Harnessing AI for Future Scenarios: Exploration Approaches for Sustainable Planning in Taranto, Italy

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Abstract. This paper explores the perspectives of traditional, human-centered Scenario Building (SB) and AI-driven Scenario Building (AISB) techniques. The context of study is to devise a sustainable regeneration strategy for Taranto by navigating its challenges through a hybrid methodological approach. While AISB methodologies swiftly process data and model future scenarios, traditional SB methods excel in capturing local knowledge. The study thus suggests the potential of a hybrid approach, emphasizing a methodological balance that harmonizes data-centric insights with human expertise, showcasing the potential for resilient and inclusive urban planning in Taranto.

Keywords: Sustainable planning · Decision support · Scenario building · Artificial intelligence

1 Introduction

The city of Taranto, in the Italian Mezzogiorno (Fig. 1), has undergone significant industrial and urban changes over years.



Fig. 1. Taranto in the national context.

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This case exemplifies how urban and industrial planning can profoundly impact a region's social, spatial and natural environment organization. Taranto was planned as a development pole in the 1960s. Since then, it has experienced rapid and often controlled expansion, which brought complex and intertwined issues. Admittedly, anticipating future outcomes, a core aspect of planning, frequently introduces shifts that complicate the diverse and detailed nature of available information. This can lead to subjective interpretations of varied and fragmented data. Researchers and practitioners have made numerous efforts to organize this intricate information for better decision-making [1]. In recent times, increasing popularity has been gained by methodologies that blend qualitative and quantitative approaches to organize distributed knowledge. This has long been an area of activity for the field of the so-called futures studies. Notably, the future workshop methodological approach stands out because it allows for the integration of individual and group perspectives, both critical and forward-thinking, to develop potential strategies and alternative future possibilities [2].

In this background, the present study is an attempt to explore whether innovative technologies and approaches can better mirror this complexity to derive alternative research and operational perspectives. In particular, hybrid methods have been explored for building up future scenarios oriented to Taranto's sustainable regeneration. The purpose was to combine traditional (SB) and technological (AISB) scenario-building approaches to address the city's multiform challenges.

After this introduction, the paper is structured as follows. Section 2 examines Taranto's evolution from a development pole to an environmentally and socioeconomically problematic city. Section 3 delves into both traditional and AI-driven scenario-building methodologies experimental sessions for Taranto. Section 4 analyzes some strengths and weaknesses of SB and AISB approaches, with key findings and insights for future research in Sect. 5.

2 Taranto Case Study: From Development Pole to Troubled City

In the mid-20th century, Taranto became a key industrial center for Italy, inspired by François Perroux's growth pole theory [3]. According to this theory, focusing resources and investments in selected areas and particular sectors could spur economic progress. But following a first apparent confirmation of this concept, Taranto's evolution diverged from expectations for various reasons [4]. While physical and industrial growth continued, quality of life and environmental sustainability have started to decline severely.

Taranto has received explicit association in recent years to one of the European Union's socioeconomically shrinking industrial cities, a paradox for a region meant to be a growth model. From the perspective of physical growth, which experienced substantial urban and industrial expansion, the shrinkage issue was not apparent (Fig. 2) [5].

This development led to increased environmental issues and a decline in quality of life, showing evidence of a development that ignored environmental sustainability and social needs (Fig. 3). Taranto's rapid expansion severely impacted the environment. The 2000s saw dangerously high levels of pollution, with Taranto recording Europe's highest

dioxin emissions, which are notoriounsly very toxic. This pollution directly affected public health, increasing respiratory diseases and pollution-related health problems. Taranto became one of Europe's most affected areas in terms of pollution-related morbidity and mortality [5].



Fig. 2. The state of industrial and urbanized areas in Taranto in 2024

Citizens' quality of life has been increasingly worsened by environmental pollution, contributing to urban malaise and reduced livability. The environmental crisis was exacerbated by inadequate mitigation measures and industrial expansion without considering environmental impacts.

Taranto's economic and employment deterioration significantly affected its social frame. After initial growth and industrial employment, Taranto saw flimsy stabilization and then a reduction in jobs since the 1970s. Central city residents, once integral to the industrial sector, now represent just about a third of total employees, leading to economic and social cohesion decline.

This employment decline spurred suburbanization. In pursuit of improved living circumstances and economic prospects, residents have migrated from core regions to suburban and provincial communities. The population distribution has changed as a result of this transition, with the urban core becoming less populated and the outlying settlements becoming overcrowded. This has caused an imbalance and significantly deteriorated the urban condition [5].



