al. 2005; Amer et al. 2013; Cordova-Pozo and Rouwette 2023): Intuitive Logics (IL), Probabilistic Modified Trends (PMT), and La Prospective (LP). There is also a fourth school, influential in transport scenario planning, that of backcasting (Stead and Banister 2003). LP and PMT are rare in transportation scenario planning published in English, with such work being most often informed by IL, backcasting, or quantitative forecasting (Banister and Hickman 2013; Tori et al. 2025). For brevity, definitions of, and a full comparison between, schools/traditions are not provided here.

2.2. Scenario planning in transport planning

2.2.1. Historical context

This section (§2) provides historical context for transport scenario planning, with particular focus on the United States and the United Kingdom. As a historical baseline, writing in the 1970s concerning transport forecasting methods, McDaniel (1971) does not mention scenario planning, but does consider more qualitative approaches (including judgement, Delphi, and cross-impact techniques) alongside quantitative approaches, recognising their pros and cons in going beyond near-term forecasts where there is certainty concerning societal and institutional contexts. Likewise, McDaniel (1971) primarily considers single forecast and normative scenarios over multiple scenario approaches. That scenario planning was uncommon in transportation at this time is supported by few and relatively pioneering applications of scenario planning to transport during this decade (e.g., Gray and Helmer 1976; Curry et al. 1977; Godot 1979). These may have had some influence, as a highly-constrained variety of scenario planning for environmental impact was legislated in the USA with the 1969 National Environmental Policy Act, termed “alternative analysis” (Bartholomew et al. 2010).

Later academic writers discuss scenario planning as a potential solution to problems identified within US professional transport modelling practice and the planning system more generally (Pearman 1988; Myers and Kitsuse 2000; Wachs 2001; Zegras et al. 2004). Initial peer-reviewed scenario planning applications – projects in Baltimore (Mordecai 1984), Seattle (Rutherford and Lattemann 1988), and Houston (Zegras et al. 2004) – appear as demonstrations challenging a perceived institutional status-quo, and identifying with grass-roots normative scenario planning by community groups, rather than activity within US institutions (Rutherford and Lattemann 1988; Bartholomew et al. 2010); indeed, by contemporary standards, the scope of these early projects is relatively constrained (Pearman 1988), giving way to more open and intuitive scenario approaches partly informed by the IL school (Myers and Kitsuse 2000). Importantly, mixed or hybrid (qualitative with quantitative) approaches predominate, with scenario planning part of the project of long-range forecasting.

Uncertainty was a key motivation for this transitional change (Mordecai 1984; Rutherford and Lattemann 1988; Zegras et al. 2004). One form of uncertainty was internal, as transport planning becomes increasingly complex, computerised and expert-led, raising concerns over fairness and transparency. McDaniel (1971) had indicated, forecasters' could be influenced in their choices (see also: Goodwin and Wright 2025), entailing ethical issues of best-practice and accountability (Zegras et al. 2004; Abou Jaoude et al. 2022). Indeed, many of these concerns remain (Brömmelstroet et al. 2017; Brömmelstroet et al. 2022) and have been identified also in institutional scenario planning (Ayambire and Moos 2024; Pan et al. 2024). When implemented with equity and representativeness in mind, multiple scenarios become a tool for allowing forecasters to offer impartial advocacy beyond the partial advocacy for just one

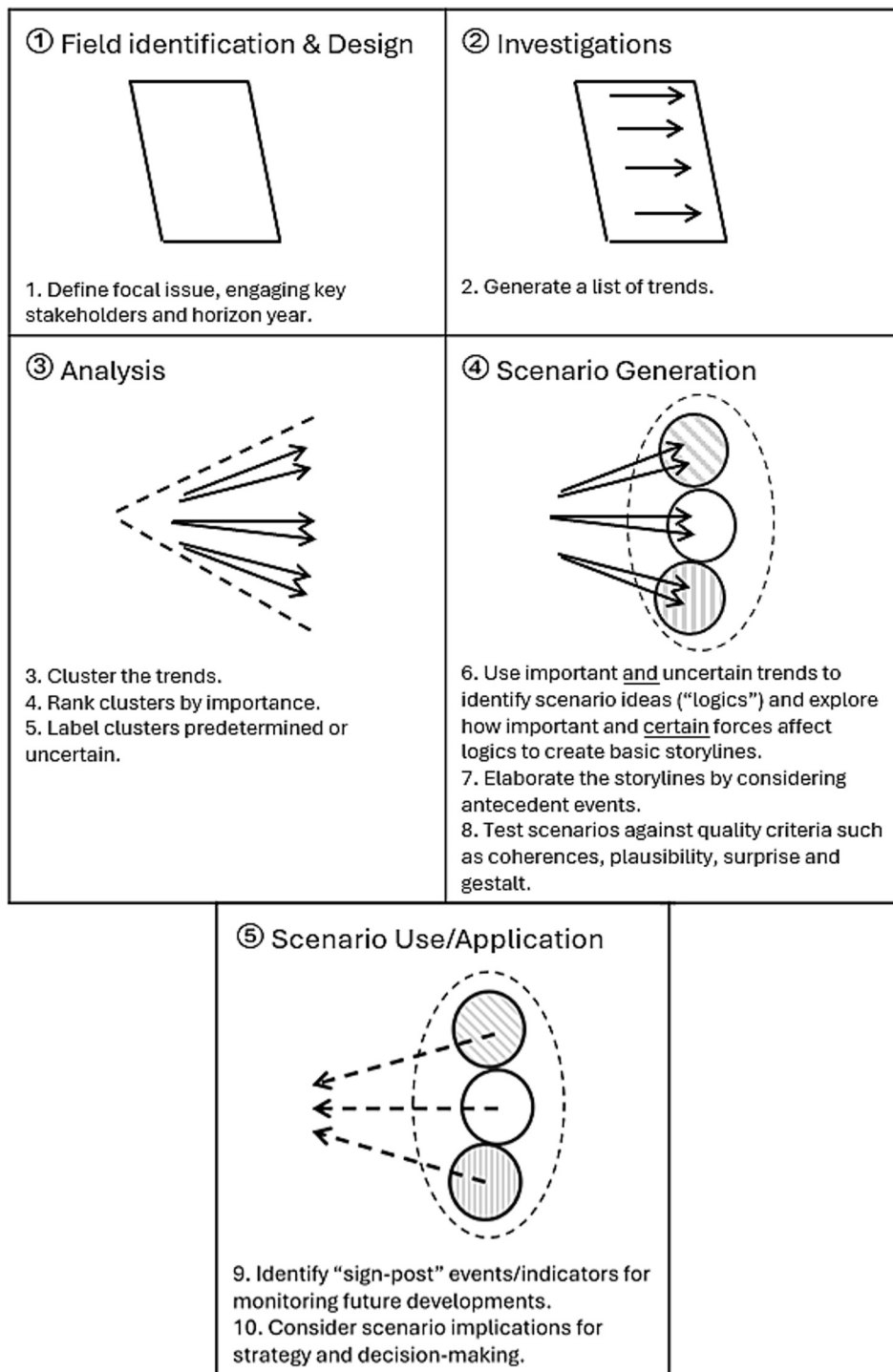


Fig. 2. Schematic illustration of scenario planning phases and one common procedure (Adapted from: Kosow and Gaßner 2008; Ramírez and Selin 2014; MacKay and Stoyanova 2017).

(purportedly optimal) scenario (Myers and Kitsuse 2000). This is also relevant to the balance in scenario planning between contributions of scenario planning experts, such as through a traditional 'think-tank model' (Ogilvy 2005; Börjeson et al. 2006), and favouring a consensus arrived at by wider stakeholder engagement (Andersen et al. 2021).

Hence, in contemporary US land and transport planning, it is important to emphasise that scenarios are not simply an alternative to difficult or problematic forecasting but are utilised for making effective and concrete planning decisions (Machiels et al. 2023). Often,

Table 3
Some Common Scenario Planning Techniques

Phase†	Name	Description	Indicative Source
Any	Judgement	Some individuals or teams have ability (sometimes “genius”) for intuitively integrating key trends to create scenarios through judgement alone, without extensive methodological support.	(Gordon 1992; Bishop et al. 2007)
1, 2	Horizon Scanning	Systematic search activity for signs of emerging trends or future developments across a variety of sources.	(e.g., Zahraei et al. 2019)
2	PESTL	Acronym of Political, Economic, Social, Technological, and Legal. This or similar frameworks/typologies are often employed alongside other techniques to identify and organise trends.	(Puyt and Madsen 2025)
3	Causal Map/Influence Diagram	Diagrammatic approaches used to cluster trends into causal chains, hence over-arching trends.	(Derbyshire and Wright 2017)
1,2,3,4	Delphi	Iterative anonymous expert survey technique (controlled debate) with an emphasis upon identifying the expert consensus.	(e.g., Plazier et al. 2024)
Any	Workshop	Meeting of project team and/or stakeholders who, through engaging in creative tasks (e.g., mind mapping, brainstorming, nominal-group), generate or refine ideas.	(Kosow and Gaßner 2008)
1, 4	Interview/Focus-Group	Individuals (or small groups of) stakeholders are questioned concerning a particular topic.	(e.g., Morton et al. 2017; Camilleri et al. 2022)
3, 4	Scenario templates and archetypes	Templates can provide useful starting points in scenario development, for example the templates of baseline, best-case, and worst-case scenarios. This reflects the possibility that scenarios may share underlying commonalities, captured by archetypal scenarios (e.g., a free-market scenario, a policy reform scenario, etc.).	(Boschetti et al. 2016)
3, 4	Morphological Analysis (MA)	A systematic algorithmic comparison of combinations of uncertainties to develop or evaluate scenario ideas.	(Godet et al. 2008)
4	GBN (2x2) Matrix	Using two key uncertainties to deduce four possible scenario ideas.	(Schwartz 1998)
3, 4	Cross-impact analysis (CIA)	Generating scenario ideas by using an algorithm to calculate conditional probabilities using a matrix of single-event probability data.	(e.g., Tori et al. 2023a)
4, 5	Sensitivity Analysis	Comparing the results of different combinations of mathematical models, model parameters, and/or model inputs.	(Bishop et al. 2007)
4, 5	Multi-Criteria Decision Analysis (MCDA)	Structured evaluation and comparison of different options against multiple criteria	(e.g., Acheampong et al. 2023)

† These are suggestions and not guidelines; see also Börjeson et al. (2006).

such scenarios are more normative than explorative, considering what is desirable more than considering external trends, but the latter approach is seeing increasing use to mitigate the inherent risks of megaprojects through robust scenario-based planning (Goodspeed et al. 2023; Machiels et al. 2023).

A second, and related, source of uncertainty behind adoption of scenario planning practices is external, particularly arising from the uncertainties of environmental pollution, sustainability and climate change. This is related to the extent that environmental concerns can be a principal concern of local stakeholders, especially in disadvantaged areas, whose exposure (e.g., to pollution) can be greater than the exposure of institutional planners. It is in this context that Bartholomew (2007) reviewed land use-transport scenario planning studies, noting shortcomings with respect to stakeholder involvement and transparency. The focus on land use-transport planning is significant both due to the advanced (hence opaque and less accountable) nature of the modelling and because land-use and transport are both (and together) trends pivotal in greenhouse gas emissions contributing to global warming (Bartholomew et al. 2010). This work identified mainstreaming of a particular style of “integrated transportation scenario planning” that is subsequently outlined by the guidelines at the FHWA (FHWA 2011), notable in contrast to IL for emphasis upon mixed or hybrid qualitative and quantitative approaches as well as multi-step processes where baseline scenarios are used as impetus for public engagement in further scenario planning (e.g., Goodspeed et al. 2023). Environmental concerns are also evident in national-level US transport scenario planning produced through consultancy and by academia in the IL tradition (e.g., Zmud et al. 2013).

Scenario planning in Europe and the UK, in long-range transport planning, is also a relatively recent development, also often driven by issues of sustainability and global climate change (Tori and Boveldt, 2025). In the UK, the UK Government Office of Science – exploring future science and technology – embraced scenario planning, including several scenario planning projects in transportation (e.g., UK Government Office for Science 2019). This approach is mirrored in the UK Department for Transport uncertainty toolkit within its Transport Analysis Guidance (TAG) (UK Department for Transport 2025). These are linked to initial academic futures work from at least two strands, and in IL and backcasting traditions (Stead and Banister 2003): the EU POSSUM scenario planning project (Rienstra et al. 1997; Banister et al. 2000), informing the subsequent VIBAT – Visioning and Backcasting for Transport – project (Hickman et al. 2009), and work by the academic Transport Visions Network and the consultancy Mott MacDonald (Lyons et al. 2021), influential upon IL scenario planning by/for transport authorities in the UK from the 2000s onwards. Both projects were often directed towards environmental uncertainties and adopted/informed sustainable transportation paradigms (Banister 2008).

While brief, this elaboration of historical context identifies some important aspects of scenario planning in transportation. First, there is a strong tradition of quantitative modelling for forecasting. This points to the prevalence of mixed or hybrid approaches to contemporary transport scenario planning. Second, the purpose of scenario planning in addressing potential inequity in transport systems explains the emphasis placed on public participation and engagement in transport scenario planning. Finally, historical context underlines the importance of mitigation of deeper uncertainty being the driving purpose of the use of scenario planning in long-term transport planning, particularly surrounding environmental and social sustainability.

