



Re-thinking the role of exploratory scenarios for adaptive policymaking: An application for land use and transport planning

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ABSTRACT

While scenario-building has proven useful in situations marked by considerable uncertainty in the context of land use and transport policymaking, additional research is needed to develop adaptive and dynamic scenario-building schemes. To address this gap, the present paper conceptualises an adaptive scenario-building approach that would facilitate adaptive policy responses by using exploratory scenarios as intermediate tipping points. An empirical research design is also conducted following a participatory approach, with a case study of the Henares Corridor in the Metropolitan Area of Madrid, Spain. Three exploratory scenarios are assessed as experimental tipping points for the basic policy pathways initially adopted by regional and local governments. The use of such tipping points suggested different adaptive policy responses: (i) preserving policy responses when exploratory scenarios are strongly aligned with the basic pathways; and (ii) transforming policy responses when significant deviations are perceived between the exploratory scenarios and the basic pathways. The paper also discusses the real-life application potential of this adaptive scenario-building approach, further research steps, and future horizons for scenario-building.

1. Introduction

The future of cities and transport systems is now – more than ever – shaped by disruptive events with low predictability, which trigger dynamic responses and social change (Marchau et al., 2019; Lyons & Marsden, 2021). For example, the ongoing COVID-19 outbreak shapes urban planners' perceptions of the future as deeply uncertain, where any predictions are strongly contested (Batty, 2020). In this highly dynamic context, supporting policymaking processes that effectively address Land Use and Transport integration (LUTI) is crucial for achieving sustainable outcomes (Banister, 2005; Bertolini, 2017; Ariza-Álvarez et al., 2021). However, achieving this goal demands high flexibility and adaptability among policymakers, to be able to cope with unexpected futures marked by turbulences (Van Dorsser et al., 2018, 2020; Walker et al., 2010; Soria-Lara et al., 2021; Van Druenen et al., 2011). Such approaches may result in alternative policymaking schemes based on interaction and learning processes between stakeholders and institutions,

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just-in-time mechanisms for monitoring planning outcomes, and, most innovatively, adaptive LUTI policy pathways.

The field of future studies provides planning actors with a set of social science methods to consider future outlooks under situations of high complexity and uncertainty (Åkerman & Höjer, 2006; Banister et al., 2000; Lyons & Davidson, 2016; Vergragt & Quist, 2011; Hickman & Banister, 2014). It can be identified three main types of scenario-building studies that illustrate alternative ways of thinking about the future (Amara, 1981; Bøjerson et al., 2006; Vergragt & Quist, 2011): (i) predictive scenarios, based on foreseeing the most probable futures; (ii) normative scenarios, orientated towards searching and achieving a desired future; (iii) exploratory scenarios, which examine plausible futures to cover a wide scope of possible future situations. In the view of this paper, the nature of exploratory scenarios is particularly of interest for the development of robust policies that survive to various external future developments, becoming a promising basis for transforming traditional policymaking into an adaptive scheme.

To cope with the complexity and dynamism of cities and transport systems, previous studies have constructed multiple and simultaneous exploratory scenarios for a limited set of possible or plausible long-term contexts (Tuominen et al., 2014; Liimatainen et al., 2014; Varho & Tapio, 2013; Soria-Lara et al., 2021). The predominant approach sees such futures as long-term endpoints, which are ultimately connected to the present situation through separated policy pathways following a static and just-in-case policymaking scheme (Höjer et al., 2011; Olsson et al., 2015; Soria-Lara & Banister, 2018; Hickman et al., 2011; Zimmermann et al., 2012). These pathways are only activated if there is a clear intention to achieve the expected outcomes from a specific future state, usually seen as the most appropriate one (Keseru et al., 2021; Soria-Lara & Banister, 2018; Hickman et al., 2013). This approach strongly limits the ability of scenario-building methods to adapt the established policy pathways to changing situations and unexpected futures (Walker et al., 2001, 2010, 2013; Kwakkelis et al., 2010). A research gap exists to examine how scenarios could be used for activating adaptive policymaking processes (Zapata & Kaza, 2015; Chakraborty et al., 2011; Hallegatte, 2009). Moreover, the present research seeks to address this gap by re-thinking the role of exploratory scenarios for considering an alternative paradigm that can trigger adaptive policy responses.

Specifically, this paper aims to explore the following research question: *to what extent it is possible to obtain different adaptive policy responses using exploratory scenarios as intermediate tipping point, rather than using them as independent long-term future endpoints?* First, a theoretical framework for an adaptive scenario-building approach has been conceptualised, transferring traditional concepts from adaptive policymaking to scenario-building methods (Walker et al., 2010; Marchau et al., 2010). Under this framework, exploratory scenarios are proposed as intermediate tipping points, identifying situations in which the adopted policy pathways might fail in achieving strategic goals and suggesting different potential policy responses. Second, a total of 25 experts were used to assess the capacity of such intermediate tipping points for resulting in a variety of policy responses for LUTI planning. The context of the Henares Corridor in the Metropolitan area of Madrid, Spain provides the empirical focus.

The paper continues by discussing the theoretical framework for an adaptive scenario approach in the next section. Further, Section 3 shows the empirical research design, while Section 4 details the main results. Finally, Section 5 closes with concluding remarks on the proposed framework, its implementability, research design validity, and further research developments.

2. Moving from static to adaptive scenario building

2.1. The static approach: scenarios as long-term endpoints

Despite the bounded rationality inherent in planning (Chermack, 2004; Van Drunen et al., 2011), future studies have made significant progress in creating multiple scenarios combining desired and plausible long-term endpoints that cover the widest range of future outlooks (Liimatainen et al., 2014; Von Der Gracht & Darkow, 2016; Soria-Lara et al., 2021). Following a static scheme, such endpoints will be reached through separate and specific policy pathways (Höjer et al., 2011; Olsson et al., 2015; Soria-Lara & Banister, 2017b; Hickman et al., 2011) (Fig. 1). The designed policy pathways are only activated if there is a clear objective to reach the outcomes of a specific desired future after appraisal processes (Keseru et al., 2021). The selected future and pathway would be eventually adopted, while the remaining possible futures and policy pathways are no longer used. This static approach strongly limits the ability of scenario-building methods to change or adapt policy pathways over time, reducing the chances to implement a robust policymaking process for complex, dynamic, and highly uncertain future contexts.