Fig. 3. A daytime snapshot of Taranto pollution days (2012).

Suburbanization posed further challenges, particularly in infrastructure and transport. Despite demands for better public transport and urban infrastructure, developments were poorly implemented, increasing reliance on private transport, traffic congestion, and pollution. Inadequate public transport worsened livability issues, causing pollution and traffic to spiral out of control.

This puzzling paradigm emphasizes the necessity of integrated approaches to urban planning that take into account the demands of infrastructure and transportation as well as sustainable physical growth.

3 Envisioning Scenarios of Futures

3.1 A Traditional Perspective of Scenario-Building

In order to address these complex and interrelated issues, the Municipality asked the Polytechnic University of Bari to set up a process for building up scenarios for the future of Taranto.

The process aimed at involving the local community in identifying new visions and strategies for the city's future. Scenario building uses participatory approaches integrating expert knowledge and community contributions to identify and valorize the city's socio-environmental resources (Table 1) [6].

Community involvement ensures proposed solutions align with citizens' needs and expectations. This participatory approach builds shared visions for the city's future, fostering community and responsibility among local knowledge agents and stakeholders. The process of building up future scenarios originally involved exchanging messages on paper (Fig. 4).

Our process, using digital platforms (as is normally the case today: PC-based SB), involved various Taranto neighbourhoods and a wide range of participating people, including citizens, institutional agents, and industry representatives (Table 2).

The experiment highlighted the ideas put forward by the participants, summarized as follows:

Table 1. A traditional future workshop layout [1].

Future Workshops		
PHASE	CONTENTS	EXPECTED RESULTS
1. Preparation	The issue to be analysed is decided and the structure and environment of sessions are prepared	Summary of contributions
2. Critique	Clarification of the issue selected, of dissatisfactions and negative experiences in the present situation	Problematic areas for the following discussion
3. Fantasy	Free idea generation (as an answer to the problems) and of desires, dreams, fantasies, opinions concerning the future. The participants are asked to forget the practical limitations and the obstacles of their present reality	Indication of a collection of ideas and choice of some solutions and planning guidelines
4. Implementation	Going back to the present reality, to its power structures and to its real limits, to analyse the actual feasibility of the previous phase solutions and ideas. Identification of obstacles and limits to the plan implementation and definition of possible ways to overcome them	Creation of strategic lines to be followed in order to fulfil the traced goals. Action plan and implementation proposal drawing



Fig. 4. Experimental sessions of traditional SB.

Table 2. Participants of Taranto SB sessions

Place			Participants	
Sched	District	Location	#	Profiles
1	Inner city	public hall	150	residents; local associations; fish sector
2	Lama San Vito	church yard	50	residents; students
3	Lido Torretta	public playground	50	residents; tourists
4	Talsano	church hall	15	residents
5	Paolo VI	church hall	30	residents; industrial workers
6	Salinella	church hall	30	residents; students
7	Tamburi	public hall	5	public officers; local associations
8	City Centre	public library	30	residents; scholars; students

- Redevelopment of Coastal Areas. Participants emphasized transforming the San Vito coastal district into a tourist area, improving the beach, and building tourist villages. Remediating polluted waters near the military port was a priority.
- Revision of the Master Plan. Participants discussed the need to update Taranto's Master Plan, suggesting reducing landscape constraints from 300 m to 150 m to support tourism and housing development.
- Promotion of Tourism and Cultural Activities. There was strong interest in promoting cultural and historical tourism, with proposals for creating city brands and organizing cultural events to attract tourists and enhance Taranto's historical heritage.
- Improvement of Infrastructures and Services. Participants highlighted the importance of improving urban infrastructure, including sewerage networks, roads, and integrating cycle paths for sustainable mobility.
- Environmental Sustainability and Innovation. Participants recognized the need for sustainable technologies, such as renewable energy for new housing and converting the local economy towards agriculture, technology, and tourism. They also discussed retrofitting existing buildings and introducing energy efficiency measures.
- Community Involvement and Participatory Planning. Continuous community involvement in urban planning was a central aspect, allowing for a wide range of opinions and scenarios reflecting local needs and aspirations.

In summary, the traditional SB process resulted in specific visions and practical suggestions for urban regeneration. A synthesized report is shown below, with alternative final visions grouped by participants.

1) ***Taranto city of green and cultural renaissance***

   – Redevelopment and use of abandoned state-owned areas for cultural, tourist, and environmental projects, with particular attention to the Cheradi Islands. The restoration of monuments and historic buildings will be accompanied by initiatives to improve urban mobility and encourage sustainable mobility.