2.2.2. Examples of transport scenario planning projects

Transport scenario planning projects from the recent past disseminated in the grey literature illustrate engagement with transport scenario planning by national and regional authorities, as well as corporations and charitable foundations (Table 4) and provide a useful comparison to sampled (often peer-review journal) published transport scenario narratives that are considered in Section 3 (see also: TRANSvisions 2009a; Banister and Hickman 2013; Venturini et al. 2019). It is important to be mindful of publication biases towards publicly disseminated broad-scope public- or third-sector reports and away from private-sector and narrow (regional) scope projects whose reports are less-often publicly disseminated.

TRANSvisions (2009a,2009b) was a European Commission funded project executed by several academic institutes and consultancies. It focused upon future sustainable mobility, utilising a mixed qualitative and quantitative approach, the former drawing upon stakeholders/expert consultation and Delphi survey techniques. Three basic quantitative scenarios (baseline, high-growth, low-growth) were contrasted with four exploratory scenarios each depicting a post-carbon society, but with varying levels of economic and social values. Thus, zero-emissions transport is realised through balanced policy (*decoupled mobility*), policy-led behaviour change (*reduced mobility*), market-led innovation (*induced mobility*), or system-led economic and social decline (*constrained mobility*). Like TRANSvisions, World Energy Council (2011) employed a mixed qualitative and quantitative approach, with expert/stakeholder consultation in scenario development through workshops. They continue to develop future energy and transport scenarios periodically. Like TRANSvisions, sustainable transport was a focus of this 2011 project. Unlike TRANSvisions, different uncertainties were explored, with their report contrasting two scenarios: an open-market scenario of economic growth and increasing travel demand (*Freeway*) and a market-intervention scenario in which authorities intervene with sustainable and social policy goals (*Tollway*).

Deutsche Post DHL (2012) is a rare example of a report of a disseminated transport scenario planning study from the private sector. DHL commissioned scenario planning to understand future uncertainty in their market of mail and logistics. While methodology is not reported at length, expert consultation and cross-impact or consistency analysis are both indicated. The report identifies five scenarios: three were environmentally unsustainable and two environmentally sustainable. Unsustainable scenario were an untamed world market economy leading to environmental collapse; individualistic lifestyles supported by digital innovation; and “paralysing protectionism” induced by economic hardship and resource shortages. Sustainable scenarios were an environmentally (but not socially) sustainable “mega-city” urbanism-and-automation scenario; and an entirely sustainable scenario of global resilience and local adaptation driven by the effects of climate crisis.

In a report sponsored by the Institute for Mobilities Research and produced by RAND corporation for the benefit of policymakers, Zmud et al. (2013) report a scenario development project exploring US passenger transportation futures. Investigations included expert consultation and analysis cross-impact (consistency) analysis, with a quantitative trend element provided for scenarios. The report produced four scenarios. Two plausible scenarios contrast low fuel-prices and high transport demand (*Fuelled and Freewheeling*) with high fuel-prices and sustainable policy restricting transport demand (*No Free Lunch*). Two possible-but-unlikely scenarios explored a global recession originating from the Chinese economy (*Red Dawn: China Stumbles*) and rapid technological advances (*Autonomous Vehicle Revolution*). Likewise, Lyons et al. (2014), in scenario planning for the New Zealand Ministry of Transport, identify energy cost as a key uncertainty, alongside appetite for digital technology. Using a 2x2 scenario grid they define four scenarios: *traveller's paradise*, in which travel is frequent and cheap due to low fuel prices and mistrust of social media; *cooperative and close*, in which high fuel costs and digital security concerns lead to stronger local communities and less travel; *global locals* in which sustainable digital and technology, precipitated by oil shocks and extreme weather, reduce mobility; and *digital decadence* in which virtual worlds become prevalent alongside grass-roots response to climate change.

Rohr et al. (2016), similar to Zmud et al. (2013), was a RAND corporation report sponsored by Innovate UK, but was specifically focused upon the effect of technological trends upon future UK transport. They identified three scenarios: one in which economic growth has diffused autonomous vehicles at the expense of increased traffic congestion (*driving ahead*), one where people travel digitally from local communities through telepresence rather than congregating in cities (*live local*), and a complex scenario in which society becomes unequal with only some benefiting from transport technologies while others forego travel (*digital divide*). By contrast, Kirkey et al. (2017) and Transport for the North (2020) are examples of more regional (rather than national or international) scenario planning projects. Kirkey et al. (2017) report more strategic scenario planning in the context of the San Francisco Bay Area transport and land-use planning, using a two-step approach consistent with integrated transportation scenario planning (see §2.2.1). In the first step, three scenarios were created: one baseline scenario that focused on new towns and rail links (*connected neighbourhoods*), another

Table 4
Transport Scenario Planning Project Examples

Reference	Scope		Focus
	Geographical	Temporal	
TRANSvisions (2009a,2009b)	Continent	2050	Sustainable transport
World Energy Council (2011)	World	2050	Sustainable transport
Deutsche Post DHL (2012)	World	2050	Logistics
Zmud et al. (2013)	Country	2030, 2050	Passenger transport
Lyons et al. (2014)	Country	2042	Transport demand
Rohr et al. (2016)	Country	2035	Innovation and congestion
Kirkey et al. (2017)	Region	2040	Land use and transportation
Transport for the North (2020)	Region	2050	Transport demand

with land-use mix in urban city centres (*main streets*), and a third focusing on development of and connection to primary employment areas (*big cities*). In the second step of public engagement, a fourth scenario was developed, in which various specific policies combine to promote social mobility, fairness and the environmental sustainability (*environment, equity and jobs*). This illustrates the dialogue between a technical/institutional approach and local stakeholder response. By contrast, [Transport for the North \(2020\)](#) is a more explorative and less strategic scenario planning project, using an IL approach to create four scenarios using combinations of six uncertain trends. These vary from the economic and social vulnerability and inertia of *just about managing*, through the geographical social mobility *prioritising places* and the technologically led digital uptake in *digitally distributed*, each of which scenarios involve decarbonisation of transport to an extent. The most environmentally sustainable scenario, *urban zero carbon*, involves economic prosperity and changing public attitudes both driving decarbonisation, but social inequity rising with technological diffusion and urban/rural divides.

The diversity of scenarios, despite often relatively similar concerns and approaches, illustrates the ideographic nature of scenario planning, whereby similar component trends (e.g., economic, social, environmental, technological, policy) are interpreted in a variety of different ways, often approaching similar issues from different directions. Hence, while it is useful to explore scenario content by aggregating issues and concerns ([Holden et al. 2020](#); [Miskolczi et al. 2021](#)) it is also potentially beneficial to explore the diversity between scenarios. The sources of these works are also noteworthy. Most of these studies are commissioned from professional scenario planners; such professionals actively monitoring trends, drawing connections between ongoing and past projects, and building expert/stakeholder networks ([Schwartz 1998](#)). It is important to add that these examples were selected due to their expression of scenarios as narratives, hence the expectation of the use of approaches, like IL, that favour narratives. Nevertheless, several of these examples mix quantitative and qualitative approaches, which tends to indicate the favouring of quantitative approaches (e.g., predictive modelling), or attention to scenario planning only when also quantified.

2.2.3. Transport modelling and scenario analysis

Transport modelling is often undertaken to anticipate transport infrastructure needs and consequences, such as providing sufficient road capacity for future automobile traffic or anticipating traffic flows following new road construction ([Boyce and Williams 2015](#)). A single accurate forecast is produced, termed “baseline” or “status-quo”. Beyond this, modelling can apply confidence intervals to these predictions or employ sensitivity analysis to explore the bounds of the modelled prediction under different circumstances (all else being equal). Different quantitative scenarios can also be explored by creating combinations of variable inputs and parameters that reflect combinations of trends; scenario modelled outputs can then be compared to baseline outputs (e.g., [Asgarpour et al. 2023](#)). This corresponds to predictive “what-if” scenario planning ([Börjeson et al. 2006](#)), as mentioned in [Table 2](#), above; they retain the aim of accurate prediction while exploring uncertainty ([Amer et al. 2013](#); [Ramírez and Selin 2014](#)), though they have been associated with a paradigm of “predict and provide” in long-range transport planning that has received considerable criticism ([Owens 1995](#)), such as for unwarranted assumptions about the certainty of future developments. This article focuses on scenario narratives, and not quantitative scenarios, so an extensive survey is beyond this article’s scope, but their importance in the context of transport scenario planning has been noted. Instead, here, consideration is given to the interface between modelling and narrative in the investigation stage ([Wack 1985b,a](#)) and the scenario transfer stage (e.g., [TRANSvisions 2009b,a](#)); see also [Section 2.1](#) and [Fig. 2](#).

[Boyce and Williams \(2015\)](#) provide an extensive introduction to transport modelling for forecasting (see also: [Profillidis and Botzoris 2019](#); [Nie 2025](#)). The most common approach amongst a variety ([Nie 2025](#)) is balancing more and less desirable determinants of travel in demand and cost functions within a four-step process of trip generation, trip distribution, modal choice, and traffic assignment ([Profillidis and Botzoris 2019](#)). Through this process, data on individual journeys are used to generate several metrics reflecting demand, such as traffic flows between geographical areas (‘zones’). Such forecasting anticipates future transport system requirements, informing transport policy and practice, so it is mostly an institutional practice undertaken primarily by transport authorities and transportation firms, including consultancies ([Boyce and Williams 2015](#)). This model may be supplemented with discrete choice elements or extended to an activity-based model that considers elaborate tours rather than simple trips and how people spend their time, which can involve engaging with uncertainty through stochastic modelling ([Rasouli and Timmermans 2012](#)).

Scenario planning provides one means to identify scenarios for scenario analysis ([Profillidis and Botzoris 2019](#)). For instance, the UK DfT national road traffic projections for 2022 model a set of common analytic scenarios arrived at through scenario planning ([UK Department for Transport 2022](#)). Creativity is necessary where a scenario element is not intrinsic to the model or cannot be grounded in available data. As existing models, data, theory and practice tend to prescribe specific inputs as influential upon transport demand, it follows that most (though not all) “what-if” scenario forecasts vary these inputs as representative of less certain changes, for instance adjusting a transport demand/utility parameter as indicative of a wider societal change or the benefits/drawbacks of a new transport technology. For example, [Asgarpour et al. \(2023\)](#) utilised scenario planning ([Neef et al. 2020](#)) to model freight and passenger road transport demand in the Netherlands (Noord-, Zuid-Holland, and Utrecht) with four different scenarios. Here, trends in teleworking, electrification, and carbon taxation were modelled through remote days worked, fuel-price demand elasticities, and fossil-fuel excise duty, respectively.

It is also important to consider the conceptual difference between “what-if” predictive scenarios and explorative scenarios further. The key difference is at the analysis stage (see [Fig. 2](#)), being typically divided between mathematical modelling for prediction, producing forecasts, or active judgement/creative analysis for exploration, producing narratives. Hence, “what-if” scenarios are more nomothetic (relying on general principles) whereas explorative scenarios are more ideographic (relying on specific characteristics). This implies that the two approaches are not completely compatible (convergent), but necessitate compromise, either of the integrity of the modelling or the freedom of the narrative, leading to convergence upon middle-certainty futures that may be most applicable to the medium-term ([Fig. 3](#)); see also [Fig. 2](#) in [Amer et al. \(2013\)](#). Hence, when approaching quantitative scenario studies, it is worthwhile

asking through what process these trends are identified and whether these promote both requisite balance between comprehensive coverage of uncertainties and modelling predictive accuracy and robustness.

2.2.4. Key features of transport scenario planning

From this section (§2), several key observations can be drawn about transport scenario planning. First, there is a historical precedent for the emphasis placed upon public and stakeholder engagement when selecting scenario planning techniques, and this can also be understood as a migration of a technique used primarily in business and consultancy into the sphere of public sector planning (Abou Jaoude et al. 2022). A similar shift reflected in futures scenario planning is identifiable from the “thinktank” approach, where emphasis is placed upon the talents of a team of professional practitioners (Ogilvy 2005; Börjeson et al. 2006), to engaging public and stakeholder groups in the process (Andersen et al. 2021; Tori and Boveldt, 2025).

Second, there is a clear preference for mixed or hybrid studies in which scenarios are described both quantitatively and qualitatively. This differs from scenario planning in futures/foresight, which (in itself) tends to employ either one or the other approach (Goodwin and Wright 2025). Importantly, however, the order in which these approaches are implemented can vary (Fetters et al. 2013), from “quant->qual” (using predictive scenarios as evidence in explorative scenario planning) to “qual->quant” (using explorative scenarios to frame “what-if” predictive scenarios). There is a more sophisticated ordering in the integrated FHWA approach, which mixes institutional scenario planning and public/stakeholder engagement (FHWA 2011).

