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Society Optioneering: Designing Societal Alternatives Through Morphological Analysis

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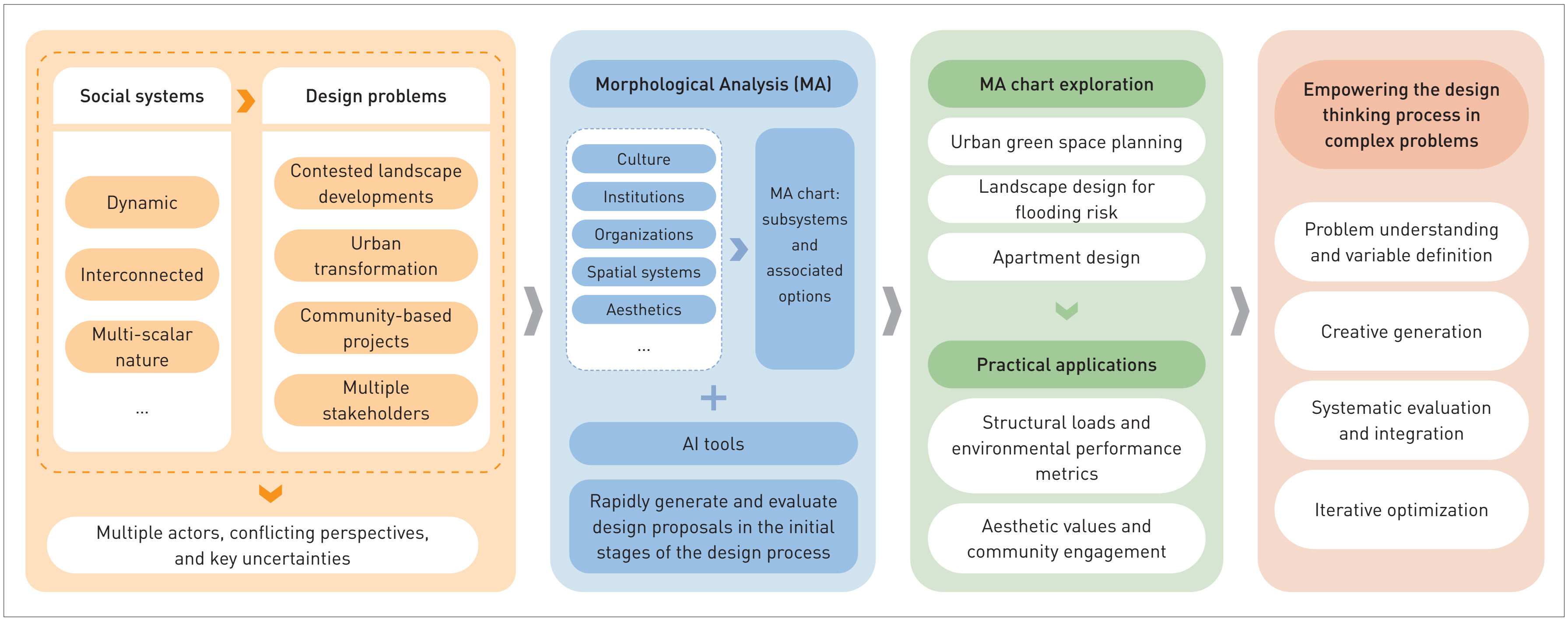
GRAPHICAL ABSTRACT



ABSTRACT

In urban planning, landscape and architecture design, designers and planners often confront intricate and multidimensional societal issues. To effectively address these challenges, this paper introduces a Morphological Analysis (MA) approach that systematically explores and aids generation of a variety of societal design solutions. MA involves constructing a matrix of subsystems and the corresponding options. It integrates both quantitative and qualitative factors and allows designers to explore concepts and to clarify the certainties or uncertainties of a problem at an early stage of the design process through arising evaluation. This paper further integrates MA with artificial intelligence generated content (AIGC) to rapidly generate and evaluate design proposals, thereby enhancing the innovation and practicality of the design process. The proposed Society Optioneering framework improves the scientific and

adaptability of solutions and fosters interdisciplinary collaboration. This integration enables designers to explore problems from multiple perspectives, discover a broader array of solutions, and evaluate them effectively using systematic tools. Thus it can maintain flexibility and adaptability throughout the design process, continually optimizing and adjusting the design strategy. This study enriches design theory and provides practical tools and guidance for related fields.

KEYWORDS

Societal Design; Morphological Analysis; Artificial Intelligence Generated Content; Sustainability; Urban Planning; Landscape Design

HIGHLIGHTS

- Introduces MA as a tool to address social complexity and uncertainty in urban and landscape design
- Proposes Societal Morphology to link culture, institutions, organizations, and spatial systems in sustainable design
- Combines MA with AIGC to enable rapid scenario creation and participatory visualization
- Develops Society Optioneering framework for diverse design options guided by inclusivity and sustainability principles

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1 Introduction

Understanding and modeling society is inherently complex due to the dynamic, interconnected, and multi-scalar nature of social systems. Rather than treating society as an abstract totality, this paper conceptualizes it as a functional system composed of interacting subsystems, particularly within the spatial contexts of urban and rural environments. This functional lens enables the targeted modeling of concrete social scenarios, such as contested landscape developments, urban transformation, and community-based projects.

Conventional approaches to social system modeling, ranging from computational simulations and agent-based models to qualitative methods and social network analysis, have generated valuable insights into diffusion processes, behavioral dynamics, and governance networks. However, these tools often encounter significant limitations when confronted with problems marked by high uncertainty, competing stakeholder values, and intangible or unquantifiable variables.