Multiple examples following the static scenario approach can be found in academic literature (Liimatainen et al., 2014; Varho & Tapio, 2013; Höjer et al., 2011). For example, Tuominen et al. (2014) create eight radically different 2050 scenarios to address CO₂ transport emissions in Finland. For each scenario, a separate policy pathway is designed, without a comprehensive consideration of all possible futures and their respective pathways. Similarly, Hickman et al. (2011) and Banister and Hickman (2013) develop a

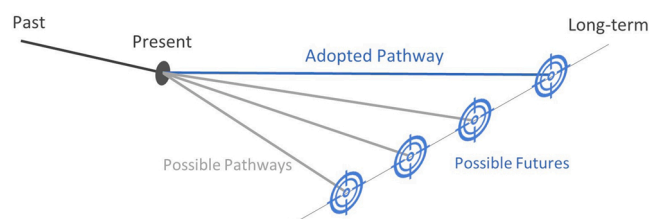


Fig. 1. Traditional scenario-building schemes: a static approach.

business-as-usual baseline and alternative scenarios for the UK and India. For each scenario, single policies are listed and grouped into packages and separate paths without considering potential options for adaptive schemes. Another example comes from [Shifftan et al. \(2003\)](#), who design two separate policy pathways, respectively based on likely and desired policies to reach two different futures in Tel Aviv Metropolitan Area, Israel. [Olsson et al. \(2015\)](#) also construct two future scenarios for a post-fossil fuels road transport system in Stockholm, and then, two different just-in-case policy pathways linking the present with each scenario. [Soria-Lara and Banister \(2017a\)](#) develop three policy pathways to reach a desired transport future for Andalusia, Spain. Although the three individual pathways are integrated in a single pathway, the system cannot evolve and be adaptive to future uncertainties. [González-González et al. \(2020\)](#) propose single policies grouped into large packages to reach a driverless transport scenario as future endpoint. Again, a static framework prevails against other possible adaptive approaches.

Although the focus of this research is mainly on land use and transport sectors, static scenario approaches are also found in adjacent fields: energy efficiency ([Kishita et al., 2017](#); [Svenfelt et al., 2011](#)), economic development ([Nikolakis, 2020](#)), sustainable lifestyles ([Neuvonen et al., 2014](#)), and water management ([Kok et al., 2011](#)).

2.2. The adaptive approach: exploratory scenarios as intermediate tipping points

Previous research on adaptive policymaking and dynamic adaptive planning is seen as useful for overcoming the static scenario approach ([Walker et al., 2001; 2010](#); [Kwakkel et al., 2010](#); [Swanson et al., 2010](#)). Adaptive policymaking has been used in several fields, including transport ([Marchau, Walker, & van Duin, 2008](#); [Marchau et al., 2010](#); [Agusdinata et al., 2007](#); [Rahman et al., 2008](#); [Wall et al., 2015](#)). It ideally establishes that policy pathways should incorporate the ability to adapt dynamically to a rapidly changing world, in which static policymaking approaches are likely to fail ([Kwakkel et al., 2010](#); [Walker et al., 2013](#)). The basis of adaptive policymaking is the adoption of a basic policy pathway, together with the identification of both the vulnerabilities and opportunities of that path. A monitoring system is activated and tipping points are defined, determining the conditions under which the basic policy pathway no longer meets its specified goals. When one tipping point reaches predetermined critical levels, a series of adaptive pathways are implemented, ensuring that the basic pathway stays on track to reach the desired planning goals. Both tipping points and adaptive pathways consider the timing of actions explicitly in their approach ([Walker et al., 2013](#)).

This research proposes to transfer the concept of tipping points and adaptive pathways to scenario-building methods, providing a new theoretical framework that would offer more robustness and adaptability to policymaking in highly uncertain futures. This adaptive scenario approach proposes to simultaneously use exploratory scenarios as intermediate tipping points, activating possibilities to adopt alternative policy responses when necessary. The process would follow several steps ([Fig. 2](#)):

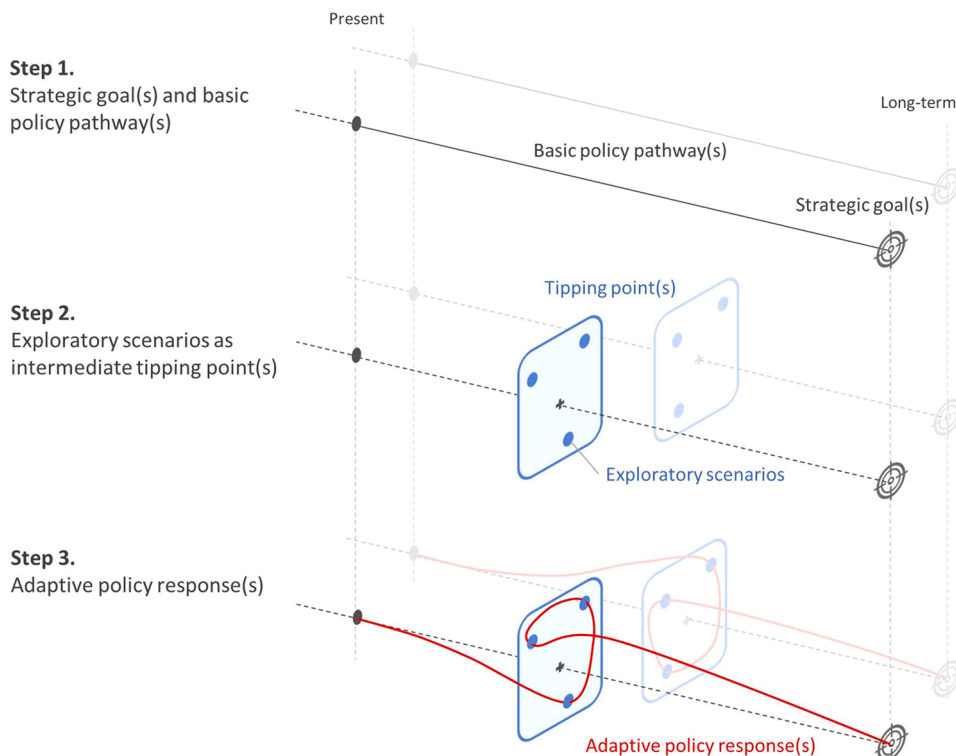


Fig. 2. The process for an adaptive scenario-building approach.