Third, in Europe, the UK, and more broadly, and in contrast to its use historically, scenario planning is increasingly becoming an academic research activity as much as an institutional activity and so is increasingly reported in the academic literature. With this comes peer-review and further scrutiny of the theoretical basis for scenario planning, the efficacy of its methods, and the quality of the scenarios generated (Wright et al. 2013). In Sections 3 and 4, qualitative analysis and synthesis of sampled published transport scenario narratives are reported. This research provides further understanding concerning the role of scenario planning in transport analysis but also provides insight into the scope and concerns of current transport scenario planning and the key issues that it explores,

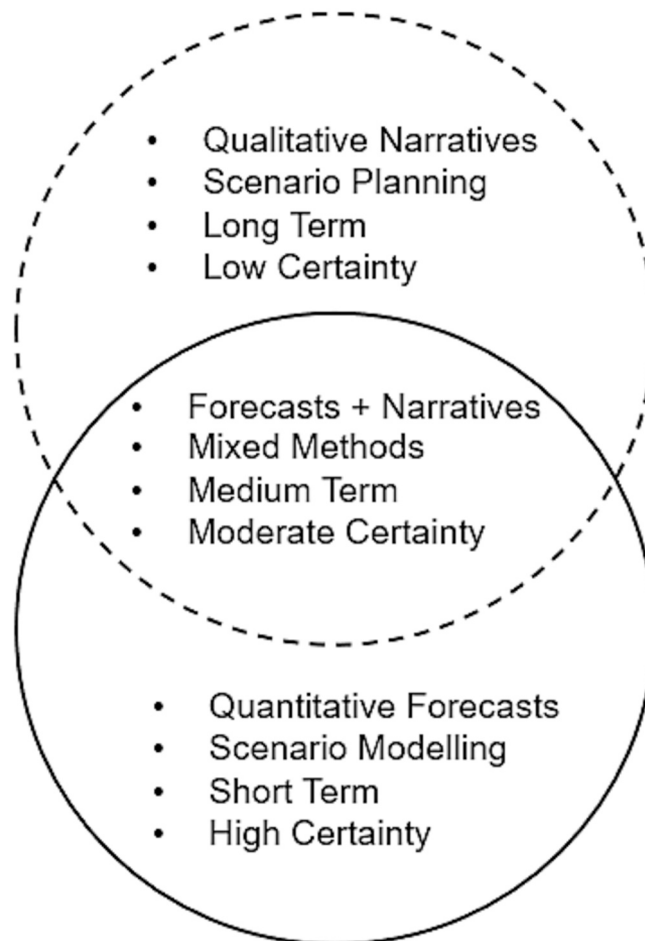


Fig. 3. Overlap between scenario planning (producing narratives) and “what-if” scenario modelling (producing forecasts). (Source: the authors)

such as sustainability and decarbonisation. Evidence synthesis from scenario planning can be scarce (Abou Jaoude et al. 2022): it has been previously applied to scenario planning to critically evaluate the equity of professional practice (Bartholomew 2007; Ayambire and Moos 2024; Pan et al. 2024) but has rarely been used to explore current trends or to elucidate its application within specific fields, such as transport (Holden et al. 2020; Miskolczi et al. 2021). Thus, the present study is timely in mapping themes in a sample of published contemporary transport scenario narratives and examining these critically to identify areas for improvement.

3. Sources and analysis

3.1. Sources and narratives

Contemporary published transport scenario narratives (i.e., written accounts of linked future events pertaining to transport) were sampled (extracted and collated) from relevant articles or reports (sources) as text data prior to analysis. (Please note that only published scenario narrative texts, not the full scenario-planning processes behind them, were considered.) Sources were sampled purposively and iteratively (Suri 2011) rather than systematically, focusing on producing a heterogeneous (rather than complete) set of contemporary published transport scenario narratives concerning the future of urban land transportation. Six basic screening criteria were applied. (1) To obtain substantial transport scenario narratives, at least three sentences of text were required; only full transport scenario narratives (as opposed to summary or partial narratives) were used (c.f., Goodspeed et al. 2023). (2) Where the same transport scenario narratives recurred across sources, primacy was given to an original source or a source providing the most-substantial transport scenario narrative(s). (3) Only sources published after 2016 were included, targeting contemporaneous transport scenario narratives alone. (4) Transport scenario narratives that did not pertain (at least in part) to urban land transport (as opposed to inter-urban land, maritime, or aviation transport) were excluded. (5) Transport scenario narratives were sampled irrespective of moniker, thus inclusive of scenarios, narratives, visions, pathways, etc. (6) Likewise, sampling was not prescriptive concerning scenario planning style or technique, hence transport scenario narratives generated through judgement alone (see Table 3), such as conceptual frameworks, were included, as were transport scenario narratives describing primarily quantitative scenario planning. The sampling procedure is shown in Fig. 4.

Prospective sources were identified through literature searches using Google Scholar. They were also identified by forward and backwards snowball sampling (Wohlin 2014). Three queries were used in the first instance to collect a variety of sources. The first 200

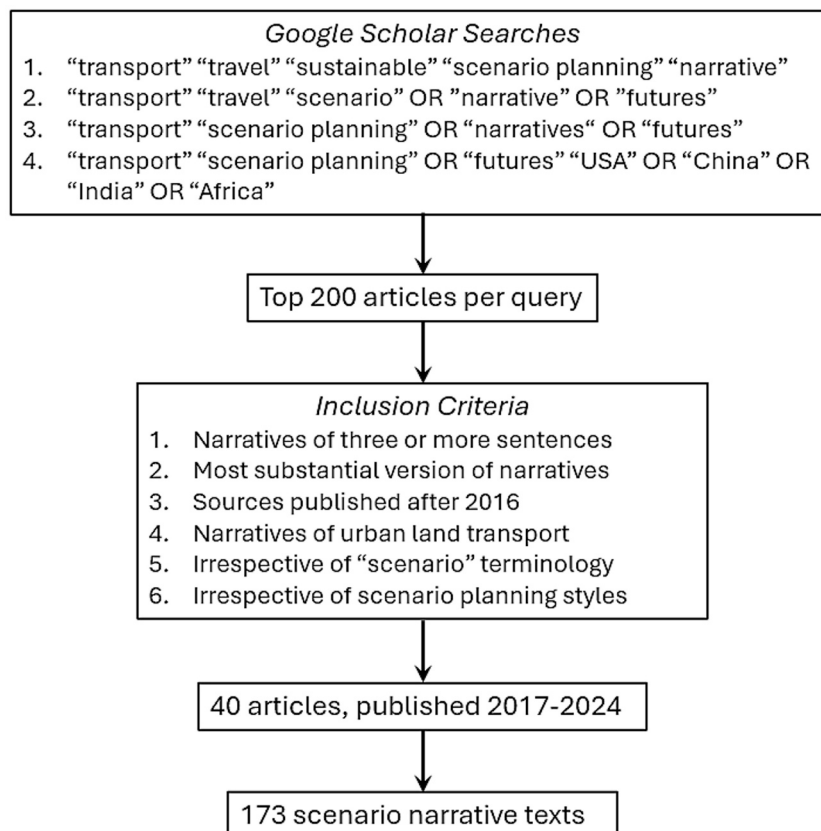


Fig. 4. Article selection and scenario narrative extraction procedure

results of each search (i.e., 600 results in total) were filtered according to the criteria outlined above yielding 113 scenarios from 25 sources. This revealed primarily sources from Europe, Southeast Asia and Australasia, hence lacking geographical heterogeneity. This was addressed through a fourth search targeting the USA, China, India and Africa specifically, but also searching for English-language sources from regions not yet represented in the sample. Thus, a further 200 results were filtered from which 15 further studies (60 further transport scenario narratives) were selected. Source information, including a complete list of sampled transport scenario narratives, is provided in [Supplement Table S.1](#). The search strategy favoured identification of academic sources (i.e., scenario planning by professional academics), and, in the final dataset, only one study was reported only in non-academic sources ([UK Government Office for Science 2019](#)) and most were written by university academics acknowledging publicly funded research grants (e.g., Horizon-2020). Eight sources pertained to transport generally without a region being specified; others pertained to 26 specific countries or regions, 14 in Europe, 5 in Asia, 2 in North America, 3 in Africa, 2 in Australasia.

3.2. Analysis and synthesis

Complementary thematic analysis ([Braun and Clarke 2006](#)) and thematic synthesis ([Thomas and Harden 2008](#)) techniques were applied to the narrative data collected. Qualitative and interpretive, these techniques identify recurring content (themes) within a single dataset (e.g., [Nikitas et al. 2019](#)) or across published studies (e.g., [Graham et al. 2018](#)). Analysis was primarily semantic and, with respect to opinions articulated through transport scenario narratives, realist rather than constructionist or discursive ([Braun and Clarke 2006](#)). Thematic analysis was flexible and exploratory to incorporate consideration of a range of different sampled published transport scenario narratives designed in different ways and for different purposes; this was at the cost of more generalisable results through systematic analysis of a more homogeneous sample of transport scenario narratives. This analysis was guided by the research questions introduced in [Section 1](#), asking how foresight into transport, including key ideas in transport, is reflected in these sampled published transport scenario narratives, and what role they play in transport analysis.

Analysis progressed through six phases ([Braun and Clarke 2006](#)). (1) Familiarity was obtained through repetitive reading and comparison with tentative initial coding (labelling). This was done by one author. These codes ($n = 153$) became more systematic and defined (2), for instance, in some scenarios electric vehicles were prevalent, in others there was rapid diffusion, and so these were all given the superordinate code of “vehicle electrification”. Phase 2 involves both coding and collation of coded extracts to verify that the 134 codes are grounded in data. This is illustrated in [Appendix Fig. A.1](#) and is a process that is repeated for all data and all codes. Codes shared resemblances, allowing (3) demarcating groups of codes as tentative themes. Here, following [Braun and Clarke \(2006\)](#), codes were sorted into tentative themes by potential overarching, linked or overlapping relationships, which was executed by listing themes in columns on a digital whiteboard. For example, 31 codes – including “vehicle electrification”, “shift to green electricity/power generation”, “autonomous vehicles replace public transport”, and “Leveraging consumer data, or other IT, for efficiencies” – were identified as concerned with innovation and efficiency, in a way that other codes – such as “physically active travel popularity” or

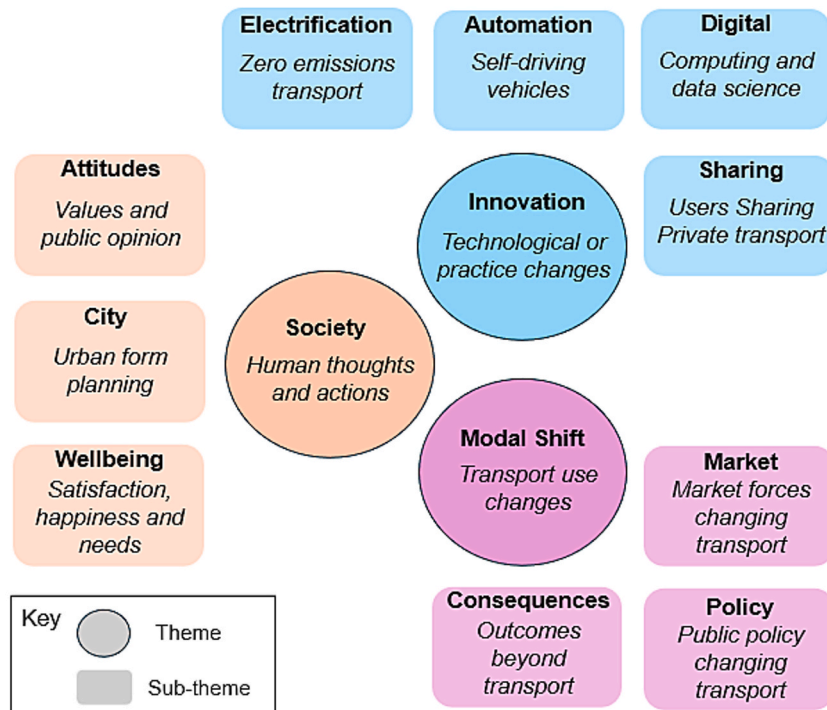


Fig. 5. Map of themes identified through thematic analysis.

“urban sprawl generates additional car-use/ownership” – were not, so these were grouped together.

This stimulated (4) a process of comparison between groups, codes and data to refine and further demarcate themes. For instance, in the initial grouping, three codes relating to electric vehicles were placed alongside two codes relating to energy and these five codes were identified as conceptually related, a sub-theme of “electrification” within the emerging theme of “innovation”. (5) Drafting an initial report prompted further reflection and deepening of themes, discussed amongst all authors. For example, data from an electric vehicle policy code was mostly relevant to a developing “policy” theme, with “electrification” becoming more centred on interaction between aspects of electric vehicle adoption and energy systems. Difficult or ambiguous cases were resolved through discussion and consensus. One such was whether and how to best separate themes more ostensibly concerned with antecedents (e.g., “policy”, “market”) and consequences (e.g., “outcomes”, “wellbeing”); it was agreed that this was permissible in so far as these accurately reflect the event sequences in narratives sampled, independent of causal chains beyond these narratives. Another was whether “built environment” (usually buildings and infrastructure) could be a subtheme of “society” (i.e., collective thoughts and actions of human beings), which was resolved by regarding the former as instantiation of human action (e.g., planning decisions, choosing how and where to live). The final phase (6) was implemented alongside the writing process and involved going beyond this content to develop critical or analytical aspects of the themes (Thomas and Harden 2008). For instance (as reported in Section 4.4) narratives of successful electrification tended to lack detail concerning energy solutions to problems posed in unsuccessful electrification narratives, challenging the plausibility of the former. While the first five phases had been largely inductive, the last phase involved critical comparison between narratives and the wider literature. Importantly, progress through these six phases was iterative, in so far as earlier phases were often revisited to further refine the analysis. For example, during phase 4, it became clear that the “integration (fragmentation)” code (illustrated in Appendix Fig. A.1) actually coded two distinct but inter-related integration (fragmentation) types – of policy/law and of data/systems – hence the techniques employed in phase 2 were re-applied and the code split into two separate codes assigned to separate themes, though many of the extracts carried both themes.