Morphological Analysis (MA), situated within the broader category of Problem Structuring Methods (PSMs)[1], offers unique advantages for addressing aforementioned challenges. By systematically mapping situational parameters and their interrelations, MA facilitates the exploration of multiple possible futures and design configurations. Importantly, it supports early-stage decision-making in contexts where formal predictive modeling is unfeasible, while accommodating diverse stakeholder perspectives. Despite this potential, the application of MA to socially contested, spatially anchored design problems, particularly in landscape design and urban planning, remains underexplored in existing scholarship.

Thus, this gap leads to the central research question of this study—How can MA support the structuring and exploration of socially contested scenarios in landscape and urban design contexts? The paper argues that MA provides a participatory and optioneering-oriented design methodology, which is capable of improving sustainability-oriented planning practices where traditional approaches prove insufficient. This paper makes three key contributions to address the gap.

1) Methodological advancement: It introduces MA as a structured yet flexible framework for navigating complex social scenarios in landscape and urban design, providing a methodological bridge where conventional modeling falls short.

2) Contextual innovation: It situates MA within real-world, community-based contexts such as stormwater infrastructure planning and community garden development, demonstrating its utility in mediating spatial conflicts and integrating divergent social values.

3) Integration with emerging tools: It explores the potential synergy between MA and artificial intelligence generated content (AIGC), positioning generative design tools (e.g., Midjourney, Vizcom) as complements for scenario creation and visualization. This integration represents a novel methodological pathway for accelerating participatory design processes in the creative industries.

2 MA and Its Methodological Basis

2.1 Societal Design

The concept of society relates to the organization of a community of people who may share some cultural characteristics, activities, and traditions, and access the same institutions. Following Geoffrey M. Hodgson's definition[2], institutions in this context include entities such as government, law, social norms[3], and academia, and provide a key function in society via enabling ordered thought, defined expectations, and action by imposing form and consistency on human activities. Indeed, institutions enable behaviors as well as providing constraints. Rules, be they explicitly defined by an institution or implicitly, can open up possibilities enabling choices and actions that might otherwise not arise. An example of this is in mobility where the rules and expectations associated with vehicle driving behaviors enable, on the whole, effective passage for the majority of vehicle users on a given road each day. As Hodgson noted, regulation, far from being a limiter, can provide freedoms[2].

Institutions, representing systems of established and embedded rules that structure social interactions, depend on individual actions, and also mould them in return. Through this institutional feedback they have self-reinforcing and self-perpetuating characteristics. Hodgson defined an organization as a special institution, with criteria to establish boundaries and to distinguish its members from non-members[2], as well as principles that determine authority, chains of command, and associated responsibilities for the people within it. As society involves so many interrelated functionalities, it can be useful to consider constructs that require agreement between groups of people. For example, John R. Searle ascribed the term "social fact" to constructs that depend on human collective acceptance such as money, property rights, marriage, sports, and celebration dates in contrast to physical objects[4].

A systems approach is manifest in literature on economic development. Charles Edquist noted, in his systems of innovation, that innovations may be brand new or, more often, combinations of existing elements, and that such innovations arise through emergence and diffusion of knowledge as well as translation to products and processes[5]. James Fleck's notion of systems, referring to "complexes of elements or components, which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function"[6], has consistency across many domains. Although a system may be apparent in a society, it should be noted that not all national systems have been consciously designed[7]; they may have arisen from multiple actors that have influenced the development of the current state, sometimes in the form of unintended consequences from previous actions.

Society and its associated institutions, organization, and interactions exhibit various forms of complexity[8]. Elliott Ash et al. noted that complexity describes a particular form of system where a constellation of actors and relationships give rise to specific types of system dynamics[9]. Complex adaptive systems, in which agents are capable of learning and changing behaviors, are typical in social systems. While states may be dominant actors in society, significant parties can also include non-governmental organizations, multi-national companies, social movements, expert communities, and even individuals[10]. Inherent to some institutions (e.g., government, organizations, individual actors) is the concept of power and, as such, needs to be considered in modeling.

If a systems approach is accepted, then inclusion of factors such as land, urban and rural interrelations, and labor and physical capital as associated with classical economics may be appropriate in modeling. However, the notions of human capital[11–12] and social capital[13] also need to be considered. Any concept of social design and development and its modeling would need to address such possibilities[14–15].

As indicated, society is a highly complex entity, due to the vast number of variables required to visualize both its boundaries and structure, whilst being exacerbated by high levels of inter-connectivity. This is not only due to the variety of components that must be considered in the (problem) structuring process, but also due to the intangible factors within the nature of individual and group behavior inherent in the concept of society. Indeed, the issues to be confronted are similar to those in design processes across domains such as engineering, architecture, and industrial design. And design thinking[16–18] principles including frame creation, human-centered approaches, and abductive and integrative thinking, and a focus on value creation can be readily applied and adapted to the social domain.

"Social design" refers to design for inclusive, user-led social value creation. It emphasizes creating social equity, inclusion, and user participation, especially the needs and experiences of individuals and communities. In contrast, "societal design" refers to the systemic modeling and structuring of social systems and interactions, particularly in policy and planning contexts. It focuses on the overall functionality of social systems, the relationships between subsystems, and how systemic interventions can achieve societal goals.

Societal design must address high levels of complexity and uncertainty. In the initial stages, much design activity is unstructured. The further a design concept is from being realized as a finished item—whether a product, service, system, platform, or entity—the more it is prone to varying conditions of uncertainty. Additional factors impacting the development process include the inter-connectivity and complexity between all components, compounded by dynamic and non-linear complexity. If not addressed early, these uncertainties can escalate into undesirable outcomes that are difficult for the design team to correct in later stages—especially when the project is constrained by resources (time, money, people, techniques). These issues impact not just the creative, early stage of the project, but the entire design spectrum.

