

Society Optioneering: Designing Societal Alternatives Through Morphological Analysis

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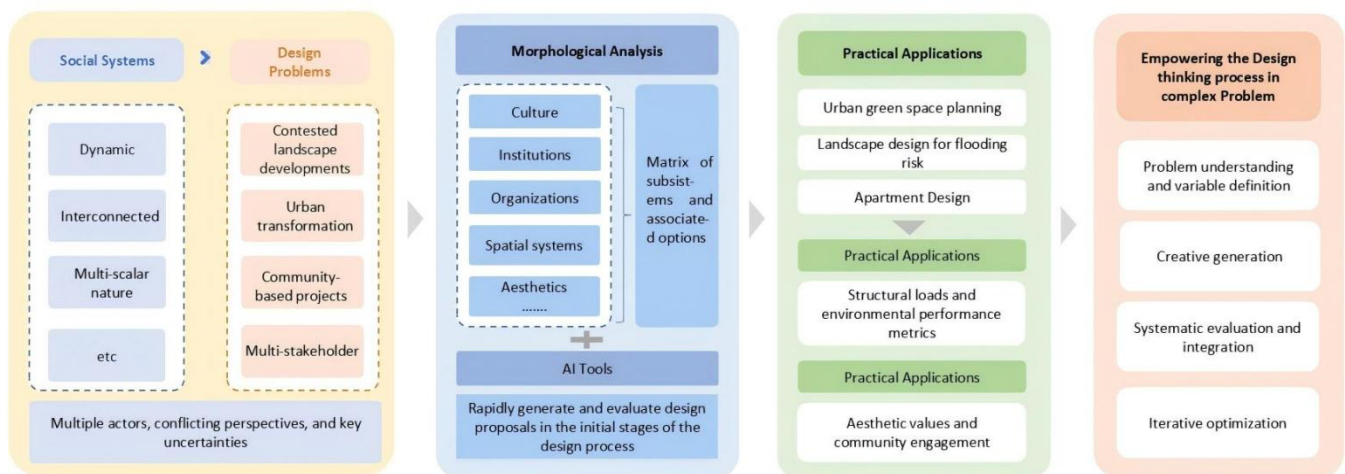
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GRAPHICAL ABSTRACT



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 approach that systematically explores and aids generation of a variety of societal design solutions. Morphological analysis involves construction of a matrix of subsystems and associated options, the method enables designers to explicate certainties and uncertainties at the earliest project phases while simultaneously integrating quantitative metrics and qualitative insights. The research further advances this framework through deep integration with Artificial Intelligence Generated Content (AIGC). Leveraging AIGC's capacity for rapid, high-variance generation, the approach accelerates the production and iterative evaluation of design proposals during the formative stages, thereby amplifying both innovative potential and pragmatic viability. Within this

hybrid structure, designers are positioned to interrogate problems from multiple epistemic vantage points, revealing an expanded solution space. Systematic evaluation tools embedded in the workflow ensure rigorous, evidence-based assessment, enhancing the scientific grounding and adaptive capacity of the design process. Consequently, design strategies can be continuously refined and recursively upgraded. The study contributes to design theory while furnishing practitioners with a robust, operational toolkit.

KEYWORDS

Urban Planning; Landscape Design; Design; Morphological Analysis; AIGC; Environment; Sustainability

HIGHLIGHTS

- Introduces Morphological Analysis as a structured tool to address social complexity and uncertainty in urban and landscape design.
- Proposes the concept of Societal Morphology to link culture, institutions, organizations, and spatial systems within sustainable design.
- Combines Morphological Analysis with AI-generated content to enable rapid scenario creation and participatory visualization.
- Develops the Society Optioneering framework, Embeds Morphological Analysis within iterative design thinking, delivering urban and landscape diversity design options guided by principles of inclusivity and sustainability, enhancing systematic exploration and evaluation.

1 Introduction

Understanding and modelling 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 modelling of concrete social scenarios, such as contested landscape developments, urban transformation, and community-based projects.