4. Results

Three main themes and ten subordinate themes were identified by the thematic analysis of sampled published transport scenario narratives (Fig. 5). The complete list of these is shown in Appendix Table A.1. Consistent with thematic analysis (Braun and Clarke 2006), data extracts (texts from these) are used to illustrate and describe themes. Likewise, quantifying words (e.g., “some”, “many”, etc.) are used, according to rhetorical convention (Braun and Clarke 2006), to express approximately how prevalent or prominent an idea or concept was across scenario narratives, and not as a meagre substitute for more-precise quantification, which is of questionable value as an index of the importance of an idea interpreted from reading text (Polat 2025). Inferences in this section pertain to sampled published transport scenario narratives and may not generalise to all scenarios.

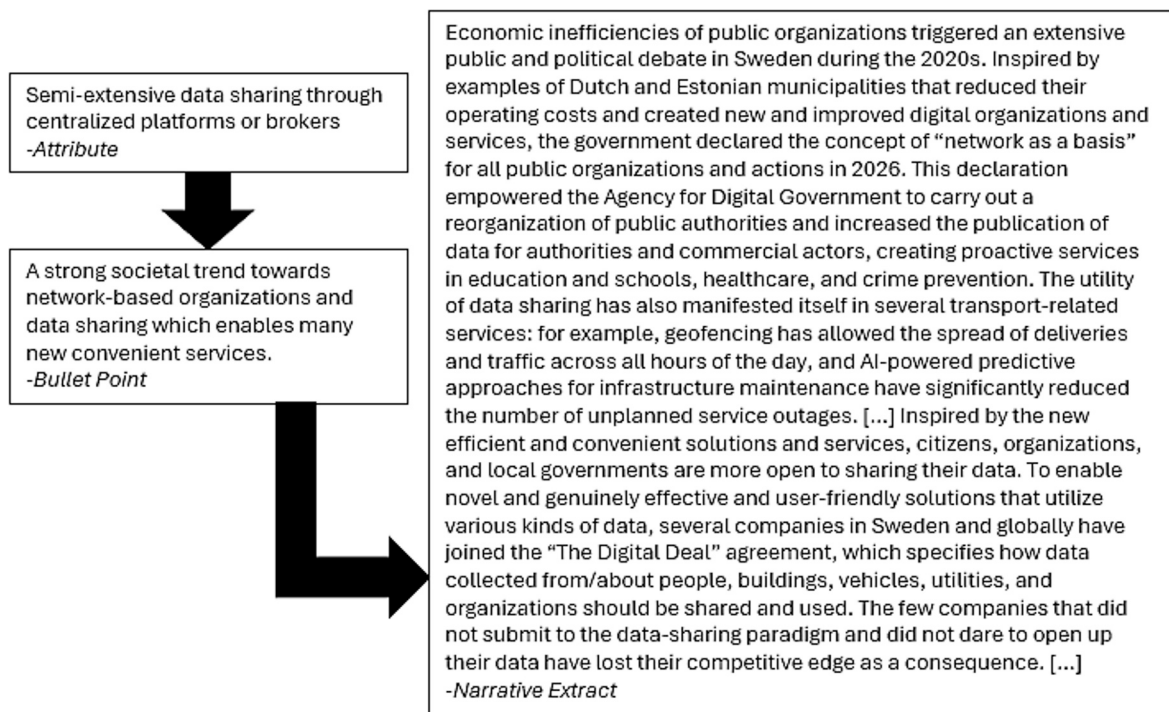


Fig. 6. Example of transition in text from trend (attribute) into an idea (bullet point) and into narrative text in scenario [22] *Swimming in Data* (Pernestål et al. 2021; Raofi et al. 2023).

4.1. Scenario narrative characteristics

The 173 sampled published transport scenario narratives (from 40 sources) varied in length between 39 and 2,097 words, average 375 (Median = 303, SD = 309). Most of these used storytelling to describe series of events or trends culminating in changes and their consequences. Narrative form varied, often according to the scenario planning style or technique used. Hence, the sample included transport scenario narratives using bullet-points (e.g., [Acheampong et al. 2023](#)), indicative event timelines (e.g., [UK Government Office for Science 2019](#)), vignettes of day-to-day life or “vox-pop” ([Enoch et al. 2020](#); [Tori et al. 2023b](#)), and academic analysis ([Holden et al. 2020](#); [Filippi 2024](#)). However, the modal narrative form was plain prose in the manner of a history textbook, describing series of events and their underlying driving trends ([Steinmüller 2018](#)).

Sampled transport scenario narratives often reflected an underlying deductive process of scenario planning in which trends (certain or uncertain) were combined. A common structure was to use separate paragraphs to cover separate trends. Thus, a transport scenario narrative quite often began with an outline of its defining characteristic(s) and their antecedents. Scenario narratives 19 to 22 provide insights into this process of composition, because their authors report the combinations of pre-determined elements used to create them, elaboration of these into thumbnail scenario narratives expressed as bullet-points ([Pernestål et al. 2021](#)), and subsequently-published longer and more elaborate scenario narratives ([Raooft et al. 2023](#)). This is illustrated in [Fig. 6](#), where a defining attribute (from morphological analysis), an elaborated bullet point, and a corresponding extract from the scenario narrative are juxtaposed. Notably, a single idea (trend) is elaborated using multiple ideas (additional trends and elaborating details) and placed within a plotline (around migration of data sharing from the public sector into innovations and societal change).

For example, one of the defining attributes selected for [22] *Swimming in Data* ([Pernestål et al. 2021](#); [Raooft et al. 2023](#)) was “semi-extensive data sharing through centralized platforms or brokers”, elaborated in the bullet-point “a strong societal trend towards network-based organizations and data sharing which enables many new convenient services” ([Pernestål et al. 2021](#)). In a holistic scenario narrative ([Raooft et al. 2023](#)) this defining characteristic is outlined in the first two paragraphs (281 words), describing its antecedents and consequences and linking it to other pre-determined (e.g., transport automation) and elaborating (e.g., AI innovation) scenario elements. Specifically, this text tells the story of how economic inefficiencies inspired data-sharing for efficiency in the public sector, which subsequently migrated to wider society, precipitating innovations in AI and automation that result in economic and sustainability improvements.

4.2. Theme 1: Modal Shift

The Modal Shift theme is prevalent across most sampled published transport scenario narratives and can be understood as a spectrum between radical modal shifts and notable status quo or baseline scenarios in which current trends persist or proceed along their present trajectory. While prevalent as a scenario trend, this was rarely an uncertainty defining multiple contrasting scenarios ([Enoch et al. 2020](#); [Kiviluoto et al. 2022](#)). In certain scenario narratives, modal shift (gradual or radical) was towards greater or sustained automobile use. This is typified by [50] *Car-dependent lifestyles persist* ([Kiviluoto et al. 2022](#)), in which current trends converge to support societal automobile reliance, [26] *All of Brussels on four wheels* ([Tori et al. 2023b](#)), in which rising motorised transport is driven by fragmented policy and rising societal inequality, and [109] *Mobility market* ([Enoch et al. 2020](#)), in which car-use is driven by its comparative advantages in a more open transport market. In a subset of automobile scenarios, the antecedents are (perceived) pre-existing trends (e.g., free-trade, urbanisation, inequality, individualism) rather than new trends, such as technology innovations (e.g., 22, 50, 83). Hence, in [83] *The Infraconomy Revolution* ([Neef et al. 2020](#)), in the context of long-distance transportation, increased demand for motorised transport is driven almost entirely by trade supported by economic growth.

By contrast, some sampled published transport scenario narratives are defined more by shifts to traditional public transport and/or active transport, such as [49] *Public transport serving all* ([Kiviluoto et al. 2022](#)) and [40] *The Culture of Public Transportation* ([Sunitiyoso et al. 2023](#)), in which the government supports integrated public transportation as a means of addressing sustainable policy goals. Likewise, others are marked by shifts to non-traditional (innovative) transport modes that are potentially more sustainable, such as mobility as a service [66], hyperloop [88], or advanced autonomous vehicles [110]: these shifts are elaborated upon further in [Section 4.4.](#), but are instances of radical modal shift akin to radical shifts to minority modes, such as the shift to cycling in [48] *The Era of Soft Modes* ([Kiviluoto et al. 2022](#)). Differences in modal shift between scenario narratives are important due to their strong implications for future transport sustainability ([Banister 2008](#)) and the reflection of both perennial and novel ideas concerning potential for system change ([Feitelson and Salomon 2004](#)).

The Market subtheme refers to the role of industry, and market forces, in modal shift and/or modal stability. This can be the focus of scenario projects; notably, [Enoch and Potter \(2023\)](#), in considering the future of Mobility as a Service (MaaS), contrast a sector “highly competitive [comprising] many thousands of transport service providers” [46], to those of monopolism in either (a) “global oligopolistic [...] multi-national commercial organizations” [44], (b) “a range of service providers [...] in a monopolistic environment” [45], or (c) “each public transport authority [establishing] its own [...] monopoly” [43]. This resembles [Marletto \(2019\)](#), contrasting incumbent and reconfigured autonomous vehicle market scenarios, and a similar pattern is found in contrasting [132] *Urban electrification* ([Venturini et al. 2019](#)), where incumbents maintain dominance by quickly integrating EV and battery manufacturing in place of traditional fossil fuels, with [133] *Green individuals alone* ([Venturini et al. 2019](#)), where energy providers enter into a newly electrified transportation market to compete with the incumbent automobile industry. More abstractly, fossil fuel prices (hence energy prices), as market forces, drive several future transport scenario narratives (e.g., [Keseru et al. 2019](#); [Chen et al. 2020](#); [Knaap et al. 2020](#)), with fuel prices reducing car-use and encouraging investment in renewable alternatives (see also: [Zmud et al. 2013](#)).

Researchers often cast the incumbent automobile and fossil fuel industries as recalcitrant, helping to drive worst-case scenarios [e.

g., 1, 59, 122, 139) or sustain existing car-dependency trends [e.g., 22, 26, 78, 100], an insight captured by Miskolczi et al. (2021) in both the [59] *Grumpy Old Transport* and [60] *At an Easy Pace* scenarios, where either automobiles remain dominant or become sustainable only slowly through incremental innovation. These perspectives draw less upon classic economic conceptions, such as equilibrium and competition, than upon theoretical traditions sceptical of incumbency perpetuating car-based psycho-social systems (Feitelson and Salomon 2004; Geels 2005), where, for instance, “powerful incumbent actors [try] to suppress innovations through market control or political lobbying” (Geels 2005). This is manifest in [1] *Automobility city* (Filippi 2024) where vested interests in automobile markets are linked with a “culture and lifestyle [of] every person as a self-sufficient individual, deeply rooted in car ownership for daily transport [where] automobiles protect us by surrounding our fragile, soft, and vulnerable human skin with a new shell of steel”. This characterisation of automobile culture is also manifest in [161] *Havana gridlock* (Blanco and Moudon 2017), where the lifting of US trade embargos upon Cuba marks a worst case scenario in which there is “an auto-dependent expansion in the metropolitan area” that “the Havana government fails to control [...] which ensures gridlock and the further deterioration of road infrastructure” as well as “street fights erupt[ing] over parking spaces” and the erosion of “Cuba’s longstanding tradition of local community engagement and collaborative behavior”. Here, car-culture is evident as a facet of contrasting ideology, but the different characterisations of the role of markets and firms reflect disciplinary preconceptions as to whether driving trends are (speaking broadly) primarily economic or primarily social.

Policy, as a sub theme of modal shift, reflects change through internal or external policy intervention. A particularly clear example is [49] *Public transport serving all* (Kiviluoto et al. 2022), where external pressures “led politicians and officials to examine public transport more closely”, developing “key aims” to create “a perfectly functioning service [...] a well-functioning public transport service network together with good infrastructure”. Taking sampled published transport scenario narratives as whole, a variety of key policy instruments are mentioned, but separately, so even scenario projects with a policy focus tend to cover policies at the abstract or categorical (type) level rather than more strategically (e.g., Soria-Lara and Banister 2017; Paddeu and Lyons 2024). Such types include those directed to reducing car use, through incentives or regulation of urban access, as well as those encouraging ridership or innovative shared or sustainable private modes. Other policies target active travel modes specifically, through improved environments or dedicated infrastructure. Policy interventions can be facilitated by digital innovations, including direct taxation/regulation of greenhouse gas emissions. Policy and market themes interface in collaboration with industry (e.g., public innovation funding) or direct intervention in the marketplace, such as a public provision of a MaaS platform [43] or last-mile delivery services [9]. Less prominent across sampled published transport scenario narratives are behavioural science led (“soft”) policy instruments. For example, in [58] *Green and active mobility* (Camilleri et al. 2022), “cycle training [is] carried out in schools and available for adults provid[ing] the individuals with the necessary skills to use the bicycle” and “active travel is heavily advertised and marketed so that these forms of travel become associated with high status [and connote] safety and [...] health benefits”.