When confronted by such challenges, methods exist to support decision-makers (as well as designers and analysts). One such method is MA, which supports groups dealing with problems involving multiple actors, conflicting perspectives, and key uncertainties[19–20]. It also helps generate viable possibilities from a large array of potential scenarios or configurations. MA enables the structuring and analysis of complex problems which: 1) are inherently non-quantifiable; 2) are stakeholder-orientated with strong socio-political, cultural, and technical positions; 3) contain non-resolvable uncertainties; 4) cannot be modeled easily or simulated; or 5) require a judgmental approach to be placed on a sound methodological basis[21].

The temporal period and spatial proximity are important factors to consider for society, with the persistence of activity being essential for its formation, maintenance, and definition. The notion of “societal makeup” can be defined in many ways, for example, 1) by common culture, institutions, and patterns of social relations; 2) by predominant daytime activities among various age groups within a spatial region; or 3) by system modeling, in which subsystems are defined by function.

This paper adopts a functional approach, representing society as an overall system with interactions between subsystems. MA is used to classify subsystems and create a matrix of options. The methodology is demonstrated through a cascade of charts, enabling increased levels of embodiment relevant to urban and rural contexts and their interrelations. This functional approach allows for tolerance of overlap and even mismatch across classifications, and provides opportunities for both implicit and explicit consideration of factors.

2.2 MA and Charts

The term “morphological analysis” is common to several subject disciplines including linguistics. Here, however, it refers to a specific creativity tool for the generation of alternative concepts by developing generic subfunctions for a product or process, and considering potential means for implementing each subfunction. This paper emphasizes a formal, theoretical interpretation of MA[1]. Formal MA is a method for systematically structuring and examining the total set of possible relationships in a multidimensional, usually non-quantifiable, Problem Space. The complexity of such problems is further exacerbated by high levels of inter-connectivity. Each set of configurations generated can be considered a bundle of attributes. By identifying all the variables (configurations) relating to the problem, all possible combinations of them are examined. A final set of viable solutions can be compiled for further analysis through a reductive process by filtering out inconsistent individual pairs of variables using software, and only computing those configurations where all variables are consistent with one another. MA allows for all ideas to be considered at the first stage of the analysis process, making itself an exploratory method par excellence[1].

In essence, MA provides managers and policy makers with the ability to identify informed and innovative solutions to complex problems. This process mitigates the risk of making the wrong decision in the face of uncertainty. Additionally, MA processes unstructured ideas and concepts and renders them down to a set of modular components, which can be used in the construction of new and innovative “products” or concepts.

MA and charts in this context refer to the synthesis of constituent parts that make up an overall whole. The methodology is widely used in design and engineering[22], while also being applied in management, strategy, and risk assessment. The methodology was originally formulated by Fritz Zwicky[23] as part of efforts to accelerate technology development for jet engines in the USA, and further developed with contributions from the Swedish Morphological Society[24]. Zwicky identified key technical factors of aviation engines, including the thrust mechanism, oxidizer, and fuel type, and broke down each of them into constituent parts under respective parameters or subsystems[23]. Possible permutations were considered and listed, such as a ramjet that could use atmospheric oxygen and solid fuel. For some permutations, an existing product or solution already existed, which potentially enabled rapid adaptation and deployment. Zwicky viewed new or original permutations of options as stimuli for creativity and thinking. MA has been demonstrated as an effective ideation and innovation realization methodology for new product development, services, patent definition, and value management. The technique comprises two key elements: 1) systematic analysis of the current and future structures of a domain, as well as identification of key gaps in that structure, i.e. the Problem Space; and 2) stimulus for invention of alternatives that fill these gaps and meet the imposed requirements, i.e., the Solution Space.

In generating unconventional product concepts, MA involves defining the function of a generic solution to a problem, and breaking it down into a few systems or subfunctions. The notion of functionality is common in design, with consideration given to form and functional attributes. However, finer granularity is possible to be achieved by incorporating technical, aesthetic, economic, social, and latent functions[25]. The simultaneous fulfillment of a set of attributes is reminiscent of Abraham H. Maslow's hierarchy of needs[26] in its various formulations, which considers physiological, safety and social requirements, self-esteem, and actualization needs.

A variety of options to fulfil each system, subsystem, or subfunction would be generated in an MA study, which can be arranged in a grid as illustrated generically in Table 1[22]. By selecting one means for each subsystem and combing them, a group of solutions will be formulated. The grid can be populated with text or sketches depicting the potential means[22,27]. This technique relies upon the user's selection. The user can explore the design space systematically guided by their experience, or they can explore it experimentally or using defined criteria. Care should be taken when defining the functional requirements to avoid specifying functions and subsystems with a preconceived solution.

A typical morphological field may contain various orders of magnitude of formal configurations. The number of permutations is likely to be far too many to be inspected carefully nor systematically. To overcome this, the internal relationships between the field parameters can be examined, and the field can be reduced by eliminating mutually contradictory conditions. In addition, increased levels of sophistication can be applied to MA, e.g., incorporating weighting of ideas based on cost information to guide users to select from the subfunctional options. In the absence of coherent strategies for identifying preferred solutions, it has been observed that, once a few plausible alternatives have been tried, the search for a better solution gets abandoned[28]. Charles S. Whiting noted that, in practice, the development of too many possibilities can lead to problems in effectively evaluating the alternative concepts[29]. However, computational approaches have helped exclude non-consistent combinations[20].

3 Case Study: Applying MA to a Contested Urban Landscape Planning

Urban green space planning is often characterized by competing interests, spatial constraints, and divergent visions among stakeholders. In rapidly urbanizing contexts, community landscapes can become arenas of social contestation, where ecological restoration goals, municipal regulations, and community aspirations collide. For example, debates may arise over whether limited land should prioritize stormwater management infrastructure, recreational amenities, or community food production. Such conflicts highlight the difficulty of achieving consensus when multiple actors hold different values, priorities, and time horizons.