Conventional approaches to social system modelling, ranging from computational simulations and agent-based models to qualitative methods and social network analysis, have generated valuable insights into diffusion processes, behavioural 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 such 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 modelling is unfeasible, while accommodating diverse stakeholder perspectives. Despite this potential, the application of MA to socially contested, spatially anchored design problems, particularly in landscape and urban planning, remains underexplored in existing scholarship.

This paper makes three key contributions to address this gap: (1) Methodological Advancement: It introduces morphological analysis as a structured yet flexible framework for navigating complex social scenarios in landscape and urban design, providing a methodological bridge where conventional modelling falls short. (2) Contextual Innovation: It situates MA within real-world, community-driven 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 AI-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.

The central research question guiding this study is: How can morphological analysis support the structuring and exploration of socially contested scenarios in landscape and urban design contexts? In answering this, the paper argues that MA provides a participatory and optioneering-oriented design methodology, capable of enriching sustainability-oriented planning practices where traditional approaches prove insufficient.

The structure of the paper is as follows: Section 2 introduces the theoretical foundations and methodological principles of morphological analysis; Section 3 demonstrates its application through a scenario-based design process addressing landscape conflicts; Section 4 discusses findings and limitations; Section 5 concludes with reflections on the integration of MA with generative AI tools and highlights future research directions for sustainable landscape and urban design.

2 Morphological Analysis and Its Methodological Basis

2.1 Societal Design

The concept of society relates to the organisation of a community of people that may share some cultural characteristics, activities and traditions, and access the same institutions. Institutions in this context following the line of thought developed by Geoffrey M. Hodgson (2006)^[2] include entities such as government, law, social norms^[3] and academia, and provide a key function in society enabling ordered thought, defined expectations and action by imposing form and consistency on human activities. Indeed, institutions enable behaviour 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 behaviours enable, on the whole, effective passage for the majority of vehicle users on a given road each day. As Hodgson notes, regulation, far from being a limiter, can provide freedoms^[2].

As institutions, representing systems of established and embedded social rules that structure social interactions, depend on the actions of individuals they also mould behaviours. Through this institutional feedback they have self-reinforcing and self-perpetuating characteristics. Geoffrey M. Hodgson^[2] uses the distinction that an organization is a special institution that involves criteria to establish boundaries and to distinguish their members from non-members. This also includes principles defining who is in charge, and chains of command and associated responsibilities for the people within the organization. As society involves so many interrelated functionalities it can be useful to consider constructs that require agreement between groups of people. As examples of such constructs, John R. Searle (2005)^[4] ascribed the term social fact to constructs that depend on human agreement such as money, property rights, marriage, sports and celebration dates in contrast to physical objects.

A systems approach is manifest in literature on economic development. Charles Edquist^[5] (2013) notes, 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. The 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' as described by James Fleck^[6] has consistency across many domains (1993). Although a system may be apparent in a society, it should be noted that not all national systems have been consciously designed^[7] and may have arisen from multiple actors that have played a role in the influencing the development of a current state, in the form sometimes of unintended consequences from previous actions.

Society and its associated institutions, organisation and interactions exhibits various forms of complexity^[8]. Elliott Ash et al.^[9] note that complexity describes a particular form of system where a constellation of actors and relationships give rise to specific types of system dynamics. Complex adaptive systems where agents are capable of learning and changing behaviours are typical in social systems. While there are many actors in society, and states may be dominant, significant parties can also include non-governmental organisations, multi-national companies, social movements, expert communities and

even individuals^[10]. Inherent to some institutions such government, organisations and even individual actors is the concept of power and as such needs to be considered in modelling.

If a system approach is accepted then inclusion of factors such as land, urban and rural interrelations, labour and physical capital as associated with classical economics may be appropriate in modelling. However, the notion of human capital^{[11][12]} and social capital^[13] also need to be considered. Any concept of society design and development and its modelling would need to address such possibilities^{[14][15]}.