Evaluating the role of policies in sampled published scenario projects, almost all of these projects are directly or indirectly publicly funded and, hence, directed more towards the benefit of public sector actors with more strategic control over policy (see Table 2). (By contrast, for corporate foresight, public policy can be an external trend demanding strategic response.) However, with the known tendency towards optimism in long-term transport planning (Cruz and Sarmiento 2020), one should also be cautious in devising scenarios optimistic concerning the strategic impacts of policy upon environmental sustainability in transport, such as treating this as a scenario-defining uncertainty. For example, some sampled published transport scenario narratives explore how financial costs of policies become prohibitive (Batty et al. 2015); here, financially unsustainable policies are vulnerable to failure as environmentally sustainable policies. Indeed, in sampled transport scenario narratives from studies beyond the political West, public financing is cast in this role, with emphasis on external investment over reallocation of existing public funds (Blanco and Moudon 2017; Idriss-Yahya 2018; Sikazwe et al. 2021; Gerdri et al. 2022; Dixon, 2023; Sunitiyoso et al. 2023). In [67] *Railway freight status quo* (Sikazwe et al. 2021), “low availability of infrastructure financing mechanisms” leave [...] Zambian railways “underdeveloped” hence “dilapidated [with] limited railway infrastructure, outdate railway technology and other infrastructure and performance challenges”, whereas [70] *Railway freight paradise* involves both the high traffic volumes and investment to support growth and improvement. Such is arguably true of scenarios of sustainable development generally (e.g., Gerdri et al. 2022), though at least one sampled transport scenario narrative mentions institutional malfeasance as a related challenge to overcome (Idriss-Yahya 2018).

Consequences, as a sub theme of modal shift, reflect important outcomes beyond transport, including byproducts, spillovers and knock-on effects in other domains. Positive and negative consequences in sampled published transport scenario narratives include efficiency impacts (e.g., traffic congestion), environmental impacts (e.g., carbon emissions and climate change), and health impacts (e.g., from sedentary lifestyles or increased accident risk). Such scenario narratives may be explorative or normative (see Table 2), which will affect a scenario narrative’s emphasis upon evaluating consequences, as opposed to stating them for the evaluation of the reader (c.f., Sovacool et al. 2020).

For environmental sustainability, climate change is a key example of consequences upon which to focus. While environmental consequences are often cited in sampled published transport scenario narratives in terms of carbon emissions or global temperatures, the reciprocal consequences of climate change for transport are introduced in a small number of these, hence they may not fully consider the importance of climate change resilience (Koetse and Rietveld 2012). For example, in [160] *Meltdown* (Sadatsafavi et al. 2017), extreme weather from rapid climate change leads to “struggling with nature” as “catastrophic events lead to [public] resources totally diverted to repairing or rebuilding affected infrastructure to help revitalize the area impacted”. Beyond this example, this issue receives only some brief mentions [12, 25, 26, 29, 30, 172], contrasting with extensive scenario planning undertaken in sustainability science more generally (Kishita et al. 2016).

4.3. Theme 2: society

The theme Society reflects collective thoughts and actions of human beings, as some sampled published transport scenario narratives focus primarily on other aspects, such as the economy or public policy (e.g., Zhao et al. 2021; Enoch and Potter 2023). The urban environment is relevant in society-driven scenario narratives sampled as a key mediator between societal change and transport change. The scenario narrative [124] *Slow is beautiful* (Keseru et al. 2019) is a typical example of a society-driven transport scenario narrative. Here (enabled by public policy and slow economic growth) there is a societal shift towards localism, self-sufficiency and valuing what is “slow, healthy and sustainable”. Here, “people appreciate spending more time with their friends and family within their neighbourhood and rediscover their local environment.” Consequently, transportation and urban form both change, as “mixed-use developments aim to decrease the distance between residential areas, jobs, education and services” as well as “cities introduc[ing] car-free city neighbourhoods”, “a growing market for electric cargo-bikes that are used to distribute goods”, and “popularity of cycling and other electric two-wheelers”.

The theme of Attitudes refers to orientations towards public issues in transport and sustainability. Attitudes reflect orientations to public issues generally, including fundamental changes in values or social norms. While this can be through public (i.e., leadership) policy priorities, of environment over economy (Pernestål et al. 2021; Raoofi et al. 2023), these are often about an enlightened (responsible, aware, etc.) populace, such as in [102] *The responsible traveller* (Holden et al. 2020) where “an enlightened population consciously chooses more sustainable alternatives for mobility [...] low-carbon lifestyles are an aspirational goal”. Sometimes the enlightened populace is contrasted with current popular attitudes and sometimes with a scenario narrative depicting more extreme and opposing attitudes, whether more individualistic/consumerist attitudes, as in [81] *Data world* (Keseru et al. 2019), or radical political reaction, as in [87] *The Missed Boat Revolution* (Neef et al. 2020), where “political turbulence (e.g., mouvement des gilets jaunes; growth of climate-sceptic political parties) occur and delay environmental advancements”. Attitudes may revolve around the role of automobiles in society and culture, clearly depicted in [1] *Automobile society* (Filippi 2024) where auto-dependence is not merely material but psychosocial, fulfilling symbolic needs for safety and self-esteem. By contrast, other sampled published transport scenario narratives show car-dependence as dispensable: in [23] *Green Circle* (Pernestål et al. 2021) “just as, in the EU, smoking indoors went from something taken for granted to something almost unthinkable during the 2010s, cities and streets without vehicles have been something people have become accustomed to and appreciative of”.

Importantly, sampled published transport scenario narratives generally depict enlightened attitudes as driving sustainability, and it is rare to find a scenario narrative in which sustainable transport is not achieved through societal attitude change, though, arguably, this seems an equally likely outcome where other conditions for change are not met, such as in [12] *In a Fix* (Paddeu and Lyons 2024), where change backfires: there is “heightened public consciousness” and “concerted efforts [...] to address climate change [...]”, however “transformational economic green recovery failed to create the momentum hoped for and crippled public finances [which] dampened progress on greening consumption” such that “climate change effects are now very much part of people’s lives and a source of anxiety and concern”. Also, attitudes are sometimes identified as a key uncertainty and used to define contrasting scenarios (e.g., Perveen et al. 2017; Keseru et al. 2019; Raoofi et al. 2023; Paddeu and Lyons 2024), consistent with a general lack of consideration given to the antecedents of attitudinal change in scenarios. Yet attitude change is a cognitive process studied by psychologists and sociologists (e.g., Maio and Haddock 2007) and, much as scenario planners are encouraged to scan the technological horizon, there is an opportunity here to incorporate a more-informed understanding of how societal attitudes change or remain the same (e.g., Thøgersen et al. 2021), even if the valency of change is complex and unpredictable.

Urban environment, as a sub theme, refers to how urban form and land-use choices affect travel distances and modal choice. It is mainly introduced as a contrast between ‘density’, an urban form that is spread-equally, high-density and eclectic and an urban form that is ‘sprawling’, sparse and monolithic. Consequently, density favours physically active transport whereas sprawl favours car-use; hence, pessimistic transport scenario narratives sampled often feature the latter, and optimistic scenario narratives the former. In some extreme sampled transport scenario narratives, the sprawl also favours urban aviation services as journey distances increase [e.g., 15, 25]. External drivers of urban change, such as population and urbanisation (Angelidou et al. 2022), are not always considered, though Perveen et al. (2017), focusing on planning aspects, is an exception, emphasising inevitable urbanisation to explore realistic scope for sustainable urban planning. Similarly, Ariza-Álvarez et al. (2021) contrast policy-led and trend-led scenarios: [74] *Non-motorized city centres* portrays policy-leadership – “the full restriction of private vehicles access to city centres” leading to “cities that offer a high mix of residential, shopping, leisure, and working places” fostering active mobility as trip distances decrease, whereas two contrasting scenarios are trend-led, defined by trends of overpopulation and rising crime rates, respectively [75,76]. Importantly, urban environment as a theme is rarely considered with respect to available public policy levers: careful policy-packaging and compromise is necessary to regulate and incentivise the actions of private developers, with evident barriers due to the efficacy or feasibility of such policy instruments as well as the social and political context (Patterson et al. 2021). Hence, sampled transport scenario narratives involving urban environment change may be enhanced by considering the challenges of bringing about such changes and how these might be surmounted (e.g., Mouratidis 2024). Importantly, the US style of transport land-use scenarios did not appear in the corpus, and so we do not draw a comparison, however they are discussed in Section 2.2.1, above, with an example from Kirkey et al. (2017) described in Section 2.2.2, and are further summarised by Bartholomew et al. (2007, 2010).

Wellbeing – satisfaction, happiness or the meeting of needs – appears mostly through equity (fairness), a key element of sustainability. Declining equity is often attributed to free market forces and insufficient welfare policy in the advent of rapid technological innovation and diffusion. For instance, in [73] *Fragmented Mobility* (Lempert et al. 2021), where “navigating competing systems with different pricing structures involves a significant learning curve” there is “a dramatic shift in mobility” and “those who are physically disabled, low-income, or without a credit card/smartphone are left out of the mobility revolution” and “many options are sufficiently

expensive to be limited only to the wealthy". Similarly, Lazzarini et al. (2023) contrast a transport scenario narrative of [16] *Continuity*, in which policy to support ICT adopters favours public transport uptake, with a scenario, [17] *Lost opportunity*, in which failure to do so (coupled with a rapidly growing economy) leads to ICT adoption favouring private motorised transport. These are known byproducts of rapid technological diffusion, but a significant unknown addressed in surprisingly few sampled transport scenario narratives is the delegation of equity decisions to a biased or arbitrary artificial intelligence (Mavrogiorgos et al. 2024). This is explored in [147] *The pessimistic scenario* (Papa and Ferreira 2018), where potentially fatal traffic accidents involve the autonomous vehicle system's artificial intelligence assessing "the value of human lives [with] optimum decisions being made regarding whose lives should be sacrificed", favouring "people whose salaries are higher and who have better insurance coverage" at the expense of "the elderly, immigrants from undesirable origins and refugees".

Wellbeing as a scenario narrative theme often reflects the sustainability paradigm in transport and the alternative transport policies it advocates (Banister 2008). Hence, several sampled transport scenario narratives enfold themes of dense urban land use, telepresence through digital technologies, transport mode shift, and consequent improvements in welfare, to construct a sustainable transport scenario where wellbeing is a natural byproduct. For instance, in [137] *Shared world* (Zahraei et al. 2019), 3-4km² districts becoming "self-sustaining zone[s]" with mixed residences and vital services, thus allowing "residents including the elderly and the physically challenged to pursue many activities without traveling long distances". This "fundamentally change[s] travel patterns" and also fosters "a greater sense of belonging" with residents "contributing actively to the betterment of their districts and the welfare of the [other] residents". Likewise, in [115] *The liveable shared city* (González-González et al. 2020), shared autonomous vehicles reconfigure urban space, with "a great amount of public space [...] freed: former parking lots and buildings have been transformed into attractive green parks, playgrounds, cultural and community buildings, urban facilities, new affordable residential areas or urban farming lands [...] thereby increasing the densification [...] and attracting a more diverse population in a vibrant and liveable city". In navigating sampled published transport scenario narratives, it is important to remain aware that these may reflect this paradigm as a future vision, rather than weighing the pros and cons as evidence accumulates concerning the effects of densification upon welfare (e.g., Badland and Pearce 2019).

4.4. Theme 3: innovation

The theme of innovation captures the tendency for sampled published transport scenario narratives to identify new technologies and/or practices as driving trends or uncertainties that shape future transportation. For example, in [88] *The hyperloop Revolution* (Neef et al. 2020), hyperloop technology (vacuum tube transport) radically changes transportation, addressing many existent issues, including environmental sustainability (see also: Tori et al. 2023a). Sub-themes of innovation were identified through manifest recurring innovation types – electrification, digital, automation, and sharing – rather than exploring latent elements of innovation in scenarios (Sovacool et al. 2020). Innovations are clear in several sampled published transport scenario narratives, such as [62] *Tech-eager mobility* (Miskolczi et al. 2021), [118] *Revenge of the nerds* (Knaap et al. 2020), and [122] *Data world* (Keseru et al. 2019), where all subthemes (innovation types) contribute to shaping future events. Innovation is also thematically clear in transport scenario narratives where only one subtheme is prominent, such as [110] *Personalised pods* (Enoch et al. 2020) or [129] *Technology unleashed* (UK Government Office for Science 2019), emphasising automation and digital themes, respectively. Innovations (i.e., these sub-themes) may also be compared and contrasted between scenario narratives as uncertainties – the scenarios of Kane and Whitehead (2017) exemplify this, with suboptimal scenario narratives involving only subsets of innovations and an optimal scenario narrative in which electrification, automation and sharing all appear, in the context of urban densification (see §4.3), being mutually-supportive of environmental sustainability. While innovation is a key theme in sampled transport scenario narratives (and future studies more generally), some sampled transport scenario narratives are manifestly low-tech and sustainable, such as [77] *Urban structural change & lifestyle change* (Dillman et al. 2021) and [131] *Urban hippie* (Venturini et al. 2019), tending to reject technological optimism in favour of value-driven changes in lifestyles (see §4.3).

Net-zero emissions propulsion technology was almost entirely represented in sampled published transport scenario narratives through electrification, the diffusion of electric vehicles (EVs) and their infrastructure; hydrogen fuel cell technology is mentioned occasionally [e.g., 36, 97]. Some of these indicate public policy as a driving factor in electrification, such as [111] *Technological substitution to BEVs* (Köhler et al. 2020) where "large-scale introduction of BEVs and fuel cell vehicles" is "strongly supported by the Dutch government strategy". However, in [141] *Smart* (Marletto 2019), electrification is market driven as "energy operators enter the domain of urban mobility and take over the dominant position of the individual car [...] system". Detailed accounts of electrification (rather than its antecedents or outcomes) tend to be lacking in transport scenario narratives sampled, however there is some consensus that electrification would render motorised transport environmentally sustainable. However, it is valuable to query this consensus by briefly considering what insights are available from scenario planning in the domain of energy, rather than transportation.