The goal of this case study was to explore how MA can be applied as a problem-structuring and decision-support tool in contested landscape planning. Specifically, the study aimed to: 1) identify the principal subsystems and parameters that structure urban green space planning under conditions of conflict; 2) map alternative configurations to visualize the breadth of possible solutions; and 3) test how MA, combined with participatory discussion and AI-supported visualization, can support more inclusive scenario design.

To construct the relevant MA chart (Table 2), this case study

Table 1: A generic MA chart

Subsystem	Means				
Subsystem 1	Means 1 of fulfilling subsystem 1	Means 2 of fulfilling subsystem 1	Means 3 of fulfilling subsystem 1	...	Means *N* of fulfilling subsystem 1
Subsystem 2	Means 1 of fulfilling subsystem 2	Means 2 of fulfilling subsystem 2	Means 3 of fulfilling subsystem 2	...	Means *N* of fulfilling subsystem 2
Subsystem 3	Means 1 of fulfilling subsystem 3	Means 2 of fulfilling subsystem 3	Means 3 of fulfilling subsystem 3	...	Means *N* of fulfilling subsystem 3
...	...	...	...	...	...
Subsystem *M*	Means 1 of fulfilling subsystem *M*	Means 2 of fulfilling subsystem *M*	Means 3 of fulfilling subsystem *M*	...	Means *N* of fulfilling subsystem *M*

Table 2: MA chart of 12 key subsystems of contested urban landscape planning

Subsystem	Means of fulfilling the subsystem					
Energy mix	Solar photovoltaic only	Oil only	Photovoltaic thermal	Solar + wind	Solar + wind + gas turbine engines	Solar + gas turbine engines
Cityscape	None-distributed living	Mega-cities	Urban sprawl	Status quo	Historic core with modern perimeter	Multi-nodal
Housing	High-rise only	Low-rise only	Garden city (Gartenstadt)	Terraced only	Mixed	Detached family homes
Land distribution	Status quo	Equal per person by value	Equal per person by area	Market-assisted land reform	Zoned	Cooperatives
Personal autonomy	None (state control)	High	Medium	Low (e.g., rigid control on personal rights)	—	—
Economic	Boom growth/rapid recovery	GDP remains stagnant	GDP falls by up to 5% (recession)	GDP falls by up to 10% (mild depression)	GDP falls by 10% ~ 20% (severe depression)	GDP falls by over 20% (very severe depression bordering on catastrophic)
Social	No fundamental change in social relationships (return to pre-pandemic state)	Increasing search for scapegoats as the economy weakens	Increasing hedonism and "me" attitudes	New social awareness emerges, hedonism and "me" attitude become less prevalent	Seek comfort in smaller social groups, family, and local communities (community spirit)	Major social fragmentation under economic stress
Technological	On the current course pre-pandemic (no change)	Remote access to technologies accelerates	Physical representation technology expands	Pollution control tech expands	Declined interest in transport tech	Medical advances to majority of current diseases and health conditions
Other global catastrophic risks	None-foreseen	Covid-19 second surge	Covid-19 mutation (and/or new major pandemic)	Climate change speeds up	AI accidents or rogue behavior	Nuclear accident
Time horizon	≤ 1 year	1 ~ 2 years	2 ~ 5 years	> 5 years	Never	—
Personal transport	Status quo	Status quo evolution	Rush to electric for all forms of transport	Train, E-Bus, E-Bike mix	Model E "Ford" paradigm (electric cars everywhere)	Massive reduction in people's movements and requirements
Environment	+ 2 °C (300 kph wind events become regular)	+ 1.5 °C (200 kph wind events become regular)	+ 1°C (people can live with it, but energy demands for heating, ventilation and air conditioning would rise, and biodiversity would be a distant memory)	—	—	—

NOTE

The options marked in green are the choices of Group 1, while those marked in blue represents the choices of Group 2. The options marked in orange are common choices, e.g., "Medium" and "Train, E-Bus, E-Bike mix."

combined expert-informed group discussion and literature review on participatory green infrastructure and community land use. A facilitated workshop was conducted with 12 participants: 4 landscape designers, 3 community representatives, 2 municipal planners, and 3 environmental policy analysts. Participants were selected for their expertise in participatory design, prior involvement in local greening projects, and their ability to represent diverse perspectives (e.g., policy, grassroots, technical). The workshops were conducted in 2 half-day sessions (4 h each), involving morphological decomposition exercises, option elicitation, and concept synthesis. Discussions centered on questions such as: 1) What key subsystems structure the planning of a contested community landscape? 2) What are the primary tensions between stakeholder groups? And 3) what types of solutions are considered viable by different actors?

The morphological chart generation process led to the identification of 12 key subsystems with multiple internally consistent options (Table 2), considering aforementioned broad requirements, needs, and principal enablers, with reference to relevant domains and areas of expertise such as urban design[30–32]. Although alternative subsystems could be defined, the chart in its current form has been found useful across differing nationalities and political contexts. In addition, using a tabular format in a spreadsheet makes it easy to add items that have not been listed.

Table 2 illustrates a practical illustration of scenario planning, where personal preferences guide the selection process. Once the choices are made, it is essential to synthesize the overall selection and give it a tangible form. Envisioning and discussing what such a scenario would entail can be supported by a preliminary sketch or visual aids employing more advanced tools, such as prompt engineering and AI visualizers like Vizcom (Figs. 1, 2). However, such visualizations may not fully capture the intentions of the selector, thus iterative refinements may be required to ensure that the AI-generated imagery aligns with the original vision. Recently, the use of AI large language models, including ChatGPT and Gemini, to craft abstract narratives for chosen solution configurations has shown promising, albeit with limited success[33].