As indicated, society is a highly complex entity, due to a vast number of variables required to visualize both the boundaries and structure, whilst being exacerbated by high levels of inter-connectivity. This is not just due to the variety of components that have to be considered in the (problem) structuring process but also due to intangible factors within the nature of individual and group behaviour inherent in the concept of society. Indeed, the issues to be confronted are very similar to those encountered in the broader design process familiar in domains such as engineering, architecture and industrial design, and design thinking^{[16][17][18]} principles such as frame creation, a human centred approach, 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, focusing on the needs and experiences of individuals and communities. In contrast, "societal design" refers to the systemic modelling 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 and thus faces a range of uncertainties. The further a design concept is from realization 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 at later stages—especially when the project is constrained by resources (time, money, people, requirements). These issues impact not just the creative, early-stage of the project but across the entire design spectrum.

When confronted by uncertainty, complexity, and inter-connectivity, methods exist to support decision-makers (as well as designers and analysts). One such method is morphological analysis, a powerful decision-support tool within the category of Problem Structuring Methods (PSMs). Morphological analysis 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. Early consideration of the actual problem space can mitigate some inherent uncertainties during the overall design process.

Morphological analysis enables the structuring and analysis of complex problems which:

- Are inherently non-quantifiable
- Are stakeholder orientated with strong socio-political, cultural and technical positions
- Contain non-resolvable uncertainties
- Cannot be modelled easily or simulated
- Require a judgmental approach to be placed on a sound methodological basis^[21].

Temporal period and spatial proximity are important factors in consideration of society with persistence of activity important in the formation and maintenance and definition of society. The notion of societal makeup can be defined in many ways, such as:

- Common culture, institutions and patterns of social relations
- Principal daytime activity by age group within a spatial region

-System modelling with subsystems defined by function.

This paper adopts a functional approach, representing society as an overall system with interactions between subsystems. Morphological analysis 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. Moreover, the methodology used for exploring options, morphological analysis, provides opportunities for both implicit and explicit consideration of factors.

2.2 Morphological Analysis and Charts

There are numerous interpretations of morphological analysis. Two generic versions are considered here, the first embracing a more formal, theoretical interpretation and secondly a more user-based perspective^[1]. Formal morphological analysis is a method for systematically structuring and examining the total set of possible relationships in a multidimensional, usually non-quantifiable, problem space. Such problems are not only complex but exacerbated by high levels of inter-connectivity adding further complexity to the problem. Each set of configurations generated can be considered as a bundle of attributes. By identifying all the variables relating to the problem, all possible combinations of these variables (configurations) are examined. Through a reductive process, whereby inconsistent individual pairs of variable are filtered out with the help of software, computing only those configurations where all variables are consistent with one another, a final set of viable solutions can be compiled for further analysis. Morphological analysis allows for all ideas to be considered as a first stage in the analysis process and as such is an exploratory method par excellence ^[1].

In essence morphological analysis provides management and policy makers with the ability to identify informed and innovative options when confronted with complex problems. The process mitigates the risk of making the wrong decision in the face of uncertainty. It does this by structuring the problem, filtering out inconsistent relationships within the problem boundary, to generate a much-reduced set of workable solutions. Additionally, it processes unstructured ideas and concepts and renders them down to a set of modular components, which can be used to help in the construction of new and innovative “products” or concepts.

Morphological analysis 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] but has also found applications 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 United States, with contributions to the development of the methodology from the Swedish Morphological Society^[24]. Zwicky (1969) identified key parameters of aviation engine technology, including the thrust mechanism, oxidizer and fuel type and broke each of these functions down into constituent parts under each parameter or sub-system^[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 and solution already existed, potentially enabling rapid adaptation and deployment. New or original permutations of options were viewed by Zwicky as stimuli for creativity and consideration. Morphological analysis has been demonstrated as an effective ideation and innovation realisation methodology for new product development, services, patent definition and value management. The methodology has been further developed for risk assessment^[19] and has found widespread adoption in engineering and design curriculums to augment exploration of diverse concepts^[22]. The technique comprises two key elements:

-Systematic analysis of current and future structures of a domain as well as identification of key gaps in that structure – or the Problem Space.