- **Step 1: strategic goal(s) and basic policy pathway(s).** One or several strategic goals would be established for the long-term. These goals would illustrate “universal values” in pursuit of e.g., social, economic, and environmental sustainability (e.g., reduction of car dependency, abolition of social inequality). For reaching each strategic goal, a basic policy pathway would be designed. Such basic pathways would be initially conceived with no consideration of potential disruptive events that can alter the system(s) significantly.
- **Step 2: exploratory scenarios as intermediate tipping point(s).** In a second step, mid-term exploratory scenarios would be elaborated. These scenarios would explore plausible intermediate situations, developments or turning points that may originate an impact in the system(s) (e.g., overpopulation, social conflicts). In particular, exploratory scenarios would conform one or several tipping points that inform policymaking by identifying potential situations in which a basic pathway would fail or succeed.
- **Step 3: adaptive policy response(s).** In a third step, the use of exploratory scenarios as tipping point(s) would result in determining the policy response needed to ensure that a specific strategic goal can be finally reached. This policy response would adjust or significantly modify the basic pathway to adapt the system(s) against deviations.

Two main types of policy responses could be activated by intermediate tipping points: *preserving* and *transforming* (Fig. 3). *Preserving policy responses* would result from tipping points in which non-significant deviations are seen between the basic pathway(s) and the content of exploratory scenarios. Only minor readjustments to the basic pathway would be necessary over time. Such readjustments rely on smooth and incremental actions, as radical changes would not be necessary to finally achieve a specific strategic goal. On the contrary, *transforming policy responses* would result from tipping points in which significant deviations between the basic pathway(s) and exploratory scenarios are identified. Major modifications to the basic pathway are necessary over time, including changes in planning assumptions and models. Different types of actions can be distinguished within the context of transforming policy responses. On the one hand, such transforming responses could be *outcomes-oriented* when deviations are perceived between the expected outcomes from the basic policy pathway and the content of exploratory scenarios. Then, *mitigating actions* to avoid possible vulnerabilities are necessary and/or *seizing actions* that take advantage of possible opportunities (Fig. 3). On the other hand, transforming responses could be *priority-oriented* when deviations are perceived between the basic policy pathway and the exploratory scenarios for prioritizing the achievement of certain strategic goals. Then, *recovery actions* to guard against the possibility of underprioritizing the achievement of a strategic goal can be necessary and/or *boosting actions* to harness overprioritizing situations. It must be considered that both outcomes and priority-oriented policies are not exclusive, but they can simultaneously coexist.

3. Research design

An empirical research design has been used to explore potential answers to the main objective of this paper, namely the analysis of the possibilities of obtaining different adaptive policy responses through the use of exploratory scenarios as intermediate tipping points. The Henares Corridor, located in the eastern part of the Metropolitan Area of Madrid, Spain serves as case study (Fig. 4). It expands approximately 50 km and consists of 11 municipalities reaching more than 400,000 inhabitants (Instituto Nacional de Estadística, 2020). The Henares Corridor is a highly industrialized region, hosting substantial economic and productive activity, which has led to strong demographic, urban, and transport developments during the past decades (Barreira-González et al., 2019; Cantergiani & Gómez Delgado, 2018). The complexity and dynamism of the region makes its future highly uncertain, being an appropriate location for evaluating the possibilities of an adaptive scenario approach. Achieving high levels of LUTI – supportive interconnections between land use development and transport systems – is also seen as crucial for both local and regional authorities. In this respect, most of policy actions adopted pursuit the mentioned LUTI as a priority aspect (e.g. reduction of car transit in city centres).

The methodological design implemented in this research follows the three steps previously detailed for implementing an adaptive scenario-building approach (Section 2.2): (i) strategic goal(s) and basic policy pathway(s); (ii) exploratory scenarios as intermediate tipping points; (iii) adaptive policy responses. The reminder of this Section details each step.

3.1. Step 1: strategic goal(s) and basic policy pathway(s)

A review of local and regional strategies, aimed at addressing the main LUTI planning challenges (e.g., GHG emissions, urban

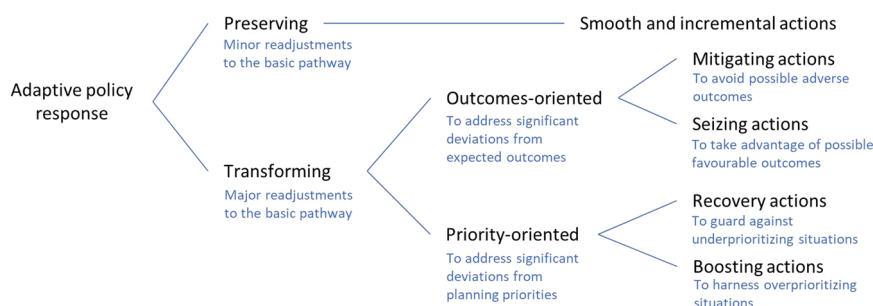


Fig. 3. Types of adaptive policy response.