2) ***A city tailored for future youth***

- Allocate abandoned areas to create youth centers and meeting spaces, encouraging young people to actively participate in urban redevelopment. Projects include converting abandoned buildings into social centers and opening new sports and cultural activities.

3) ***Taranto city of sea tourism and culture***

- Return the seafront to the city to promote tourism and maritime trade, enhancing natural and historical resources through the creation of museums, thematic routes, and tourist attractions. The promenade will be made pedestrian-friendly and bicycle-friendly, with services for visitors.

4) ***A city of innovation and sustainable technology***

- Invest in renewable energies, sustainable mobility, and waste management to make Taranto an environmentally cutting-edge city. Converting old phone booths into charging stations for electric cars and improving air quality monitoring systems are part of this plan.

5) ***Taranto historical heritage and identity***

- Recover and enhance Taranto's historic center, transforming it into an open-air ecomuseum and encouraging repopulation. The old town will be restored with targeted interventions to preserve popular architecture and noble palaces, while promoting economic and social activities related to local traditions.

This SB process collected structured ideas and suggestions for addressing Taranto's main challenges. These results could be seen as a useful basis for future planning processes, showing the importance of a distributed and integrated knowledge-based approach in addressing the city's socioeconomic and environmental challenges.

Scenario-building itself shows up as a useful approach for exploring future options and evaluating the possible impacts of political and urban decisions. Using PC-based software and models allows for detailed simulations of complex scenarios, supporting more informed decisions based on comprehensive data.

3.2 Experiments Using Generative AI (AISB)

An ex-post experimentation was conducted on this context, using generative AI tools (Google's Gemini and OpenAI's ChatGPT) [7]. The same traditional SB scheme was followed (Fig. 4) and the same questions were asked to the AI module. In the end, the AISB process showed up as a kind of structured interview with available GPT models. An excerpt of one of the sequential steps from the AISB process is shown in Fig. 5.

The AI-driven scenario-building process for Taranto delivered meaningful insights, providing somehow comprehensive projections of the city's potential futures. By massively analyzing historical, demographic, economic, and environmental documents from online sources [8], the AI identified key trends shaping Taranto's trajectory:

- Demographic decline: Ongoing population reduction, particularly in central districts, driven by internal migration to suburban areas and emigration to other regions.

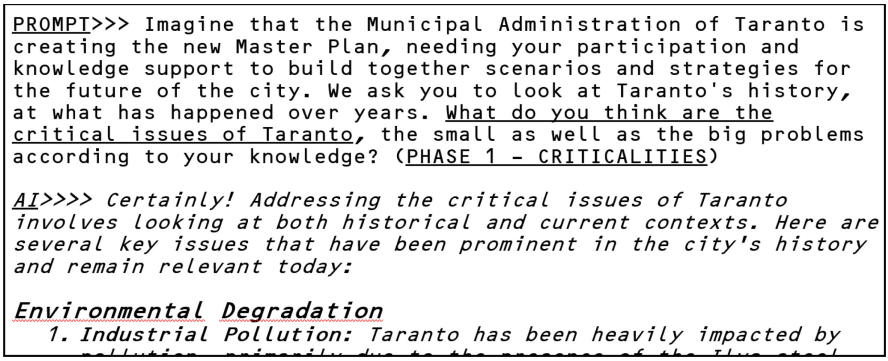


Fig. 5. The *criticalities* phase of the AISB process (excerpted from the output image)

- Environmental challenges: Continuing high pollution levels, especially affecting air quality and water systems.
- Suburban Expansion: Growth of residential areas on the periphery, coupled with increased dependence on private vehicles for transportation.

The AI employed integrated predictive modeling to generate multiple urban regeneration scenarios, evaluating various political, economic, and infrastructure interventions. Among the diverse scenarios examined, three emerged as particularly significant.

1) ***Taranto as a green city***

   – Taranto is envisioned as a hub for substantial investments in renewable energy, environmental restoration, and green infrastructure. This vision promises a marked enhancement in air quality and a decrease in emigration rates. Additionally, it forecasts an uptick in tourism and a surge in employment opportunities within the green sector.

2) ***Industrial reboot***

   – This involves the industry's rebirth through technological advancements, including the adoption of clean production technologies. It is linked to moderate economic growth, yet it continues to face ongoing challenges related to pollution and waste management.