-Stimulus for invention of alternatives that fill these gaps and meet the imposed requirements – or the Solution Space.

The term morphological analysis is common to several subject disciplines including linguistics. Here, however, the term is used to refer to a specific creativity tool for the generation of alternative concepts by means of development of generic sub-functions for a product or process, and consideration of alternative means for implementation of each sub-function.

Morphological analysis is a technique that can be used to generate additional ideas for product concepts that would not normally spring to mind. The technique involves considering the function of a generic solution to a problem and breaking it down into a few systems or sub-functions. The notion of functionality is common in design with consideration commonly given to form and functional attributes. However, additional granularity is possible with consideration of technical, aesthetic, economic, social and latent functions^[25]. The notion of a set of related attributes that need to be fulfilled simultaneously will be familiar from Abraham H. Maslow's hierarchy of needs^[26] in its various formulations with consideration given to physiological, safety and social requirements, self-esteem and actualisation.

In the example explored here we generate a variety of means to fulfil each of these systems, sub-systems or sub-functions. The sub-functions and potential means of fulfilling each of these sub-functions can be arranged in a grid as illustrated generically in Table 1. An overall solution can then be formulated by selecting one means for each sub-function and the combination of these forms the overall solution. The grid can be populated by text or sketches depicting the potential means of fulfilling the sub-system requirement^[27]^[22]. The technique relies upon the user's selection of sub-function options to synthesise an overall solution or set of possibilities. The user can explore the design space systematically, using their experience to guide the outcome, or experimentally or using defined criteria. The matrix given in Table 1 is abstract and generic in its formulation, showing the subdivision of a system into a number of relevant subsystems and a series of means for fulfilling each subsystem^[22]. Care needs to be applied in defining the functional requirements to avoid the specification of functions and sub-functions with a pre-conceived solution.

Table 1: Generic morphological analysis chart.

SUBSYSTEM	MEANS			
	method 1 of fulfilling subsystem 1	method 2 of fulfilling subsystem 1	method 3 of fulfilling subsystem 1	method n of fulfilling subsystem 1
Subsystem 1	method 1 of fulfilling subsystem 1	method 2 of fulfilling subsystem 1	method 3 of fulfilling subsystem 1	method n of fulfilling subsystem 1
Subsystem 2	method 1 of fulfilling subsystem 2	method 2 of fulfilling subsystem 2	method 3 of fulfilling subsystem 2	method n of fulfilling subsystem 2
Subsystem 3	method 1 of fulfilling subsystem 3	method 2 of fulfilling subsystem 3	method 3 of fulfilling subsystem 3	method n of fulfilling subsystem 3
Subsystem 4	method 1 of fulfilling subsystem 4	method 2 of fulfilling subsystem 4	method 3 of fulfilling subsystem 4	method n of fulfilling subsystem 4
Subsystem 5	method 1 of fulfilling subsystem 5	method 2 of fulfilling subsystem 5	method 3 of fulfilling subsystem 5	method n of fulfilling subsystem 5

A typical morphological field can contain many orders of magnitude of formal configurations. This number of permutations is likely to be far too many to inspect casually or even by systematic attempts. To overcome this, the internal relationships between the field parameters can be examined and the field reduced by eliminating mutually contradictory conditions. In addition, increased levels of sophistication can be applied to morphological analysis, such as weighting of ideas, for example, costing information to guide users in the impact of the individual selection of each sub-functional option. In the absence of coherent strategies to identify preferred solutions, it has been observed that once a few sets of plausible alternative selections have been tried, searching for a better solution gets abandoned^[28]. Whiting^[29] notes

that in practice too many possibilities can be developed leading to problems in evaluation of the alternative concepts effectively. However, computational approaches have enabled non-consistent combinations to be excluded^[20].