Sovacool et al. (2020) identified six themes ('visions') with respect to transport electrification, three of which were not core elements of the present analysis: energy grid innovation, economic revitalisation, and innovation failure. Though touched upon separately in different sampled published transport scenario narratives [41,54,55,97,129,141], only Chen et al. (2020), primarily focusing upon energy alongside transport futures, identify these as key uncertainties for future sustainability through electrification. Barriers – like developing long-lasting, recyclable, high-capacity, fast-charging EV battery technologies and corresponding grid infrastructure – remain challenging (Vrabie 2022), and Chen et al. (2020) considered these through linkage with both the necessity for finance in R&D and the potential for economic advantage through technology. Thus, in sampled published transport scenario narratives, there is scope to consider further how electrification could "accrue enhanced employment opportunities, economic competitiveness and growth" or else "[fail] to deliver on its promises" due to "uncertainty over things like vehicle performance, batteries, and charging infrastructure"

(Sovacool et al. 2020). Concerning the infrastructure of charging, there is also scope for uncertainty, for instance whether to anticipate high-capacity batteries alongside numerous rapid public chargers being utilised rather than slow hi-capacity home and workplace charging (Borenus et al. 2022). More broadly, Holden et al. (2021) identify 13 future energy narratives, only one of which primarily features centralised renewable energy and transport electrification, tending to suggest sampled published transport scenario narratives may be considering only a narrow range of possibilities with respect to the interface with energy futures; alternatives included increasingly customer-led, decentralised, and even off-grid energy systems (Kjølle et al. 2021), the transport implications of which could be considered in scenario planning.

Digital, as a sub theme of innovation, refers to innovation in computer technology and/or data usage. Specific digital innovations identified in sampled published transport scenario narratives were numerous, but included transport service platforms, teleworking, data analytics, autonomous vehicles (e.g., drones), and artificial intelligence. Several were the technological basis for innovative shared mobility, such as Mobility as a Service. In [108] *Connected corridors* (Zahraei et al. 2019), travellers interface with a connected shared transport system using the “Transport Ambassador” journey planning app: “a traveller’s best friend”, the ambassador tailors services to preferences for weather, physical activity (including health status), traveller privacy, and budgeting. This is a key interface with the subtheme of sharing transportation.

Telepresence – substituting telecommunications for travel – is also common in hi-tech sampled published transport scenario narratives. In [156] *Bits over buses* (Sadatsafavi et al. 2017), telepresence reduces traffic considerably, making transport infrastructure management possible at the local (i.e., community) level. There are concomitant issues raised through sampled published transport scenario narratives. Digital innovations are mentioned in some of these as impacting general welfare (positively or negatively) through the flexibility in working patterns [e.g., 123, 137]. In others, change is more fundamental, interfacing with the themes of society and welfare. Tori et al. (2023b), in [138] *Virtual world*, show a new domestic norm of “small sanctuary” dwellings with “advanced-technology gadgets” that constitute “a home, a virtual work, social and classroom space”, engendering a shared “virtual reality” experience. Other sampled transport scenario narratives anticipate local shared hubs where many workers telecommute together to attend different jobs virtually, thus reducing the sense of isolation. They sometimes link telecommuting to welfare through identity [27, 124, 137], describing strong local or digital identities empowering sustainability. Paddeu and Lyons (2024) give this idea particular attention, contrasting scenario narratives where cyberspace is insufficient, where “in spite of an increasingly rich and immersive digital world for work and play, people are hungry for ‘real world’ escapism” [10], with those where cyberspace is sufficient, where people “enrich their online existences [and] a need for variety in the ‘real’ world has been dampened” [11]. While cyberspace may “allow us to remain global citizens” as we lead local lives, as in [105] *The essential life* (Holden et al. 2020), there is also the converse to consider: becoming trapped within online ‘echo-chambers’ or one’s insular local culture.

A further digital innovation in sampled published transport scenario narratives is transport system efficiency, particularly the utilisation of data analytics and artificial intelligence, smart innovations, and interconnected networks that optimise traffic flows and/or commercial transport. This is clear in [22] *Swimming in data* (Pernestål et al. 2021; Raoofi et al. 2023), where widespread data sharing has enabled “geofencing”, “AI-powered predictive approaches for infrastructure maintenance”, “predictive shipping”, data sharing “to achieve environmental and social sustainability goals”, and “the few companies that did not submit to the data-sharing paradigm and did not dare to open up their data have lost their competitive edge as a consequence”. Similarly, in some sampled transport scenario narratives, efficiency innovations enhance policy instruments, such as tailored transport pricing, including penalty and concession pricing (e.g., according to congestion, weather and financial circumstances) [e.g., 125]. Plazier et al. (2024) consider such developments in the context of last-mile transportation, identifying local authority involvement and cooperation between firms as key facilitators, contrasting two “wild west” transport scenario narratives of minimal public sector involvement [4,5] with those of active policy intervention that either meet sustainability goals through cooperation [6,7] or create backfire effects through interfirm competition or lack thereof [8,9].

Data sharing in public and private sectors, such as within a legislative or policy framework, is identified in several sampled published transport scenario narratives as necessary to fully realise the benefits of data-driven digital innovation [e.g., 86, 107, 138]. This also raises cybersecurity considerations. In [127] *Individual freedoms* (UK Government Office for Science 2019), it has become normal to be worried about cyber security threats: even with personal data highly regulated, walking and cycling are preferred as “liberating and untraceable” transport modes in contrast to motorised modes. By contrast, [108] *Connected corridors* (Zahraei et al. 2019) anticipates an environment, of “universal monitoring of people using automated trains, buses, and taxis”, but that “patronage [grows] as people [feel] totally safe using these services”. As an emerging trend, there is potential to explore this through scenario planning, considering how people will respond in practice and how/whether these risks will be mitigated.

Automation, as a sub theme, refers to innovation in self-driving (autonomous) vehicle (AV) technology. Several scenario studies focus upon AV technology futures specifically (Milakis et al. 2017; Papa and Ferreira 2018; Marletto 2019; Lempert et al. 2021; Acheampong et al. 2023). Several sampled published transport scenario narratives indicate efficiencies from this technology, in terms of functionality and timesaving. Some go further and indicate it fulfilling functions somewhat beyond transport. One study (Acheampong et al. 2023) depict AVs fulfilling municipal functions in healthcare, policing, events management, hygiene/maintenance, and couriership. Likewise, one transport scenario narrative posits that AVs could have built-in ambulance capability, monitoring the driver’s vitals and rerouting to a hospital if necessary [146] (Papa and Ferreira 2018). The most extreme in this respect is [138] *Virtual world* (Tori et al. 2023b), where an AV becomes “not only a mere mobility device but also an artificial intelligent ‘life form’” playing the role of “personal assistant”, “picking up groceries from stores” and “attending office meetings in situ” as the owner’s “avatar”. The manner of AV adoption is often shown as having sustainability implications. A key aspect for sustainability is the way in which AVs are programmed to behave, whether collectively to meet sustainability goals or competitively to maximise the driver’s utility. In [147] *The pessimistic scenario* (Papa and Ferreira 2018), AV design is competitive and not cooperative, with sub-optimal

social and environmental outcomes but “competitive advantage” to firms who can replicate the most “aggressive driving styles”. Relatedly, in [116] *The unlimited individualistic city* (González-González et al. 2020), additional car use due to AVs utilised by non-drivers, “the elderly, disabled and people without a driving license”, lead to fuel efficiency advantages being outweighed by increased car-usage. Hence, in [128] *Greener communities* (UK Government Office for Science 2019), AV use is regulated and afforded only to elderly and physically disabled segments, thus promoting equitable mobility rather than inducing demand for driving. Market and employment structures may change, with welfare consequences beyond transport. Redundancies in transportation are indicated, though transport work may adapt to AVs, with drivers becoming “fleet captains” [43] (Enoch and Potter 2023) or passenger-serving “stewards” capable of emergency driving [107] (Enoch et al. 2020); smaller commercial fleets may be crowded out as firms consolidate around self-driving goods vehicles [126] (UK Government Office for Science 2019). Such considerations are reflected in different policies in sampled published transport scenario narratives, including bans on advanced AV technology, geographical limitations (e.g., geofencing), ownership/user regulation, and regulation for manual drivers (to avoid accidents with AV road users). The breadth of sampled published transport scenario narratives tends to indicate considerable social, economic and environmental uncertainty, not least over the technology’s success [e.g., 173] (Milakis et al. 2017).

Sharing, as a sub theme, reflects innovative business models (or ecosystems of models) that introduce sharing of transportation (of trips, of components, of vehicles) into the market. Much as net-zero emissions vehicles were generally manifest in scenarios as EVs, so sharing appeared in most sampled published transport scenario narratives through Mobility-as-a-Service (MaaS: Alyavina et al. 2022). MaaS separates vehicle service from ownership, often alongside self-driving vehicles. Specifically, MaaS is the trading of transport services through a digital platform and adding additional value through relevant information, helpful software, and/or payment/pricing options (e.g., contracts, bundles). In facilitating shared transportation specifically, MaaS is differentiable from the digital innovation it utilises (Lyons et al. 2020), and, being potentially disruptive and relatively uncertain, it is relevant to transport scenario planning in its own right. The environmental sustainability potential of MaaS (and other shared transport) is in reducing car ownership and transporting multiple individuals through the same journey, this being clearly indicated in transport scenario narratives such as [71] *Mobility for all* (Lempert et al. 2021) and [99] *Shared* (Marletto 2019). Successful commercialisation of MaaS remains uncertain, particularly with environmental sustainability. There is the question of the price and product-bundle at which a shift to shared sustainable transport would transpire, and to what extent such a shift would reach the most car-dependent consumers (e.g., Hauslbauer et al. 2024). Hence, plausible transport scenario narratives of sustainable shared transport should reflect MaaS elements vital for sustainability but also adoption and diffusion.

The failure/success of shared transport diffusion is sometimes linked to societal attitudes, such as in [127] *Individual freedoms* (UK Government Office for Science 2019), where prioritising personal privacy leads to “no major transport sharing except among established work, friend and family groups”. However, another key element in sharing transport scenarios narratives can be public-private cooperation. In [63] *Private vehicle addiction* (Zhao et al. 2021), such a trend leads to suboptimal sharing services (lacking “simplicity, impartiality and flexibility”) that are “not able to attract enough users to trigger the shift towards shared mobility” and this “forces people to maintain private vehicle ownership for convenience and comfort”. The nature of this cooperation differs. Sometimes, sharing automobiles is integrated within the public transportation system, through close partnership with strong oversight or direct public ownership, though, in [43] *Consolidated market; consolidated services* (Enoch and Potter 2023), with strong public-private oversight, there are higher barriers to entry and “limited levels of competition in less attractive market environments” where “diseconomies of scale and scope may also stifle innovation, reducing potential efficiency gains and limiting consumer opportunities”. Contrasting transport scenario narratives are more entrepreneurial or commercial, although some [e.g., 46, 63, 122] posit that close competition without publicly regulated or firm-strategic data sharing may have similarly negative consequences.

5. Discussion

Future expectations bring manifold uncertainty; complex real-world systems make inaccurate long-term predictions a significant risk, almost an inevitability. Against deep uncertainties, alternative approaches are a necessity. One can generate several extreme scenarios (alternative futures) to explore the spectrum of possibilities sandwiched in-between. Doing so, decision makers contemplate many potential future outcomes, allowing for them in the subsequent leadership. This attitude to uncertainty is taken in organisations, including transportation authorities, to mitigate risk. In this article, following an introduction to scenario planning in transport, scenario narratives in transportation were examined through a qualitative thematic analysis and synthesis of a sample of 173 contemporary urban land transport scenario narratives from 40 sources. This considered what the role of scenario planning in transport analysis is, how foresight and scenario planning are reflected in these transport scenario narratives, and what key ideas were explored. Hence, this article provides its reader with a timely synthesis of information, a synthesis that is otherwise scarce within the available literature (Abou Jaoude et al. 2022). These analyses benefit from an approach robust to the ideographic differences between scenario narratives and, within a non-systematic sample, offering critical insights concerning foresights captured within scenario narratives (Thomas and Harden 2008).

Thematic analysis results (see Fig. 5) explore contemporary foresight and key ideas in urban land transport. First, modal shift (or lack thereof) was prominent across sampled published transport scenario narratives, often driven by combinations of market forces and public policies, and with implied or manifest consequences for transport efficiency (e.g., road traffic congestion), human health, and the natural environment. Second, these often contrasted differences in future society – the collective thoughts and actions of human beings – particularly attitudes towards public issues in transport and sustainability, the instantiation of society in the city (urban environments), and the future wellbeing of those in society, particularly levels of fairness. Third, they anticipated different degrees of innovation in technologies and services, particularly innovations in electrification as sustainable propulsion technology, in

digital technologies such as data analytics, artificial intelligence, and telepresence, in vehicle automation, and in innovative business models for shared transportation.