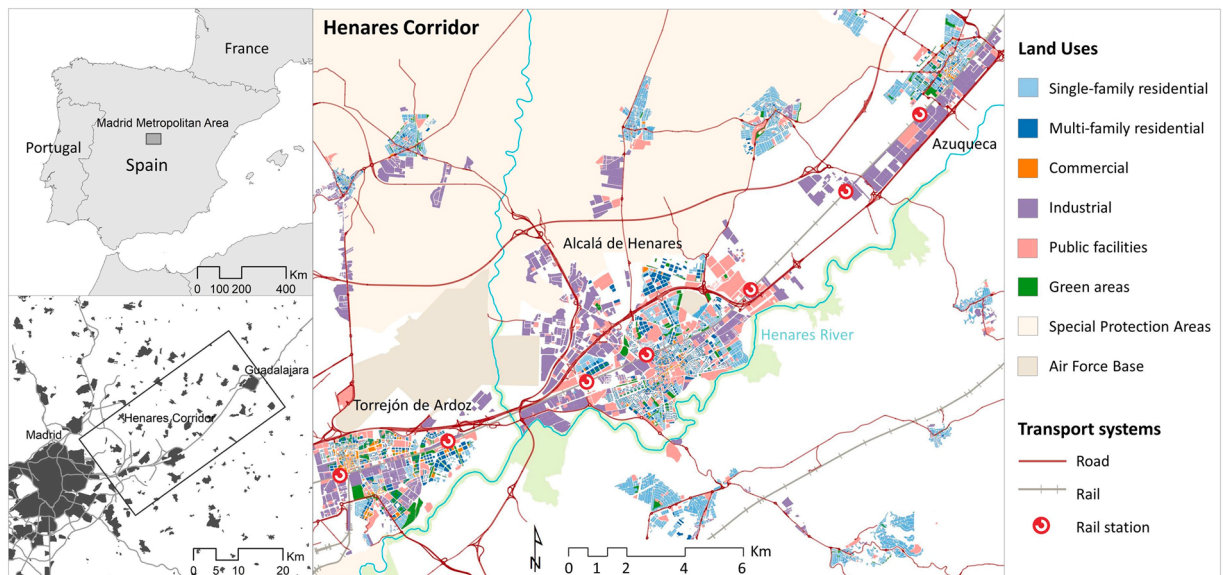


Fig. 4. Case study location.

sprawl, social inequalities, or degradation of natural ecosystems), has been conducted. In particular, a total of five long-term strategic goals for LUTI integration have been identified in the Henares Corridor: (i) spatial equity; (ii) urban compactness; (iii) transport multimodality; (iv) biodiversity and ecosystem integration; (v) urban environmental quality. To achieve these strategic goals, local and regional authorities have adopted a set of five basic policy pathways:

- **Basic pathway 1.** This pathway aims to achieve the strategic goal of *spatial equity*, which consists of an equitable location/distribution of urban land uses and transport systems for everyone. The basic policy pathway is based on regional and local strategies, focused on promoting physical, economic, and social regeneration of urban areas (e.g., achieving affordable housing prices and encouraging commercial revitalization) (Comunidad de Madrid, 2016; Ayuntamiento de Alcalá de Henares, 2014). Additionally, the regional mobility plan (Consortio Regional de Transportes de Madrid, 2013) promotes equitable and easier access for the general population and vulnerable groups to major destinations (e.g., decreasing distances to collective transport stations and providing aids for low-income populations).
- **Basic pathway 2.** This pathway seeks to achieve the strategic goal of *urban compactness*, fostering compact urban development, as a contribution to decreasing car dependency. The basic policy pathway is mainly based on regulatory and local policies seeking to prevent urban sprawl. In addition, municipalities are also implementing urban renewal policies (e.g., new public facilities in suburban areas) (Ayuntamiento de Alcalá de Henares, 2018; Ayuntamiento de Torrejón de Ardoz, 2013).
- **Basic pathway 3.** This pathway aims to address the strategic goal of *transport multimodality*, through enhancing the connectivity and complementarity of transport systems and networks. The basic policy pathway focuses on the regional transportation strategy (Consortio Regional de Transportes de Madrid, 2013), including a wide range of LUTI policies (e.g., new public transport services connecting recent urban developments, multi-modal transport hubs, and bus corridors). Improvements to the pedestrian and cycling network are also planned.
- **Basic pathway 4.** This pathway aims to reach the strategic goal of *biodiversity and ecosystems integration*. It shows the intention to achieve an effective integration of urban areas into the surrounding ecosystems, protecting and enhancing local biodiversity. The regional government has adopted a set of actions based on nature-based solutions for urban and peri-urban areas, providing relevant ecosystem services across the case study (Comunidad de Madrid, 2011, 2020a). The key policy is the implementation of a green infrastructure system (Comunidad de Madrid, 2020b).
- **Basic pathway 5.** This pathway is intended to achieve the strategic goal of *urban environmental quality*, ensuring high-quality environmental and health standards in urban areas (e.g., air and noise pollution). It is being implemented via both the regional mobility plan (Consortio Regional de Transportes de Madrid, 2013) and the regional strategy for air quality and climate change (Comunidad de Madrid, 2013). This basic pathway mainly covers traffic control policies (e.g., pedestrianisation of city centres) and energy efficiency actions (e.g., tax benefits for electric vehicles).

3.2. Step 2: exploratory scenarios as intermediate tipping points

The research team used a set of exploratory scenarios on transport and land use to construct intermediate tipping points for the five basic pathways previously described (Section 3.1). These scenarios were developed by the research team following a participatory process that included a total of 129 semi-structured interviews in the Henares Corridor (Soria-Lara et al., 2021). Both the general

public and professionals from a wide range of sectors took part during the creation of such exploratory scenarios. During the interviews, external factors with different levels of plausibility (i.e., limited vehicle access to city centres, massive population growth, an increase of insecurity in urban areas) were incorporated to stimulate the creation of a range of alternative and exploratory scenarios. The content of interviews was analysed through a systematic process, resulting in three exploratory scenarios, which are described below (Soria-Lara et al., 2021):