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Fig. 1 AI image representing the choice of Group 1, where the design plan of a megacity concept significantly influences the visual outcome (image generated with Vizcom).

Fig. 2 AI image representing the choice of Group 2 (image generated with Midjourney).

This methodology can be effectively combined with hierarchical decision-making principles, such as the Analytic Hierarchy Process[34], or other multi-criteria decision analysis methods, as well as enriched by integrating landscape design considerations. For instance, the choice of "garden city" for housing in Table 2 suggests an emphasis on green spaces and sustainable living, which can be elaborated upon in the visual and narrative synthesis. Similarly, the choice of "solar + wind" for energy mix indicates a preference for renewable sources, which can influence the design of urban and rural landscapes to incorporate solar panels and wind turbines aesthetically.

In essence, incorporating landscape design aspect introduces more in-depth scenario planning, allowing for a more comprehensive and visually engaging representation of the selected configurations within the broader context of urban and rural environments.

MA charts offer a structured approach to elaborating on various subsystems, providing a comprehensive framework for addressing complex societal issues. These charts can be tailored to specific subsystems, such as energy, mobility, and apartment typology, which are crucial for societal planning and development. By integrating landscape design considerations, these charts can be further enhanced to reflect the interplay between built environments and natural systems.

For instance, when designing energy systems, the chart can be expanded to include landscape elements, such as solar farms integrated into agricultural fields, or wind turbines positioned to complement the natural terrain. It can not only optimize energy production but also help harmonize energy facilities with the surrounding landscape, enhancing aesthetic and ecological values. In the context of mobility, the chart can incorporate options including green corridors for electric vehicles or bicycle paths that blend seamlessly with parks and recreational areas. Such integration promotes sustainable transportation while also enriching the landscape with functional and visually appealing features. For apartment typology, specific charts can explore designs that maximize natural light and views, or that integrate green roofs or vertical gardens for a better living environment. In such way this approach improves the quality of life for residents and contributes to the overall biodiversity and sustainability of urban landscapes.

Table 3 represents a valuable tool for analyzing the relationship between energy flow and morphological structures, commonly utilized in fields such as ecosystem studies, architectural environments, and industrial design. It enables consideration of options for more sustainable, efficient, and adaptive design solutions by optimizing resource utilization, energy transfer, and environmental response. For instance, in architectural design, integrating the energy morphology supports the optimization of building form, materials, orientation, window arrangement, and insulation structures through prompts for solar radiation, wind, and thermal energy transfer. At the city scale, energy morphology guides the design of sustainable city energy systems and spatial layouts by analyzing the morphology of urban energy flows, such as electrical grids, traffic flows, and waste management. Alternatively, based on natural energy morphologies (e.g., water, air flow), green corridors or rainwater management systems can be designed to balance ecology and functionality[35–36]. The application of energy morphology in design not only aids in optimizing resource use and energy efficiency, but also promotes design innovation and sustainable development. From architecture to product design, from cities to social culture, MA provides designers with a systematic perspective and methodology, helping design better serve the balanced needs of ecology and society. Of interest, the notion of morphology has been explored extensively in urban design through form-based codes, which combine concepts from historical urban morphology to enhance understanding and provide continuity in urban development[37].

Furthermore, MA charts can address broader societal challenges such as flooding (Table 4). It can evaluate options such as rain gardens, bioswales, and permeable pavements to manage stormwater effectively and enhance urban green space, by involving landscape design. This holistic approach ensures that flood mitigation strategies not only are functional, but also contribute positively to landscape aesthetics and ecological health. In summary, the incorporation of landscape design into MA charts provides a more nuanced and integrated perspective on societal subsystems, ensuring that solutions are technically sound, aesthetically pleasing, and environmentally sustainable.

Spatially, by enhancing plant coverage of river corridors, drainage basins and flood-prone depressions, urban watercourses and wetland systems can be integrated into a permeable, detention-

Table 3: MA chart for energy

Subsystem	Means of fulfilling subsystem						
Energy strategy	Zero-carbon	Free for all	Self-sustained	—	—	—	—
Energy source	Wind (onshore)	Wind (offshore)	Nuclear (fission)	Nuclear (fusion)	Solar	Biomass	Geothermal
Energy transmission	Local consumption	Air conditioning	Heating, ventilation and air conditioning	High-voltage direct current	—	—	—
Energy storage	Batteries (lithium-ion)	Hydrogen	Pumped hydro	Flywheel	Gravity	—	—
Energy use	Industrial process	Residential heating/cooling	Electric vehicles	Home appliance	—	—	—
Energy demand flexibility	None	Direct control	Time-of-use tariff	Virtual power plant	Peer-to-peer trading	—	—
Energy data	Energy market	Smart meter	Operational data	AI	—	—	—

Table 4: MA chart for flood risk mitigation

Subsystem	Means of fulfilling the subsystem							
Geographic attributes	Steep-sided channels	River drainage and surface run-off	Percentage of woodland and local vegetation	Drainable basins in urban areas	Coincidental incidence of flooding and high tides	River collusion	Ground saturation and water table	—
Meteorological attributes	Increased rainfall prediction	Are there flood warnings and climate predictors?	Rainfall distributed in local area	—	—	—	—	—
Stakeholders	Residential homes on the flood plain	Farmland on the flood plain	Public/private establishments on the flood plain	—	—	—	—	—
Social and economic actors	Infrastructure integrity value	Local economies inherent value	Percentage of residents working for public sector in flood mitigation and environmental regulation	Percentage of residents with knowledge of flood prevention	Number of insurance companies specializing in flood risk and compensation	—	—	—
Physical prevention actions	Dam construction in rural areas	Local development planning for rivers	Drainage systems and water collection strategies	Planting and effects of environmental development	Forest density	—	—	—
Mitigation policies	Planned flooding mitigation and capability of the local area	Capacity of engineering and technology to deal with flooding	Agricultural methods to mitigate farmland and livestock destruction	Capability of strategies to prevent transport disruption	Capability of strategies to maintain communication lines	Capability of health strategies to prevent water pollution and disease	Level of education value for localized flooding	Are there effective methods in place to warn the population?