As tools for describing key aspects of current transport futures, these themes act as a template for interpreting scenarios and when tracing changes in opinions concerning transport futures. It is encouraging that the thematic map resembles PESTL categories (Puyt and Madsen 2025; see also Table 3) to a certain extent while differing in important respects: first, these themes capture not just trends but also outcomes; second, they are transport-specific, thus highlighting elements that might not be immediately obvious in generic typologies (e.g., modal shift, urban form). Overlap with existing work is also encouraging. Our results encompass the six themes identified by Miskolczi et al. (2021), who synthesised 52 transport scenarios from 16 studies published between 2012 and 2021 identifying the themes of automation, shared mobility, electric vehicles, congestion, social attitude, and greenhouse gas emissions. Importantly, however, their synthesis targeted only technologies, issues and trajectories, whereas the present study was broader in scope, capturing additional themes. It is also important to weigh the role of consensus: while Miskolczi et al. (2021) report consensus across scenarios, the present study goes further in also exploring breadth and variety.

In addition to mapping the thematic content of these sampled published transport scenario narratives, thematic synthesis provided additional insights into foresight in transport scenario narratives and the role these play in transport analysis. These are summarised in Table 5 as quality criteria for use in future projects, which were informed by the empirical results of this study as well as an examination of potential quality criteria practices described in the scenario planning literature, reflected in the discussion that follows. The results of the present study are beneficial in highlighting the importance of quality to the utility of transport scenario narratives. Unfortunately, current literature on scenario quality is sparse and often confounded with defining characteristics of school/style (Curnin et al. 2025), hence warranting discussion to appreciate application to developing transport scenario narratives.

Ultimately, in the literature, scenario quality is pragmatic: a useful scenario facilitates a user or client in making better decisions through offering an effective challenge to existing suppositions (Wack 1985b; Godet et al. 2008; Lyons et al. 2021). Thus, it is important to draw a distinction between discussing the quality of scenario narratives in isolation and the quality of scenario planning studies, being the aims and methods that produced scenario narratives, and how scenario narratives are subsequently used, such as to inform strategy or policy. There is some agreement that scenario narrative quality is the product of the confluence of both considerable critical and creative thinking employed during scenario planning (Curnin et al. 2025), but there remains the question of how these efforts ensure usefulness. Thus, as is common in exposition of IL procedure (see also Fig. 2), but in the context of transport scenarios in particular, Lyons et al. (2021) differentiates the scenarios development process from the subsequent stage of “bringing them to life” creatively in the narrative. Arguably, it is this combination, and particularly the added value of the creative element, that sets IL scenario planning apart from other approaches.

One aspect of this is applying critical thinking to unlikely outcomes, as “scenarios themselves must be carefully researched and highly plausible, regardless of how unlikely they might be” (Curnin et al. 2022). Part of achieving this is the integration of a broad variety of interacting trends and not only the few trends integral to the idea (the defining characteristics or essence) for the scenario, hence the move from scenario ideas to “fleshing-out” narratives, one means to which is inclusion of both certain and uncertain trends identified during the investigation stages (Schwartz 1998).

Scenario planning is advantageous, here, in not delimiting disciplinary scope. For instance, urban land transport scenario narratives sampled – as reflected in the themes and sub-themes in Fig. 7 – are potentially driven by a breadth of trends not limited only to traditional transportation topics, but extending to issues in energy, technology, urban planning, society/culture, ethics, and the environment. The results of the present study highlight shortcomings in this respect in many sampled published transport scenario narratives. Specifically, by considering transport primarily, at the expense of other disciplinary insights, some important issues had been neglected. Several such issues are prominent. First, the importance of energy system innovations for future transport electrification (see Section 4.4). Many of the transport scenario narratives treated electrification (especially private vehicle electrification) almost as a proxy for road transport sustainability, rather than adequately addressing related issues of importance, such as energy system dependencies, infrastructural constraints, or the wider political economy of transition (Holden et al. 2021; Hopkins et al. 2023; Sharmina et al. 2025). Second, sampled transport scenario narratives that used substantial shifts in values, norms, and public

Table 5
Quality Criteria for Transport Scenario Planning with Narratives

Criterion	Potential Action	Example(s)
Variety of Trends	Interdisciplinarity/Inclusion	Consider energy system futures when scenarios involve net zero transportation. ⁽¹⁾ Utilise a diversity of expert and/or stakeholder evidence. ⁽²⁾
	Scenario narrative review/synthesis	Present study. ⁽³⁾
Order Effects	Consider evidence/theory	For modal shift scenarios, reflect on cases studies of successful modal shift. ⁽⁴⁾ For market-driven scenarios, apply both economic and sociological perspectives. ⁽⁵⁾
	Balance uncertainties	For attitude/value-driven scenarios, how far might existing psychological explanations of attitude/value change help to elaborate contrasting scenario narratives? ⁽⁶⁾
Consistency	Additional analysis steps	Use the group task of dialectical (“devil’s advocate”) reasoning to enhance analysis/development. ⁽⁷⁾
	Converging techniques	Derive synergy from both quantitative and qualitative techniques in scenario planning. ⁽⁸⁾
	Empirical validation	Use survey or choice experiment methods to validate the behavioural assumptions of scenarios. ⁽⁹⁾

Notes. (1) See §4.4, para. 2-3, pp. 42-43; (2) See §4.2, para 4 and 6, p.13-14, see also §2.2; (3) see also Sovacool et al. (2020) and Miskolczi et al. (2021); (4) see §4.2, para. 6, p.36; (5) see §4.2, para. 4, p.34; (6) see §4.3, para. 3, pp. 38-39; (7) see Wright et al. (2013); (8) discussed in §2.2.3, see also Rohr and Batley (2026); (9) see §4.4, para. 9, pp. 47-48.

preferences (e.g., towards being more responsible or more enlightened) to defined alternative scenarios often did so without substantial consideration of mechanisms through which such shifts might occur (see Section 4.3); here, they might have benefited from consideration of evaluative criteria from psycho-social theory (Maio and Haddock 2007; Thøgersen et al. 2021). Third it was noted (Section 4.3) that sampled transport scenario narratives might contrast futures with ‘dense’ and ‘sprawling’ urban form trajectories, though the external trends and policy levers for these urban trends (Patterson et al. 2021; Mouratidis 2024) were less often considered, despite these features being necessary for plausible trajectories that have both causal depth and policy specificity.

Many sampled published transport scenario narratives (even ostensibly plausible ones) lacked sufficient critical insight for verisimilitude whereas others (even ostensibly far-fetched ones) displayed such insights through interdisciplinarity (e.g., Papa and Ferreira 2018), such as those generating scenario narratives with complex or mixed outcomes reflective of a variety of considerations (e.g., Sadatsafavi et al. 2017; Enoch and Potter 2023; Raoofi et al. 2023). In Section 2.2., the roles of expert and participant were contrasted both in the context of scenario planning practice and in issues of equity in the transport planning process, and it is important to consider that a tradition in *forecasting* transport futures that rests upon expert consensus (in the absence of objective data) may sometimes overshadow the importance of interpreting this opinion data to produce effective scenarios in *scenario planning*. More concretely, stakeholder engagement limited to transport experts may tend to reflect too narrow or conventional a pool of opinion (e.g., experts and insiders); in scenario planning, value is placed on perspectives and opinions that are diverse and unconventional (Schwartz 1998; Andersen et al. 2021); a useful corrective may be to employ qualitative analysis techniques to understand expert opinion (Morton et al. 2017).

Another evident mark of quality in sampled published scenario narratives is that “order effects” (Curnin et al. 2025) have been considered, hence scenario narratives provide a sequential account of the interaction between trends. Sampled published transport scenario narratives do not typically cite empirical evidence or theory when communicating trends; traditionally, these are not part of a thesis but are informed by practitioner intuitions and experience concerning the phenomenon in question (Wack 1985b; Schwartz 1998; Ogilvy 2005; Andersen et al. 2021), which raises the question of how best to validate these insights. Sometimes they are validated explicitly: several of the scenario planning projects reviewed explicitly drew upon a single schematic framework to validate/enhance their scenario planning, such as social practice theory (Camilleri et al. 2022) or the socio-technical transitions model (Marletto 2019). What is more concerning is when transport scenario narrative content suggests implicit use of existing theories/ideas as intuitions without also considering the theoretical basis of these ideas. Hence, an intuition, about ‘how the world works’, may implicitly reflect a single theory or perspective at the expense of other potentially valid perspectives or theories. Two concrete examples are the differing ways in which the market theme manifests in published sampled transport scenario narratives (§4.2) and the employment of sustainability paradigms in societal aspects of these scenario narratives (§4.3), indicative of differing explanatory schemata. This is less about even-handed scholarship than the danger of relying upon prevalent dogma or misconception (Sovacool et al. 2020). It is important to reflect (see Section 1) that the deeper uncertainty that confounds long-range forecasting is partly due to such human cognitive heuristics and biases as these (Schoemaker 2004; Goodwin and Wright 2010) – they can also bias scenario planning if advice concerning critical thinking is not applied conscientiously and with reflexivity (Goodwin and Wright 2025), with idealistic or utopian scenarios perhaps arising from the same tendency as over-optimistic forecasts (Wright and Goodwin 2009; Sovacool et al. 2020).

Two related issues are, following the identification of crucial scenario-defining uncertainties, adopting the position that these are, therefore, inherently uncertain, without investigating to try to understand the source of the uncertainty, or failing to consider antecedents conditions such as facilitators and barriers. Steinmüller (2018) describes something similar in contrasting scenario narratives where antecedent events are integral to the scenario storyline with those where antecedents are invented as relatively contrived plot devices. A key example identified in this study was the lack of scrutiny given to how social attitudes change (§4.3), often assuming that this was inherently uncertain. Another was casting policies as a key trend in modal shift without contemplating their success criteria. While some scenario projects did focus on prohibitive costs (§ 4.2), factors in success and failure were worthy of broader and deeper consideration. As a concrete suggestion for enhanced investigation, future scenario planning around policy for modal shift would profit from investigating the few past precedents for this trend – and their antecedents and limitations – such as establishment of cycling culture in the Netherlands, Denmark and Germany (Pucher and Buehler 2008) or bus rapid transit in Latin American (Lindau et al. 2010), as well as different theoretical accounts of enablers and barriers of transport policy adoption (e.g., Feitelson and Salomon 2004).

Quality criteria for scenarios identify consistency (Curnin et al. 2025): that scenario narratives should be logical. With multiple trends to factor, inconsistency is a potential risk of increasing the depth and plausibility of scenario narratives. Avoiding such elaborations circumvents this problem, and is also potentially more agile, hence beneficial in rapidly changing environments, and scenario ideas alone may be sufficient for some clients/users. However, if the scenario narratives are to stand alone and to have utility for a variety of users in different contexts (e.g., across organisations or departments), then an alternative approach is to build enhancement steps into the scenario planning process. This may involve drawing upon tools from different “toolboxes”, such as approaching scenario planning through the lens of the historian (Bradfield et al. 2016) or using the techniques of the experimentalist to verify trends empirically, such as preferences concerning future policies or technologies (e.g., Potoglou et al. 2020). Alternatively, this may involve employing different modes of thinking in structured exercises during scenario planning, such as introducing a step of dialectic (i.e., critical) thinking (Wright et al. 2013). Drawing from different toolboxes can also involve using converging techniques to verify consistency in scenario narratives. One approach used relatively frequently in transport scenario planning is employing both quantitative and qualitative approaches, and this is considered in Section 5.1.

5.1. Convergent Scenario Planning through Modelling

Studies differed in use of quantitative methods, sometimes using these in scenario generation or presentation (e.g., Zhao et al. 2021; Kiviluoto et al. 2022) and others utilised scenarios in subsequent quantitative research (Venturini et al. 2019; Knaap et al. 2020; Dillman et al. 2021; Lempert et al. 2021). In transportation, mixed methods scenario planning is not uncommon (Bartholomew et al. 2010; UK Department for Transport 2025). It also shows the potential for synergy (Goodwin and Wright 2025; Rohr and Batley 2026). Scenario planning provides ideas beyond the sufficient explanations of short-term trends afforded through deterministic modelling. Here, there is an important distinction between recognising that some variables (e.g., value of time) may be perennially important, but that their distributions may become uncertain in the long-run, as the landscape of transport changes, and that some variables may become important but have yet to be explored through modelling due to their present uncertainty. While narrative scenarios tend to be more engaging (Goodwin and Wright 2025), scenarios described quantitatively may engage groups of professionals that traditionally utilise quantitative data (Brömmelstroet et al. 2017).

Additional opportunities may be afforded by trying other mixed methods designs (Fetters et al. 2013). A potential challenge is less the interface between quantitative and qualitative elements than the more subtle problem of the limitation of the set of possibilities (see Figs. 1 and 3) to those for which there is sufficient data or modelling precedent, thus mixed approaches may be more suited to mapping what is plausible than what is possible, though utilising quantitative techniques, such as manipulating proxy or mediating variables, may suffice. However, quantitative modelling also has the potential to draw out the consequences or implications of scenario ideas, enriching narratives, such as through estimating future trends in carbon emissions arising from particular policy packages. There may also be utility for developing the means to more readily extract narrative information into inputs for quantitative modelling as well as quantified (data) comparisons between scenarios (Colin et al. 2024).