- *Exploratory scenario 1 – “Non-motorized city centres”* – is based on the full restriction of private vehicles access to main city centres. The main municipalities of the Henares Corridor have a rich mix of residential, shopping, leisure, and working sites, reducing the distances between these urban activities. Workplaces, currently located in the city’s periphery, are transformed into mixed-use areas. This shift has initiated a change in the modal split, increasing walking and cycling levels to all daily destinations (e.g., work, shopping, and leisure activities). However, some low-density residential areas persist on the periphery. A dense network of green corridors connects different locations, including the city centres and the periphery. Public transport stations are tightly integrated with green corridors, thereby favouring the inter-modal combination of active mobility and public transport.
- *Exploratory scenario 2 – “Overpopulation”* – is marked by massive population growth. The main city centres have a very diverse land use mix, thanks to a growing number of multi-family dwellings, urban services, and facilities. Several major industrial sites are partially transformed into mixed-use areas. High-income households prefer to live in the city’s periphery in low-density residential neighbourhoods. The use of public transport is notable, especially for work commuting. Some high occupancy vehicle lanes have been created along with a new transportation hub. A dense green network of corridors connects key locations, supported by good integration with public transport stations. Car ownerships rates have decreased due to a strong preference for first and foremost public transport but also for walking and cycling.
- *Exploratory scenario 3 – “High levels of insecurity”* – is principally shaped by an increase of insecurity, violent and property crime in urban areas. The number of multi-family dwellings and commercial establishments in city centres is significantly reduced. Part of the industry has also disappeared. New, low-density residential areas have proliferated on the periphery, as the neighbourhood of choice for high-income households. Land uses are highly segregated in homogenous areas connected by motorized infrastructures. Green spaces and safe pedestrian zones are almost completely absent, and walking or cycling is highly inadvisable. The modal split is drastically different, with private cars dominating all daily trips and the construction of new roads between municipalities. Viewed as unsafe, the public network is only used by low-income populations.

These three exploratory scenarios have been used as intermediate tipping points, depicting potential deviations from the basic pathways to achieve each strategic goal. In total, such exploratory scenarios were used for five specific tipping points, one per strategic goal and its associated basic pathway (Section 3.2).

3.3. Step 3: adaptive policy responses

The five tipping points shaped by exploratory scenarios (one per strategic goal; see Section 3.1) have ultimately been used for proposing adaptive policy responses that adjust or modify each basic pathway. According to the theoretical framework described in Section 2.2, the type of policy response would depend on the level of alignment between the three exploratory scenarios and the basic

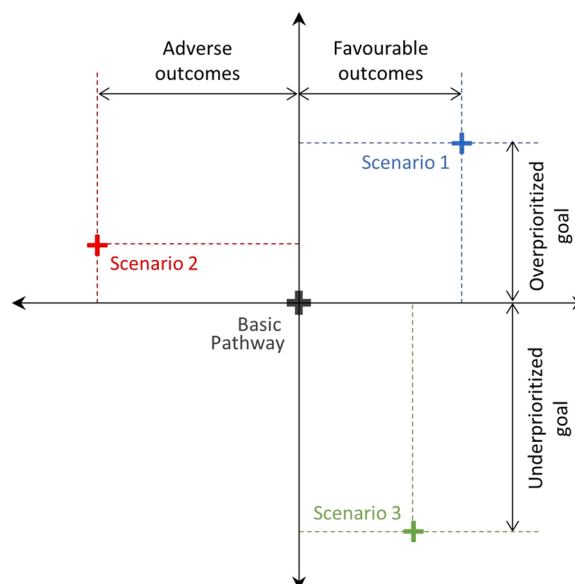


Fig. 5. Theoretical example of tipping point with 3 exploratory scenarios and the 4 alignment measures.

pathways adopted. In this particular context, a total of four alignment measures have been used to identify the type of policy response for each tipping point (Fig. 5):

- (i) *Favourable outcomes*: it measures the alignment between favourable outcomes from exploratory scenarios – if any – and the expected outcomes from the basic pathway.
- (ii) *Adverse outcomes*: it measures the alignment between adverse outcomes from exploratory scenarios – if any – and the outcomes expected from the basic pathway.
- (iii) *Overprioritized goal*: it measures the alignment between the level of priority for achieving a specific strategic goal and the possible overprioritization of such goal by the exploratory scenarios.
- (iv) *Underprioritized goal*: it measures the alignment between the level of priority for achieving a strategic goal and the possible underprioritization of such goal by the exploratory scenarios.

To translate the four alignment measures into adaptive policy responses for each strategic goal, such alignment measures were showed in two cross axes (Fig. 5). The horizontal axis illustrates the two outcomes alignment measures (favourable outcomes and adverse outcomes), while the vertical axis shows the two priority alignment measures (overprioritized goal and underprioritized goal) (Fig. 5).

To obtain the four alignment measures for each tipping point, an online questionnaire was used. The questionnaire was answered by 25 experts previously selected, living in the Henares Corridor. The expert profiles included: five transport planners, four urban/regional planners, five environmental planners, four real-estate developers, three entrepreneurs, and four representatives from non-governmental organizations and citizens associations.

In the first part of the questionnaire, participants were individually asked by the level of alignment between the three exploratory scenarios (non-motorized city centres, overpopulation, high levels of insecurity) and each basic pathway for both favourable and adverse outcomes. For this purpose, participants indicated whether each exploratory scenario would trigger favourable or adverse outcomes to achieve each strategic goal, namely: spatial equity, urban compactness, transport multimodality, biodiversity and ecosystem integration, urban environmental quality. They also had to indicate the level of alignment between such favourable/adverse outcomes and the basic pathway. A 10-point scale was used for this purpose, with 0 indicating very high level of alignment and 10 very low.

In the second part of the questionnaire, participants were individually asked by the level of alignment between the three exploratory scenarios and each basic pathway for both overprioritizing and underprioritizing the achievement of strategic goals. For this purpose, participants were asked to indicate whether each exploratory scenario would overprioritize or underprioritize the achievement of the strategic goals under evaluation. They also had to indicate the level of alignment between the initial priority given to a strategic goal and its possible over/underprioritization by each exploratory scenario. Again, a 10-point scale was used, with 0 indicating very high level of alignment and 10 very low.