3) ***A city of cultural renaissance***

   – Taranto prioritizes enhancing its cultural and historical heritage, fostering tourism, and nurturing creative industries. This leads to a surge in cultural events and improved community well-being, significantly boosting the city's appeal.

An initial socio-economic assessment by AISB analyzed potential impacts across various scenarios. Key findings include:

- Employment: Scenarios prioritizing environmental sustainability and technological innovation are projected to generate new employment opportunities, notably in renewable energy, technology, and tourism.

- Living quality: Scenarios emphasizing green and cultural regeneration are anticipated to enhance quality of life, evidenced by improved social well-being indicators, a decline in pollution-related illnesses, and stronger community bonds.
- Spatial Equity: The assessment warns of potential increases in regional disparities without strategic interventions, with suburban areas likely to expand at the expense of central urban areas.

Within this framework, AISB methodology produced targeted policy suggestions, derived from the modeled simulations. These encompass:

- Promotion of eco-friendly enterprises: Suggestions for tax and monetary encouragement to stimulate investment in environmentally sound and renewable technologies.
- Restoration of former industrial lands: Proposals for transforming abandoned industrial zones into environmentally friendly communal areas or technological centers.
- Enhancement of communal transit: Formulation of a cohesive public transportation strategy to lessen reliance on personal vehicles, strengthen connections between urban core and outlying districts, and diminish contamination.

The AI-driven process examined a broad spectrum of potential future scenarios for Taranto, offering valuable insights to aid strategic planning and informed decision-making. It proposed visions for sustainable urban development, emphasizing urban regeneration and enhancements to the quality of life for residents. However, this innovative approach, and the broader application of simulation-based (SB) methods, carries both benefits and challenges, including limitations and critical issues. The following section will delve into the implications of these aspects.

4 SB vs. AISB: An Open Comparison

In general terms, scenario building is a strategic approach that helps decision-makers envision various potential futures, allowing them to better navigate opportunities and uncertainties. Both traditional and AI-driven methods have their own strengths and weaknesses when it comes to scenario planning. Below is a general overview of each approach.

Traditional SB relies on direct engagement among stakeholders and local experts, leveraging historical data, past experiences, and collective insights to explore possible futures. The participatory sessions highlighted a set of crucial issues: the necessity to regenerate the coastal areas, with a particular focus on the San Vito neighborhood; the revision of urban planning instruments to support a more balanced development; the promotion of cultural tourism; the advancement toward a more sustainable and innovative economy. This approach offers several insights, as reported in research literature [1, 9, 10]. One key point of strength is that face-to-face interaction facilitates the capture of nuanced, context-specific knowledge, which might be overlooked in purely data-driven analyses. Additionally, discussions among diverse participants can lead to new perspectives and innovative strategies that are more aligned with local needs. Another benefit is flexibility—traditional scenarios can be adapted throughout the process, integrating real-time feedback and new information as it becomes available. Moreover, the active

involvement of local actors fosters a stronger sense of ownership, leading to greater acceptance and implementation of proposed decisions.

However, traditional SB also has limitations. The process often demands significant time and resources, especially when involving large groups or repeating sessions to incorporate evolving variables. Furthermore, human intuition—while valuable—can introduce biases, potentially distorting the perception of possible futures and leading to inaccurate predictions. This issue becomes particularly relevant in highly complex and dynamic contexts like Taranto, where oversimplification or overlooked factors could compromise scenario accuracy.

AISB has also generated alternative visions for the city, encompassing: Taranto as a green city, a city with Industrial reboot, and a City of Cultural Renaissance. These scenarios are complemented by socioeconomic impact evaluations, highlighting the potential creation of new employment opportunities in green and cultural sectors, enhancements in quality-of-life indicators, and risks of emerging spatial disparities. Generative AI utilizes advanced algorithms and predictive modeling to produce such automated future scenarios. One major advantage of our AISB experimentation was the ability to process vast amounts of documents at high speed. AI could rapidly analyze publicly available information on a given topic, detect hidden patterns, and consider a broader range of influencing factors. Since these projections are rooted in mathematical models and algorithms, they reduce subjective biases and can be consistently replicated across different scenarios. As a result, AISB proves to be particularly useful in managing complex, interconnected systems, such as urban environments where economic, social, technological, and environmental factors interact. This approach also allows for long-term simulations, assessing the possible outcomes of political or economic decisions.