oriented ecological matrix. At the neighborhood scale, permeable pavements, rain gardens, and green roofs are arranged in a cascade that incrementally retains and infiltrates stormwater, thereby reducing pluvial flood risk. At the dwelling-cluster scale, stilted or elevated podiums raise living floors above design flood levels, while multi-functional waterfront public spaces serve as everyday recreational areas and, during flood events, as temporary retention basins and evacuation zones. The coupling of “community cells” with distributed water-ecological nodes simultaneously safeguards daily life and emergency safety. Socio-economically, the plan embeds community-based education and an Information and Communication Technology-enabled early-warning system that delivers real-time flood information to residents. By aligning insurance instruments with spatial planning, the framework incentivizes homeowners and developers to invest in flood-adaptive construction and maintenance, enhancing collective resilience. Regarding infrastructure and public services, arterial roads and metro entrances are co-designed with crest-level alignment and stormwater outfall corridors; critical communication and energy assets are sited on elevated refugia; emergency medical and public-service hubs are located at blue–green junctions to guarantee rapid response and equitable coverage during disasters. Collectively, these measures weave a multi-layered flood-mitigation framework— “natural retention + community resilience + infrastructure hardening + policy enablement" —that enables the city to respond to floods across geographical, climatic, social, economic, and governance dimensions, advancing both sustainability and safety. Several illustrations of this design are provided in Fig. 3.

The MA chart for apartment typology presented in Table 5 lists functions or characteristics related to apartment design, and identifies the core requirements, such as flexibility, sustainability, and community functions. This tool allows for the decomposition or combination of key modules or design dimensions, including building height, building shape, spatial layout, functional zoning (e.g., residential areas, work areas, leisure areas), and environmental factors (e.g., ventilation, daylighting, sound insulation). Through the permutation and combination of various


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Fig. 3 AI image representing the design solutions for flood risk mitigation based on the selected options (images generated with Midjourney).

Table 5: MA chart for apartment typology

Subsystem	Means of fulfilling the subsystem					
Building orientation	East–west	North–south	Mixed	—	—	—
Building height	Low rise	4 ~ 6 stories	7 ~ 10 stories	11 ~ 30 stories	> 30 stories	—
Building shape	Block	Courtyard block	Open block	—	—	—
Building access	Single-loaded horizontal	Double-loaded horizontal	Skip-stop single	Skip-stop double	Vertical	—
Number of bedrooms	Studio	1 bedroom	2 bedrooms	3 or more bedrooms	—	—
Aspect	Single perpendicular	Single parallel	Double	Corner	—	—
Type	Studio	Duplex	Mezzanine	Dormitory	—	—
Private open spaces	Cantilever	Recessed	Semi-recessed	None	—	—
Lighting	Excellent	Satisfactory	Poor	—	—	—
Temperature control	Natural	Central heating	Individual air-conditioning	Central air-conditioning	Individual heating	—
Ownership	Freehold	70-year leasehold	40-year leasehold	Non-resalable	Shared/cooperative	Rental
Utility supply	Regional	Localized	Per dwelling	Residential rate	Commercial rate	—
Dwelling size (m^2)	≤ 30	31 ~ 60	61 ~ 90	91 ~ 120	121 ~ 300	> 300
Using type	Residential	Residential/commercial	Serviced apartment	—	—	—
Dwellings per floor	1 or 2	3 or 4	4 ~ 10	> 10	—	—

options, multiple design solutions can be generated and syntheses of selections for the charts are presented in Fig. 4. MA can enable practitioners to systematically organize the knowns and unknowns of a multifaceted issue at an early stage in the realms of landscape design, architectural planning, or spatial planning. This issue may encompass a variety of qualitative and quantitative elements, including both tangible aspects such as building materials and spatial layouts, as well as intangible ones such as user experiences and ecological impacts. MA transcends a linear or isolated examination of the problem, as it captures a more authentic portrayal of the intricacy and interconnectivity inherent in design challenges. This is particularly crucial when it is required to integrate behavioral and social considerations with the attributes of various stakeholders involved in the design process. The method's strength lies in its capability to fuse both "hard" quantitative data (e.g., structural loads, environmental performance metrics) with "soft" qualitative insights (e.g., aesthetic values, community engagement).

Furthermore, MA is equipped with the ability to pinpoint outliers and subtle indicators early on, as well as to anticipate unintended consequences, both positive and negative. This early identification is invaluable for landscape architects, architects, and planners, as it aids in the mitigation of risks associated with pursuing infeasible or inconsistent solutions. By subjecting complex design problems to a more thorough evaluation, MA supports a more rigorous and informed decision-making process. In essence, MA serves as an indispensable tool for design professionals by providing a structured yet flexible framework that accommodates the multi-dimensional nature of design challenges. It ensures that the solutions developed not only are technically and functionally sound, but also resonate with the social, cultural, and environmental contexts, which is vital for creating sustainable, inclusive, and aesthetically pleasing built environments that stand the test of time and meet the diverse needs of users.

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Fig. 4 AI image representation of design solutions for apartment typology based on the selected options (images generated with Midjourney).