In each tipping point, individual responses for the three exploratory scenarios were processed to obtain a final set of alignment values that cover the range of individual responses provided by participants (Fig. 6). These alignment values would be used to define the type of adaptive policy responses to be adopted. Outliers (i.e., extreme values that differ from most other values in a data set) were

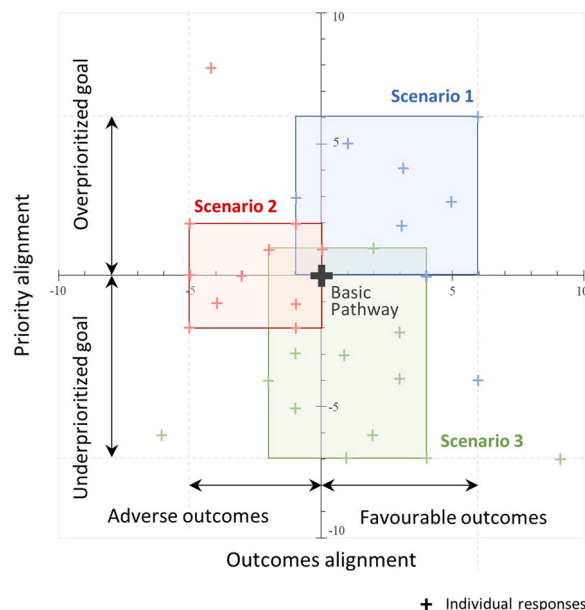


Fig. 6. Example of data processing results for each tipping point.

carefully identified and eliminated, so that they do not produce an impact in the results. To determine the type of policy response that corresponds in each tipping point, the four alignment values were classified according to 10-points scales, where 0–3 values indicate strong, 4–6 moderate, and 7–10 poor alignment. Accordingly, a tipping point would indicate the need for a preserving policy response when the four alignment measures indicate strong alignment (0–3 points). On the contrary, transforming policy responses would be recommended for moderate (4–6 points) and poor alignment values (7–10 points). Moreover, transforming policy responses could be outcomes- and/or priority-oriented, depending on whether moderate or poor alignment values between exploratory scenarios and a basic pathway are mainly found for outcomes and/or planning priorities, respectively.

4. Results

The obtained scores for the four alignment measures are summarized in Table 1, together with the type of policy response that corresponds in each case. Moreover, the responses of participants for the online questionnaire are also showed by Fig. 7.

4.1. Tipping point for the basic pathway 1

The basic pathway 1 aims to achieve the strategic goal of *spatial equity* (Section 3.1). The obtained tipping point for this basic pathway shows the need for a preserving policy response (Table 1; Fig. 7a). In particular, the four alignment measures show a strong alignment (0–3) between the three exploratory scenarios and the basic pathway for both outcomes and planning priorities. Only scenario 3 (High levels of insecurity) might lead to slightly adverse outcomes, differing from the basic pathway in terms of spatial equity.

The results of this tipping point suggest that only minor readjustments to the established basic pathway might be necessary over time to achieve the strategic goal of spatial equity. Such readjustments would rely on smooth and incremental actions. Regional and current local policies for achieving an equitable distribution of urban land uses and transport systems would remain valid. Given its robustness, current strategies for commercial revitalisation and affordable housing prices could be extended to other disadvantaged areas within the case study. Proximity to public transport networks would remain a priority to reduce the risk of social exclusion.

4.2. Tipping point for the basic pathway 2

The basic pathway 2 aims to achieve the strategic goal of urban compactness (Section 3.1). The tipping point for this basic pathway indicates a need for a transforming policy response (Table 1, Fig. 7b). Participants in the questionnaire revealed strong alignment values (0–3) between exploratory scenarios and the basic pathway for the measures of favourable outcomes and underprioritized goal. However, they only found moderate alignment values (4–6) between the three exploratory scenarios and the basic pathway for the other two alignment measures: adverse outcomes and overprioritized goal. Exploratory scenarios would trigger adverse outcomes that can be different in a significant way from those expected outcomes from the basic pathway. Only outcomes from scenario 1 (Non-motorized city centres) would be aligned with the basic pathway initially adopted. Exploratory scenarios would also lead to over-prioritizing the achievement of urban compactness as strategic goal in comparison with the basic pathway. This is particularly relevant for the context of scenario 3 (High levels of insecurity). Therefore, this transforming policy response should be both outcomes- and priority-oriented.

Based on the abovementioned aspects, the basic pathway might easily fail or become obsolete. This tipping point emphasizes the need for radical changes to the basic pathway, involving mitigating actions to drastically curtail adverse outcomes. At the same time, boosting actions would be highly needed to take advantage of overprioritized situations. Some actions could be aimed at reinvesting in existing neighbourhoods to move people from suburban neighbourhoods to city centres, including local government tax incentives. Preserving natural resources (e.g., farmlands, parks, open spaces, unused land) could also limit the construction of large, single-family dwellings. Providing residents with a sense of place and creating a better sense of community should be prioritised on the institutional and professional agendas (e.g., siting schools, offices, sports stadiums, shopping centres, and parks close to existing neighbourhoods, instead in isolated areas away from cities and suburbs). A higher level of coordination between local and regional governments could

Table 1
Alignment values obtained for each tipping point and suggested policy responses.

Tipping point	Alignment measures between exploratory scenarios and the basic pathway				Adaptive policy response
	Adverse outcomes	Favourable outcomes	Underprioritized goal	Overprioritized goal	
1	Strong (3)	Strong (2)	Strong (2)	Strong (2)	Preserving
2	Moderate (6)	Strong (2)	Strong (1)	Moderate (5)	Transforming (Outcomes- and priority-oriented)
3	Moderate (5)	Strong (3)	Strong (2)	Strong (2)	Transforming (Outcomes-oriented)
4	Moderate (5)	Strong (3)	Strong (3)	Strong (2)	Transforming (Outcomes- and priority-oriented)
5	Moderate (6)	Strong (3)	Strong (2)	Strong (2)	Transforming (Outcomes-oriented)

Note: values of 0–3 indicate strong alignment, 4–6 moderate alignment, and 7–10 poor alignment