The following section presents the application of morphological analysis to the challenge of societal design and the arising environment with specific application to urban considerations.

3 Applying Morphological Analysis to a Contested Urban Landscape

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 prioritise storm water 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 morphological analysis (MA) can be applied as a problem-structuring and decision-support tool in contested landscape planning. Specifically, the study aimed to:

- Identify the principal sub-systems and parameters that structure urban green space planning under conditions of conflict.
- Map alternative configurations to visualise the breadth of possible solutions.
- Test how MA, combined with participatory discussion and AI-supported visualization, can support more inclusive scenario design.

To construct the relevant morphological matrix (Table 2), we used a combination of literature review and expert-informed group discussion. 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 (policy, grassroots, and technical). The workshops were conducted in two half-day sessions (4 hours each) and involved morphological decomposition exercises, option elicitation, and concept synthesis. Discussions centred on questions such as: What key sub-systems structure the planning of a contested community landscape? What are the primary tensions between stakeholder groups? What types of solutions are considered viable by different actors?

Table 2: 12 key sub-systems morphological matrix

Energy Mix	None -solar PV only	None - Oil only	PVT	Solar + Wind	Solar + Wind + GTE	Solar +GTE
Cityscape	None - distributed living	Mega-cities	Urban sprawl	Status quo	Historic core with modern perimeter	Multi-nodal
Housing	High rise only	Low rise only	Gartenstadt	Terraced only	Mixed	Detached family homes
Land distribution	Status quo	Equal by value per person	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 - no growth	GDP falls by up to 5% (Recession)	GDP falls by up to 10% (Mild Depression)	GDP falls between 10% and 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 economy weakens	increasing hedonism and "me" attitudes - greed)	New social awareness, less hedonism and "me" attitudes prevail	Seek comfort in smaller social groups, family, local communities (Community Spirit)	Major social fragmentation under economic stress (inc. Rioting)
Technological	On current course pre-pandemic (no change)	Remote access visual technologies accelerate	Physical representation tech expands (Holograms)	Pollution control tech expands	Decline in interest in transport tech	Medical advances to majority of current diseases & conditions
Other Global Catastrophic Risks	None-foreseen	Covid-19 second surge	Covid-19 Mutation (and/or New Major Pandemic)	Climate change speed up(UC)	AI(UC)	Nuclear accident
Time Horizon	<1 Year	>1 yr <2 yr	>2 yr <5yr	>yr	Never	
Personal Transport	Status quo	Status quo evolution	Rush to electric (all forms)	Train, E-Bus, E-Bike mix	Model E 'Ford' paradigm (electric cars everywhere)	Collapse in people movement
Environment	+2' oC (300 kph wind events become regular)	+1.5' oC (200 kph wind events become regular)	+1 oC' (we can live with it, but energy demands for HVAC rise and biodiversity is a distant memory			

The morphological chart generation process led to the identification of 12 key sub-systems with multiple internally consistent options. These were organised into a morphological matrix (shown as first column in Table 2). While group discussion alone does not constitute sufficient justification for robust modelling, it was supported by triangulation with existing literature on participatory green infrastructure and community land use. Table 2 illustrates the morphological chart for the embodiment of society. The principal subsystems and parameters considered include energy mix, cityscape, housing, land distribution, autonomy, economy, social, technological, risks, time horizon, transportation and environment. For each a series of options have been defined. In Table 2, the options marked in red are the choices of Group 1, while the text marked in blue represents the choices of Group 2. However, for instance, "Medium" and "Train, E-Bus, E-Bike mix" are common choices were highlighted by yellow color.

The subsystems in Table 2 were developed from considerations of broad requirements and needs along with principal enablers as indicated in Section 1. Such a listing involves elements of subjectivity and can be developed as in this case from group discussion and brainstorming. Alternative subsystems could be defined, however this chart in this form has been found useful across differing nationalities and political contexts and the use of a tabular format in a spreadsheet allows for means that have not been listed to be readily added. In defining the subsystems and means for fulfilling each of these, reference can be made to relevant domains and areas of expertise such as urban design^{[30][31][32]}.