4 Discussion

The MA charts provide a valuable opportunity for exploration and experimentation, aligning with design thinking approaches where concepts for social life can be conceptualized and their adoption can be evaluated[38–39]. Unlike traditional approaches that rely on a fixed worldview, MA deliberately avoids universalism or prescriptivism from a single perspective[40]. Users of MA are not passive recipients but active agents, able to interpret options according to their own or evolving worldviews, to adapt or even subvert given categories. In this sense, the user of a MA chart becomes a societal designer—either defining a new concept or providing a stepping stone toward the transformation of an existing state. Multi- and cross-disciplinary inputs thus play a crucial role in structuring the morphological problem space, ensuring that a comprehensive set of options is derived and fairly considered.

A framework (Fig. 5) demonstrates how MA can be applied to address socially contested scenarios in landscape and urban design. The process begins with society, conceptualized as a complex system of institutions, organizations, and interactions. From this system, a set of variables is extracted, each representing a relevant dimension of social life (e.g., governance, land use, environmental risks, community needs). These variables are further decomposed into subsystems, and multiple options are identified for each, which together form the MA chart. By applying optimization techniques such as pair-wise consistency analysis, incompatible or unrealistic combinations are excluded, thereby reducing the otherwise overwhelming problem space.

The resulting framework supports the generation of *N* societal configurations, a process referred to here as society optioneering. These alternative societal constructs provide multiple lenses for imagining possible futures, especially in contexts where conflict, uncertainty, and divergent stakeholder views are present. Finally, the configurations are translated into landscape design concepts, either through traditional design synthesis or by leveraging emerging AI-based generative tools (e.g., text-to-image or text-to-design prompts). Through this integration, MA enables a systematic, participatory, and creative exploration of contested design scenarios, bridging social system complexity with spatial

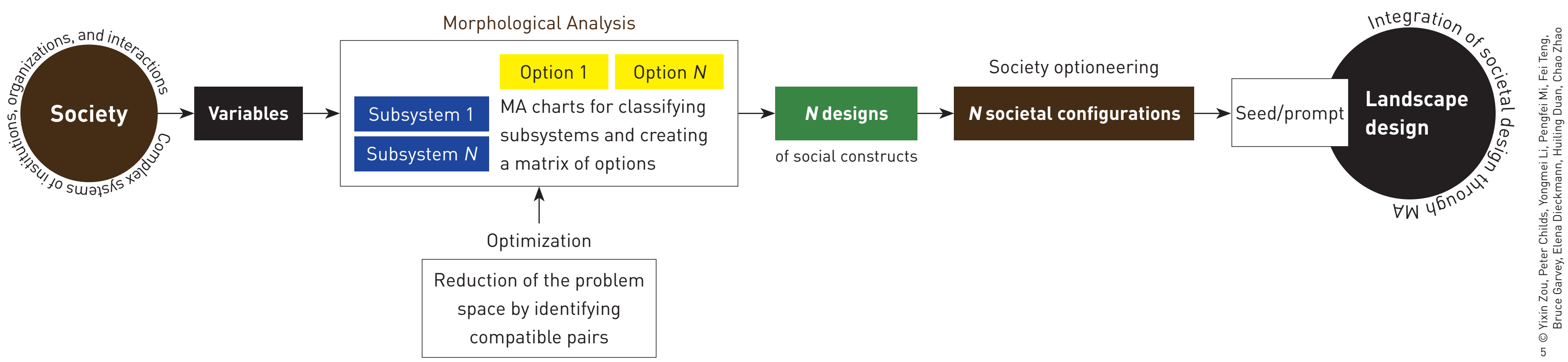

Fig. 5 A diagram exhibiting how MA can support the structuring and exploration of socially contested scenarios in landscape design.

design practice.

While this framework opens diverse pathways for envisioning alternative futures, the very richness of options also introduces a new challenge: how to navigate and evaluate such a wide spectrum of possibilities? To address this challenge, integrating MA with iterative design workflows becomes particularly valuable. Rather than treating it as a standalone analytical exercise, embedding MA within design thinking enables the systematic organization, selection, and refinement of options throughout each stage of the design cycle (Fig. 6): 1) problem understanding and variable definition; 2) creative generation; 3) systematic evaluation and integration; 4) iterative optimization. Thus, complexity can be transformed into a structured source of creativity.

Beyond its methodological role, MA underscores the interplay between technology, economy, and social structures. Manuel Castells in 2011 highlighted how information technology reshaped social forms[41], while Ezio Manzini emphasized design's central role in collaboration, community building, and driving social innovation[42]. These insights converge with MA's ability to conceptualize "societal morphology" through the structured exploration of relationships and interactions across diverse subsystems. Moreover, AI technologies are becoming significant enablers: in design practices, large language models can assist in defining subsystems and narratives, while generative AI tools can facilitate visualization and rapid prototyping[43–44].

The proposed society optioneering methodology demonstrates how MA can generate and evaluate diverse societal configurations, integrate multiple perspectives, and address complex social challenges. It fosters interdisciplinary collaboration, strengthens scientific and adaptable design frameworks, and expands innovation potential by bridging structured analysis with creative exploration. Through its flexibility and system-implicit architecture, MA ensures continuous optimization throughout the design process, offering robust pathways for sustainable societal development and advancing the theoretical and practical frontiers of landscape and urban design.