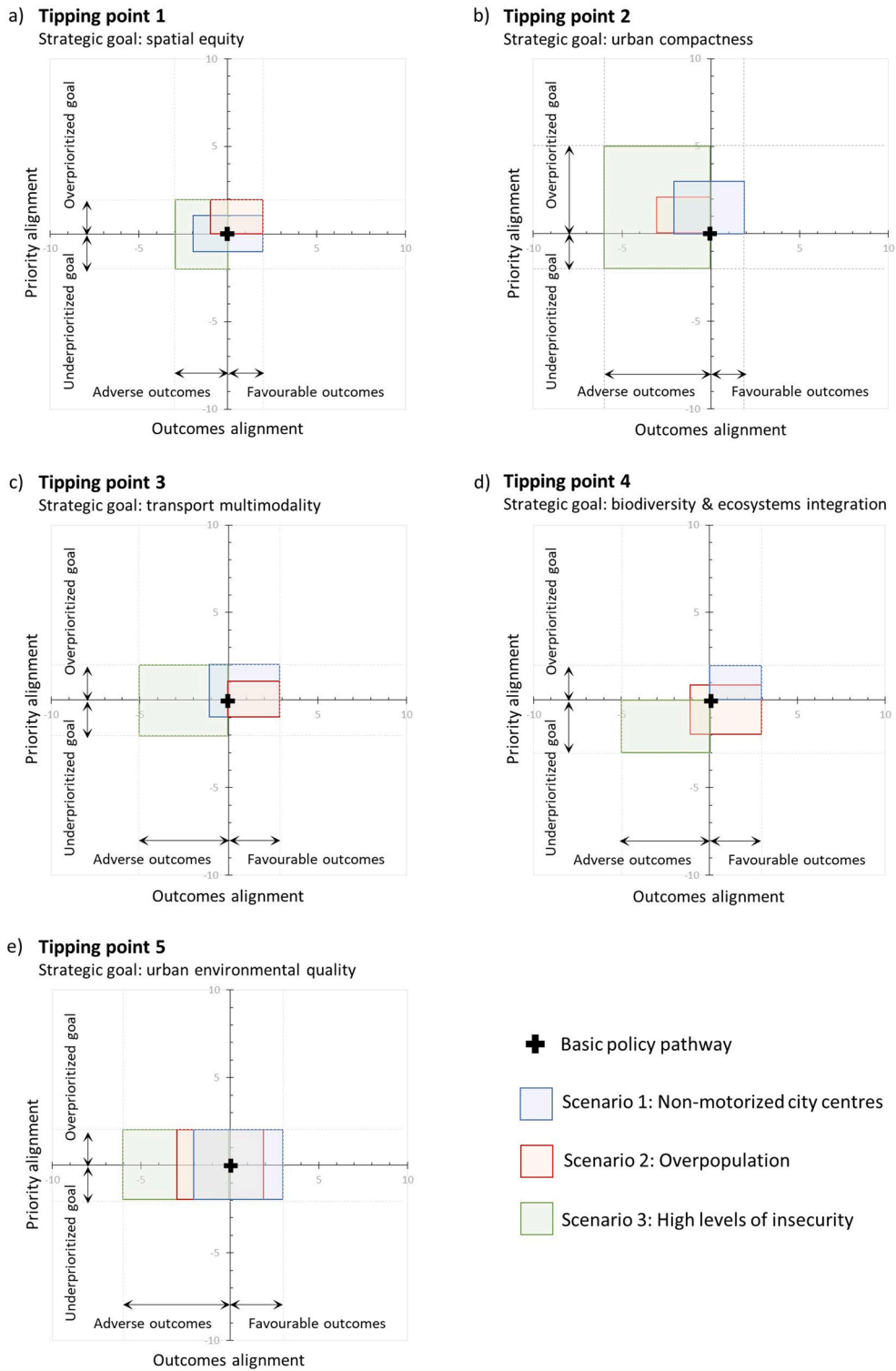


Fig. 7. Tipping points and alignment measures for the strategic goals: a) spatial equity, b) urban compactness, c) transport multimodality, d) biodiversity and ecosystems integration, e) urban environmental quality.

be required to prioritize these dense real estate developments.

4.3. Tipping point for the basic pathway 3

The basic pathway 3 aims to achieve the strategic goal of transport multimodality (Section 3.1). The tipping point for this basic pathway would trigger a transforming policy response (Table 1, Fig. 7c). The analysis of this tipping point indicates that the three exploratory scenarios are strongly aligned with the basic pathway in the priority of achieving the strategic goal of transport multimodality. In fact, strong alignment values (0–3) were obtained between exploratory scenarios and this basic pathway for the measures of overprioritized and underprioritized goal. A strong alignment value was also obtained for the favourable outcomes measure. Scenario 1 (Non-motorized city centres) and scenario 2 (overpopulation) would have minor favourable outcomes. However, a moderate alignment value (5) was obtained for the adverse outcomes measure. In this tipping point, scenario 3 (High levels of insecurity) would trigger significant adverse effects for reaching the strategic goal of transport multimodality. Therefore, this transforming policy response should be outcomes-oriented.

This tipping point shows that significant changes to the basic policy pathway might be necessary, mainly including mitigating actions to take advantage of adverse outcomes. Investment in hard infrastructure would be needed. For example, multimodal hubs would ensure easy access and interchanges between different modes. Soft infrastructure aspects could be also included, such as aligning timetables, ticketing measures, and providing information on transfer opportunities. Finally, coordination between different transport authorities and private transport providers should be also promoted.

4.4. Tipping point for the basic pathway 4

The basic pathway 4 aims to achieve the strategic goal of biodiversity and ecosystem integration (Section 3.1). The tipping point for this basic pathway shows the convenience of activating a transforming policy response (Table 1, Fig. 7d). Participants indicated strong alignment values (0–3) between the three exploratory scenarios and the basic pathway for the measures of favourable outcomes and overprioritized goal. However, moderate alignment values are obtained for the measures of adverse outcomes and underprioritized goal. While scenario 1 (non-motorized city centres) and scenario 2 (overpopulation) are aligned with the basic pathway, scenario 3 (high levels of insecurity) entail major adverse outcomes and significantly underprioritize the achievement of this strategic goal. Therefore, this transforming policy response should be both outcomes- and priority-oriented.