The chart depicted in Table 2 serves as 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. This can be accomplished by envisioning and discussing what such a scenario would entail. A preliminary sketch can be created, or more advanced tools like prompt engineering and AI visualizers, such as Vizcom, can be employed, as referenced in Figure 1. It is important to recognize that these visualizations may not fully capture the intentions of the selector, and iterations may be required to ensure that the AI-generated imagery accurately reflects 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 promise, albeit with limited success^[33]. Further selections and more refined visual representations are showcased in Figures 1 and 2, with the visualizations in instance of Figure 2 produced using Midjourney. Here, the design plan by red text of a megacity for the cityscape significantly influences the visual outcome, Figure 1. The outcome indicated by blue text in Table 2 is shown as Figure 2.



Fig. 1: AI image representations for the red text selection shown from Table 2. (Image generated with Vizcom).



Fig. 2: AI image representation for the blue text selection shown from Table 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. By integrating landscape design considerations, the process can be further enriched. For instance, the selection of "Garden Stadt" for housing in the chart 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, the landscape design aspect adds a layer of depth to the scenario planning, allowing for a more comprehensive and visually engaging representation of the selected configurations. This

integration enhances the visual appeal and provides a more holistic view of how the chosen elements interact within the broader context of urban and rural environments.

Morphological charts offer a structured approach to elaborate on various subsystems, providing a comprehensive framework for addressing complex societal issues. These charts can be tailored to specific systems or 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 considering energy systems, the chart can be expanded to include landscape-oriented elements such as solar farms integrated into agricultural fields or wind turbines positioned to complement the natural topography. This optimizes energy production and harmonizes with the surrounding landscape, enhancing aesthetic and ecological values. In the context of mobility, the chart can incorporate options like 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, integrating green roofs or vertical gardens to enhance the living environment. This approach improves the quality of life for residents and contributes to the overall biodiversity and sustainability of urban landscapes.

Furthermore, as exemplified in Table 3, morphological charts can address broader societal challenges such as flooding. By considering landscape design, these charts can evaluate options such as rain gardens, bioswales, and permeable pavements that manage stormwater effectively while enhancing the urban green space. This holistic approach ensures that flood mitigation strategies are not only functional but also contribute positively to the landscape aesthetics and ecological health. In summary, the incorporation of landscape design into morphological charts provides a more nuanced and integrated perspective on societal subsystems, ensuring that solutions are technically sound and aesthetically pleasing and environmentally sustainable.

Table 3: Morphological chart for energy.

Sub-system							
Energy strategy	Zero-carbon	Free for all	Self-sustained				
Energy source	Wind (Onshore)	Wind (Offshore)	Nuclear (Fi)	Nuclear (Fu)	solar	biomass	geothermal
Energy Transmission	Local Consumption	AC	HVAC	HVDC			
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: Morphological chart for flood risk.

Geographic Attributes	Meteorological Attributes	Stakeholders	Social & Economic Actors	Physical Prevention Actions	Mitigation Policies

Steep sided channels	Increased rainfall prediction	Residential homes on flood plain	Infrastructure integrity value	Dam construction in rural areas	Planned flooding mitigation & capability of local area
River drainage & surface run-off	Are there flood warning and climate predictors?	Farmland on flood plain	Local economies inherent value	Local dev planning for rivers	Capacity if engineering & tech to deal with flooding
% of woodland & local vegetation	Rainfall distributed in local area	Public/private establishments on flood plain	% population residing in work relating to Public sector in flood mitigation and ER	Drainage systems & water collection strategies	Ag methods to mitigate farmland and livestock destruction
Drainable basins in urban areas			% of residents with knowledge of flood prevention	Planting & effects of environmental development	Capability of strategies to prevent transport disruption
Coincidental incidence of flooding & high tides			No. of insurance cos specialising in flood risk and compensation	Forest density	Capability of strategies to maintain comm lines
River collusion					Capability of health strategies to prevent water pollution & disease
Ground saturation & water table					Level of education value for localised flooding
Here something is missing					Are there effective methods in place to warn populace?