Despite these advantages, AISB comes with challenges. First, AI models heavily depend on the quality and availability of documents to be 'statistically' processed. If the data used are incomplete, outdated, or unreliable, the resulting predictions may be misleading or incorrect. Another critical issue is transparency: AI systems typically function as "black boxes," making it difficult to trace how conclusions are reached. In our case, this lack of clarity can create skepticism and hinder trust in AI-generated scenarios. Lastly, AISB may undervalue human expertise, particularly the ability to contextualize data, incorporate ethical considerations, and assess moral and social implications within scenario planning – elements that, conversely, are a hallmark of traditional SB. All these aspects, both positive and negative, were observed in the ex-post AISB experimentation on the Taranto case and compared with the traditional SB approach.

It is important to emphasize that the *raison d'être* of this experimental comparison stems from a purely exploratory intent. Ultimately, the SB process represents the account of a real and institutionally situated framework, while the AISB process remains solely a proof of concept. Nevertheless, this comparison brings to light reflections, perspectives (and limitations) of practical implementability, potentially valuable for spatial planning, synthetically outlined in the following discussion.

5 Discussion and Conclusion

The future of Taranto hinges on its capacity to sustainably manage resources while actively engaging the community in strategic planning and decision-making. The Polytechnic University of Bari has taken a significant step toward urban regeneration by employing hybrid scenario-building approaches, aiming for a more resilient and sustainable transformation of the city.

The case study revealed both benefits and drawbacks of the two methods. First it must be said that the use of generative AI has not a conceptual but a lexical foundation. This in itself determines problems of interpretation of the meanings upstream and downstream of the interactions and the questions asked. The upstream problems concern the writing/structure of each question, which must be asked in a suitable way to obtain a useful answer. This determines a possible iterative cycle of calibration of the question towards the answer - possibly paradoxical for common sense, yet studied through specific lines of research (Prompt Engineering) [11, 12]. Downstream of the interactions, the problems concern the very consistency of the meanings of the answers obtained. These are in fact the result of computational models and algorithms of machine learning that analyze statistical frequencies and redundancies of individual words and letters through stochastic approaches. It is therefore evident that the aim of the elaborations is not the conceptual accuracy of the answers but their statistical coherence with the (very numerous) data analysed [8, 13, 14]. However, one key advantage of AISB is its speed—our experiment generated scenarios within hours, whereas traditional SB workshops can take days or even weeks. This rapid turnaround is particularly beneficial when time is a limiting factor in urban planning. However, AISB struggles with capturing the complexities of human insight and the nuances of specific local contexts. In our study, the AI model often generalized issues, overlooking important contextual factors that human participants would naturally consider. This makes scenarios generated by people potentially more realistic and relevant, as they incorporate diverse perspectives and lived experiences. Essentially, the fundamental distinction between these methods lies in how they handle knowledge: traditional SB workshops foster new knowledge through interaction and the exchange of ideas, whereas AISB relies on existing data sources, such as information available online (as in the case of GPT-based models). This limitation can reduce the potential for creativity and innovation in scenario development.

Despite these constraints, AISB presents intriguing opportunities for the future of decision-making, particularly in spatial planning. Currently, its main strength lies in trend analysis and supporting data-driven insights. Policymakers often need preliminary assessments of different courses of action, and AISB can provide valuable foresight that can later be refined through human expertise and collaborative knowledge-sharing.

The future of AISB likely depends on its integration with dynamic sensor data and multi-agent knowledge systems. For instance, incorporating real-time environmental data from sensor networks could enable AISB to develop microclimate-related scenarios. Additionally, linking AISB to external knowledge frameworks—such as multi-agent architectures—could expand the range of options available to decision-makers.

Ongoing research is focused on improving AISB's knowledge management, shifting from purely statistical methods to more conceptual approaches. One promising direction involves the use of ontologies—formal knowledge representations that help structure and

share information (e.g., OntoGPT) [15]. By integrating ontological frameworks, AISB could enhance its understanding of relationships between different data points, resulting in more comprehensive and refined scenario development.

Given the strengths and weaknesses of both methods, a hybrid scenario-building approach appears to be the most effective. This would leverage AI's capability to process vast amounts of data while incorporating the expertise, creativity, and contextual awareness of stakeholders.

In the context of Taranto's urban planning, such a hybrid approach could involve AI-driven analysis of environmental and demographic trends, complemented by input from local experts and residents based on their lived experiences and aspirations. This combination would ensure that the resulting scenarios are not only data-driven but also culturally and socially relevant.

In the end, Taranto's future will be shaped by its ability to balance sustainable resource management with inclusive, community-driven planning. The exploration of hybrid scenario-building methods represents a crucial step toward achieving long-term resilience and sustainability for this evolving urban region.

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