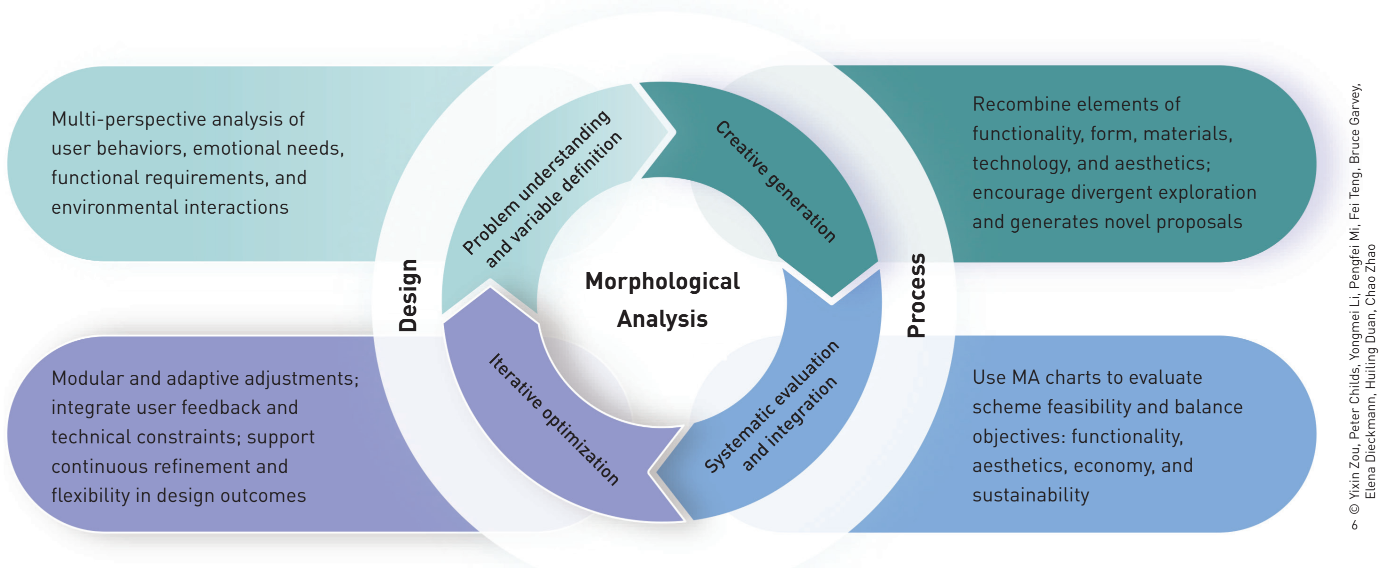

Fig. 6 A diagram exhibiting how MA is integrated with the design process.

5 Conclusions

This paper introduces the application of a structured, options-based methodology, MA, for addressing the complexities of societal design in the context of contemporary challenges. The morphological charts presented in this study support the exploration of diverse subsystems, encompassing not only functional aspects but also operational considerations such as environmental risks and social conflicts. By employing cross-consistency analysis, the extensive array of options generated can be systematically narrowed, ensuring a more focused and manageable pathway for landscape and urban design strategies.

The study makes three principal contributions. 1) Theoretical contribution: It advances design methodology by extending morphological thinking into the field of societal design, demonstrating its systematic, flexible, and innovative qualities when applied to contested urban and landscape contexts. 2) Practical value: It provides planners, designers, and policymakers with a structured toolset for navigating uncertainty and conflict in urban and landscape design, enabling more transparent and participatory processes in projects such as green infrastructure planning, community space design, and sustainable city transformation. 3) Technological integration: It identifies pathways for combining MA with visualization tools such as AIGC, accelerating early-stage prototyping, enhancing collaborative engagement among stakeholders, and broadening the creative exploration of design alternatives.

While the methodology proves effective for generating and structuring a wide spectrum of scenarios, certain limitations remain. A key challenge lies in the potential abstraction and computational demands of morphological thinking when addressing high-dimensional variables in complex social-ecological systems. To address this, future research should further integrate MA with AI and advanced visualization tools to improve efficiency, automation, and interpretability, and investigate the adaptability of MA frameworks to specific urban and landscape challenges, refining tools to better meet the requirements of sustainable spatial design.

Overall, this study contributes to urban and landscape design theory by introducing methodological approaches, expanding the application of morphological thinking in societal and spatial domains. Specifically, in landscape design and urban planning, MA offers a rigorous yet flexible framework for managing complexity, balancing stakeholder interests, and fostering innovation in contested contexts. On the practical level, its modularity and capacity for structured combination optimization provide effective guidance for projects ranging from green infrastructure planning to urban transformation and community-led design. Moreover, the integration of AIGC for scenario sketching and visualization significantly benefits the early design stages, bridging structured analytical processes with creative synthesis. This synergy highlights MA as a versatile and powerful tool in the evolving toolkit of landscape architects and urban planners, promoting both methodological innovation and sustainable spatial design practice.

Competing interests | The authors declare that they have no competing interests.

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社会未来形貌构建：通过形态分析设计多样性社会图景

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摘要

在城市规划、景观与建筑设计领域，设计师和规划师常面临复杂且多维的社会议题。为有效应对这些挑战，本研究引入形态分析方法，系统探索并辅助生成多样化的社会设计方案。形态分析可构建“子系统–选项”矩阵，同时兼顾定量因素与定性因素，让设计师能够在项目早期阶段，运用该方法评估问题的确定性或不确定性。本研究进一步将形态分析与人工智能生成内容进行深度融合以迅速生成及评估多样化的设计提案，提升设计流程的创新效能与实用价值。基于本文所提出的社会未来形貌构建框架，设计师能够从多种视角审视设计问题，发现更多元的解决方案，并依托系统化的评估工具对设计方案进行有效评估。由此，可保持设计过程的动态适应性，进而实现设计策略的持续优化与迭代升级。本研究丰富了设计理论体系，也为相关设计实践提供了实用工具与指导。

关键词

社会设计；形态分析；人工智能生成内容；可持续性；城市规划；景观设计

文章亮点

- 引入形态分析法作为应对城市设计中社会复杂性与不确定性的工具
- 提出“社会形态学”以将文化、制度、组织与空间系统纳入可持续设计
- 整合形态分析与人工智能生成内容，实现快速场景构建与参与式可视化设计
- 形成社会未来形貌构建框架，以包容性和可持续性原则为指引，探索多样性设计方案

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