5.2. Limitations

Scenario planning can be a research activity, and the analysis and qualitative synthesis of sampled published transport scenario narratives maps prevalent foresights of future transport of value to transport researchers. This approach also offers opportunities for improving current scenario planning practices in the discipline. However, several limitations (and, hence, future opportunities for research) are notable. First, through practical constraints, scenario-sampling was not systematic, as manifest in uneven representation across geographical regions; a systematic qualitative meta-analysis might yield additional insights and potentially address a wider variety of topics and perspectives. Second, this review focused particularly upon scenario narratives; these are the most important elements of a scenario planning study, however additional insights are available through analysis/synthesis of other data, like drivers/trends from investigative stages. Similarly, this research explored sampled published transport scenario narratives across a broad range of methodological traditions and written to meet different objectives, which was beneficial in producing a diverse set of exploratory insights, but the cost of this flexibility is that some results may reflect differences in methodologies or objectives between studies as much as underlying differences of opinion or evidence, distinctions that subsequent systematic review could disambiguate, at the cost of exploratory flexibility. Hence, the three-theme structure, while neat and useful, can flatten regional and methodological differences between scenarios. Moreover, a focus upon transport scenario narratives leaves open the question of scenario transfer (see Fig. 2), and how best to utilise final scenarios, such as which scenarios are most effective in different settings (Wack 1985a). Third, the approach taken to thematic analysis was realist and focused upon what was manifest (Braun and Clarke 2006) but more interpretive approaches may offer further insights into latent aspects (Steinmüller 2018); our use of thematic synthesis goes some way to making some latent aspects manifest, but a sustained analysis of latent themes could develop the insights provided in this article further. Finally, causal information cannot be reliably inferred from the data and methods in this study; causal inferences warrant verification.

6. Conclusion

Transportation is presently unsustainable, beset by problems such as traffic congestion, inequity and injustice, negative health risks, environmental degradation, and contributions to global climate change (Sultana et al. 2019). The future sustainability of transport is inherently unknowable, but may be anticipated by engaging with uncertainty and contemplating different potential scenarios (Cordova-Pozo and Rouwette 2023). Here, a critical synthesis of a sample of contemporary published transport scenario narratives with respect to sustainability is reported and is discussed with respect to scenario quality. It was found that transport scenario narratives have an important role in contemporary transport analysis as a means of addressing critical uncertainties, particularly around sustainability and climate change, but that this has not always been the practice, and there remains a strong emphasis upon forecasting and modelling, with often mixed method approaches adopted. Contemporary sampled published transport scenario narratives sampled were found to encompass a broad thematic map of key ideas, including aspects of modal change, societal forces, and innovations, providing a rich source of insight into future transportation trajectories. However, tendencies were also identified towards strong transportation focus (rather than interdisciplinary or critical development) in handling the trends that “flesh out” scenario narratives, for which we have made some initial recommendations. Further work is recommended to establish the efficacy of these recommendations (or other promising techniques) in practice, for generating improved scenario narratives from scenario planning.

CRedit authorship contribution statement

Paul Hagggar: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Omer Rana:** Writing – review & editing, Project administration, Funding acquisition. **Jonathan Radcliffe:** Writing – review & editing, Project administration, Funding acquisition. **Ashish Sharma:** Writing – review & editing, Project administration, Funding acquisition. **Dimitris Potoglou:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

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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.

Appendix A

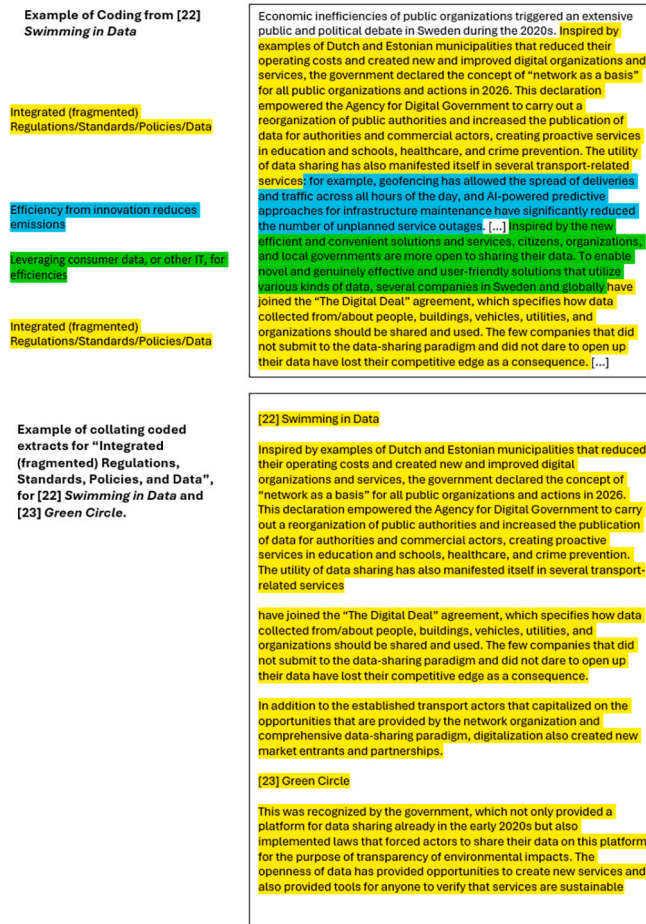


Fig. A1. Illustration of coding and collation of coded data during phase 2 of thematic analysis, limited to scenarios 22 and 23 (Pernestål et al. 2021; Raoofi et al. 2023) and focusing on the code "Integrated (fragmented) Regulations/Standards/Policies/Data".

Table A1
Transport Scenarios from Scenario Planning Literature.

Source(s)	Context	Scenario	Scenario Title
Filippi (2024)	None	1	Automobility City
		2	Multimobility City
		3	Accessible City
Plazier et al. (2024)	BE, NL, DE	4	The old wild west
		5	The new wild west
		6	New cool collective
		7	Revolution by design
		8	Thriving, individually
		9	Good intentions abound
Paddeu and Lyons (2024)	Europe	10	Too Slowly Greener
		11	Uneconomically Net-Zero
		12	In a Fix
		13	Bye Bye Car
		14	Happy Green Dispersal
		15	Tech Innovation Bonanza
Lazzarini et al. (2023)	ES	16	Continuity
		17	Lost opportunity
		18	World of contradictions
Pernestål et al. (2021); Raoofi et al. (2023)	SE	19	Base Scenario
		20	Partnership Society
		21	Social Engineering 2.0
		22	Swimming in Data
		23	Green Circle
Tori et al. (2023b)	BE	24	United Greater Brussels
		25	Maxi-Freedom
		26	All of Brussels on four wheels
Tori et al. (2023a)	BE	27	Hyper-Proximity
		28	Valencia Smart City
Dixon et al. (2023)	KE	29	Riding through the recession
		30	COVID-19: The aftermath
		31	Kuijinauo ("Know yourself")
		32	Omoka ("Growth")
		33	Fuliza ("Debt")
Acheampong et al. (2023)	UK, AU	34	Wash-Wash ("Money bag")
		35	Full Public Ownership: Manchester
		36	Public Transport Partnerships, Manchester
		37	Everything is on the Table, Melbourne
Sunitiyoso et al. (2023)	ID	38	The future is public transport and sharing †
		39	one seamless ecosystem
		40	the culture of public transportation
		41	the exclusive green community
Enoch and Potter (2023)	None	42	social dilemma; public versus private †
		43	Consolidated market; consolidated services †
		44	Consolidated market; fragmented services †
		45	Fragmented market; consolidated services †
Kiviluoto et al. (2022)	FI	46	Fragmented market; fragmented services †
		47	The Demise of Bus-Transport
		48	The Era of Soft Modes
		49	Public Transport Serving All
		50	Car-dependent Lifestyles Persist
Gerdri et al. (2022)	TH	51	Also "Business as Usual Plus"
		52	Struggling
		53	Frustrating
		54	Growth and Sustain
Camilleri et al. (2022)	MT	55	Unbalancing
		56	High-Tech Mobility
		57	Local Mobility
Miskolczi et al. (2021)	None	58	Green and Active Mobility
		59	Grumpy Old Transport
		60	At an Easy Pace
		61	[What's] mine is Yours
Zhao et al. (2021)	SE	62	Tech-Eagre Mobility
		63	Private vehicle addiction ^a
		64	The rise of private shared services
		65	MaaS trends win over policies
Sikazwe et al. (2021)	ZM	66	MaaS wins over the masses
		67	Railway freight status quo
		68	Railway Freight natural growth

(continued on next page)

Table A1 (continued)

Source(s)	Context	Scenario	Scenario Title
Lempert et al. (2021)	US	69	Railway freight future growth
		70	Railway freight paradise
		71	Mobility For All
		72	Mobility in Transition
Ariza-Álvarez et al. (2021)	ES	73	Fragmented Mobility
		74	Non-motorized city centres
		75	Overpopulation
		76	High levels of insecurity in urban areas
Dillman et al. (2021)	IS	77	Urban structural change & Lifestyle change
		78	Technological Change
		79	Integrated Approach
		80	Business As Usual
Neef et al. (2020)	NL	81	Worst Case Scenario
		82	Radical Change
		83	The Infraconomy Revolution
		84	The Techno-Pessimism Revolution
		85	The Safety Revolution
		86	The Technological Revolution
		87	The Missed Boat Revolution
		88	The Hyperloop Revolution
Chen et al. (2020)	CN	89	The Green Revolution
		90	Optimal for the country
		91	Optimal for renewable industry
		92	Positive cycle
		93	Policy-based dependence
		94	Take things as they are
		95	Low Mobility Societies
Holden et al. (2020)	None	96	Collective Transport 2.0
		97	Electromobility
		98	The green government
		99	The green purchaser
		100	The clean vehicle
		101	The public transport provider
		102	The responsible traveller
		103	The shared mobility schemes
		104	The compact city
		105	The essential life
Enoch et al. (2020)	NZ	106	The travelling electrons
		107	Shared Shuttles
		108	Connected Corridors
		109	Mobility Market
Köhler et al. (2020)	NL	110	Personalised Pods
		111	Technological substitution to BEVs
		112	Reconfiguration pathway to a new public transport regime in the Netherlands
		113	Dominance of local mobility: an alternative reconfiguration pathway
González-González et al. (2020)	None	114	The hyper-mobile city
		115	The liveable shared city
		116	The unlimited individualistic city
		117	The restricted individualistic city
Knaap et al. (2020)	USA	118	Revenge of the Nerds
		119	Free for All
		120	Blue Planet
		121	Last Call at the Oasis
Keseru et al. (2019)	EU	122	Data World
		123	Digital Nomads
		124	Slow is Beautiful
		125	Minimum Carbon
UK Government Office for Science (2019)	UK	126	Trends Unmodified
		127	Individual Freedoms
		128	Greener Communities
		129	Technology Unleashed
Venturini et al. (2019)	DK	130	Hi-tech, Hi-Reg
		131	Urban Hippie
		132	Urban Electrification
		133	Green Individuals Alone
		134	Policy and Consumer Driven
		135	No Leadership - Market Delivers
Zahraei et al. (2019)	SG	136	Last Minute Action 2050
		137	Shared World
		138	Virtual World

(continued on next page)

Table A1 (continued)

Source(s)	Context	Scenario	Scenario Title
Marletto (2019)	None	139	Individual
		140	Shared
		141	Smart
Idriss-Yahya (2018)	GH	142	East Legon (a free market world)
		143	Trasacco Valley: (A Heavily-regulated World)
		144	McCarthy Hill (Self Reliance, Local Identities)†
		145	Nima-Mamobi (Disparity, Inequality) †
Papa and Ferreira (2018)	None	146	The Optimistic Scenario
		147	The Pessimistic Scenario
		148	Lower Carbon Emissions
Soria-Lara and Banister (2017)	ES	149	Technological Innovation
		150	Urban Compactness
		151	Environment Focused
Perveen et al. (2017)	AU	152	Economy Focused
		153	Balanced
		154	Back to the Future
Sadatsafavi et al. (2017)	US	155	Government Redux
		156	Bits over Buses
		157	Many Ways to Go
		158	Baseline Scenario (Managed Decline)
		159	Escape to the Centres
		160	Meltdown
		161	Havana Gridlock
Blanco and Moudon (2017)	CU	162	Urban Removal
		163	Community-based IT Empowered Mobility
		164	Leapfrog Scenario: Sustainable Urban Mobility Powered by Renewables
Kane and Whitehead (2017)	None	165	Electrification, AVs and density †
		166	AVs, density and sharing †
		167	Electrification, density and sharing †
		168	Electrification, AVs and sharing †
		169	Electrification, AVs, density and sharing †
Milakis et al. (2017)	NL	170	Automated vehicles ...in stand by
		171	Automated vehicles ...in bloom
		172	Automated vehicles ...in demand
		173	Automated vehicles ...in doubt

Note: AU = Australia, BE = Belgium, CN = China, CU = Cuba, DE = Germany, DK = Denmark, ES = Spain, EU = European Union, FI = Finland, GH = Ghana, HU = Hungary, ID = Indonesia, IL = Israel, IS = Iceland, IT = Italy, KE = Kenya, MT = Malta, NL = Netherlands, NZ = New Zealand, PL = Poland, SE = Sweden, SG = Singapore, TH = Thailand, UK = United Kingdom, US = United States of America, ZM = Zambia.

† Scenario name shortened for ease of presentation.

a This scenario also appears as “the addition of private vehicles”.

Data availability

No data was used for the research described in the article.

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