Significant modifications to the basic pathway may be needed over time, including both mitigating actions to take advantage of possible adverse outcomes and recovery actions to guard against underprioritizing situations. In this respect, the green infrastructure projects included in the basic pathway could be extended to other urban and peri-urban areas, such as grazing grounds and rivers. Local authorities could support minimum standards in construction and rehabilitation projects (e.g., planting green roofs and facades). Authorities could also prioritize nature-based solutions (e.g., protection and management of natural ecosystems, incorporation of blue-green infrastructures in urban areas, application of ecosystem-based principles to agriculture systems) and take biodiversity into account in all impact studies.

4.5. Tipping point for the basic pathway 5

The basic pathway 5 aims to achieve the strategic goal of urban environmental quality (Section 3.1). The tipping point for this basic pathway would trigger the need for a transforming policy response (Table 1, Fig. 7e). Strong alignment values (0–3) are obtained for the alignment measures of favourable outcomes, underprioritized goal, and overprioritized goal. However, the alignment value for the adverse outcomes measure is moderate (6). In this tipping point, scenario 2 (overpopulation) and scenario 3 (high levels of insecurity) would originate significant adverse outcomes for achieving this strategic goal. Only outcomes from scenario 1 (non-motorized city centres) would be closely aligned with the basic pathway on urban environmental quality issues. Therefore, this transforming policy response should be outcomes-oriented.

According to this tipping point, significant changes to the basic pathway might be necessary to achieve the strategic goal on urban environmental quality. These changes would mainly rely on mitigating actions to reduce adverse future outcomes. According to the future outlooks analysed, current pedestrianization policies and energy efficiency measures may be insufficient. Local authorities could implement severe restrictions on the access of ICE vehicles into city centres when high CO₂ peaks are reached as well as prioritizing freight and logistics with low-emission vehicles. Other actions in the public space would focus on creating a more favourable environment for pedestrians and cyclists.

5. Conclusions and discussion

This paper explored potential answers to the following research question: to what extent it is possible to obtain different adaptive policy responses using exploratory scenarios as intermediate checkpoints, rather than using them as independent long-term future endpoints? First, a theoretical framework for an adaptive scenario-building approach was conceptualised and discussed (Section 2). Then, the research question was addressed empirically in the case of the Henares Corridor in the Metropolitan Area of Madrid, Spain with the participation of 25 respondents via an online questionnaire (Sections 3 and 4).

A set of concluding issues to be discussed emerged during the research. They provide additional insights into the robustness of the proposed framework, the validity of the empirical exploration, the main limitations, and further research developments.

- *The role of exploratory scenarios for adaptive policymaking.* The adaptive approach conceptualized in Section 2.2 discusses the traditional role of future scenarios as desired/plausible endpoints (Hickman et al., 2011; Tuominen et al., 2014; Liimatainen et al., 2014). Innovatively, this approach reconsiders the role of exploratory scenarios in two main aspects: (i) checkpoints to assess potential readjustments to the basic policy pathway initially adopted; and (ii) catalysts for specific policy responses to adapt the basic policy pathway to new realities. The new role of exploratory scenarios opens challenging scientific horizons for scenario building. On the one hand, scenarios should not be seen as producing an ultimate goal to be achieved in the long-term, but as an active part of policymaking, marked by regular reflection and adjustment. On the other hand, methodological changes are also necessary, as multiple exploratory scenarios for the short-, mid-, and long term could be needed to generate sufficient tipping points. However, the design of multiply scenarios for different moments could also result in linear processes, which may impede the development of disruptive scenarios between those time horizons (Soria-Lara et al., 2021).
- *Tipping points and adaptive policy responses.* Inspired by previous research focused on adaptive policymaking and dynamic adaptive planning (Walker et al., 2001; 2011; Kwakkel et al., 2010; Swanson et al., 2010), the paper's main theoretical contribution is the use of exploratory scenarios as tipping points for developing adaptive policy responses. Tipping points essentially assess the level of alignment between a set of exploratory scenarios and the basic policy pathway initially adopted to achieve a strategic goal(s). The assessment is based on alignment along two aspects: planning outcomes and planning priorities. In this framework, a tipping point can lead to a potential policy response that can be preserving or transforming. While the first -preserving responses- consists of only minor readjustments to the basic pathway, the second -transforming responses- entail major changes. Depending on whether such major changes address deviations in planning outcomes (outcomes-oriented policy responses) and/or planning priorities (priority-oriented policy response), specific actions should be proposed. The definition of these actions has been also part of this research. The obtained results show a variety of policy responses, ranging from preserving to transforming, and including both outcomes- and priority-oriented. In this respect, the paper's empirical contribution should be seen as a kind of proof-of-concept, rather than as validated truths. Nevertheless, the obtained results can be seen as a promising finding for further examination, development, and application in the field of scenario building and policymaking.
- *Research design validity.* The main methodological choices included the use of (i) three exploratory scenarios as tipping points and (ii) a participatory research design based on a questionnaire. Having only three exploratory scenarios can be seen as a potential limitation, as real-life application may require more. However, limiting the number of scenarios to a maximum of three provided the research team with a more controlled environment, to examine how scenarios interacted with each other as well as the relevance of that process for tipping points' evaluations. The use of a participatory scheme via online questionnaires to assess the two tipping points dimensions (planning outcomes and planning priorities) can be also seen as a limitation. Lockdown policies during the COVID-19 pandemic impeded the use of other participatory formats, such as workshops, experiential research design (simulating close-to-real-life conditions), and others. In this respect, new multi-method approaches are needed to provide a richer evaluation of the potential of exploratory scenarios and tipping points to inform practice.

In sum, this research has introduced a novel approach based on using multiple exploratory scenarios as tipping points to glimpse different policy responses that adapt basic pathways to potential future deviations. Although part of the obtained results can be seen as preliminary due to the limitations during application, they provide promising directions for re-examining the role of exploratory scenarios in coping with uncertainty and highly dynamic contexts. Controlled experiments in which tipping points and adaptive policy responses can be developed under close-to-real-life conditions are a particularly promising research avenue. Nevertheless, both the theoretical framework and its empirical validation open new scientific horizons and move scenario-building towards more dynamic and adaptive schemes.

Authors statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in *Futures*.

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