The Morphological chart for energy presented in Table 3 represents a valuable tool for analysing the relationship between energy flow and morphological structures, commonly utilized in fields such as ecosystem studies, architectural environments, industrial design. Integrating energy morphology in design 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, by integrating the energy morphology, options for the optimization of building form and materials, orientation, window arrangement, and insulation structures are prompted through prompts for solar radiation, wind, and thermal energy transfer. At the urban scale design, energy morphology guides the design of sustainable urban energy systems and spatial layouts. By analysing the morphology of urban energy flows, such as electrical grids, traffic flows, and waste management, integration of urban energy supply and utilization can be developed. Alternatively, based on natural energy morphologies such as water and air flow, green corridors or rainwater management systems can be designed to balance ecology and functionality, proposing urban design plans that offer harmony with ecological environments^{[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, morphological analysis

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 help understanding and provide continuity in urban development^[37].

Based on Table 4 (Morphological Chart), a preliminary urban-design scheme for flood governance can be derived. Spatially, the plan proposes a “blue – green network” for river corridors, drainage basins and flood-prone depressions, integrating urban watercourses and wetland systems into a permeable, detention-oriented ecological matrix. At the neighbourhood 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 recreation 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 scheme embeds community-based education and an ICT-enabled early-warning system that delivers real-time flood intelligence to residents. By aligning insurance instruments with spatial planning, the framework incentivises homeowners and developers to invest in flood-adapted 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. A design illustration of this is provided in Figure 3.



Fig. 3: AI image representation of the selection shown from Table 4. (Images generated with Midjourney).

Table 5: Morphological chart for apartment typology.

Building Orientation	Building Height	Building Shape	Building Access	Number of Bedrooms	Aspect	Type	Private Open Spaces	Lighting	Temperature control	Ownership	Utility supply	Dwelling size	using type	Dwellings per level
E-W	Low rise	Block	Single Loaded Horizontal	Studio	Single perpendicular	One	Cantilever	Excellent	Natural	Freehold	Central-regional	30-	Residential	1-2
N-S	4-6 Storeys	Courtyard Block	Double Loaded Horizontal	1 bed	Single parallel	Duplex	Recessed	Satisfactory	Central heating	Leasehold-70 years	Central-local	31-60	Residential/commercial	3-4
Mixed	7-10 Storeys	Open Block	Skip-Stop Single	2 bed	Double	Mezzanine	Semi-recessed	Poor	Individual air-conditioning	Leasehold- 40 years	Per dwelling	61-90	Serviced apartment	4-10
	11-30 Storeys		Skip-Stop Double	3+ bed	Corner	Dormitory	None		Central air-conditioning	Non-resalable	Residential rate	91-120		10+
	30+ Stories		Vertical						Individual heating	Dormitory	Commercial rate	121-300		
										rental		300+		

The morphological chart for apartment typology presented in Table 5 lists functions or characteristics related to apartment design and identifies core requirements of apartment design, such as flexibility, sustainability, and community functions. This tool allows for the decomposition or combination of key modules or design dimensions in apartment design, including aspects such as building height, building shape, spatial layout, functional zoning (residential areas, work areas, leisure areas), and environmental factors (ventilation, daylighting, sound insulation). Through the permutation and combination of various options, multiple design solutions can be generated and syntheses of selections for the charts presented in Figures 4.



Fig. 4: AI image representation of the selection shown from Table 5. (Images generated with Midjourney)

The significant benefit of employing morphological analysis in the realms of landscape design, architectural planning, or spatial planning is its capacity to enable practitioners to systematically organize the knowns and unknowns of a multifaceted issue at an early stage. 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 factors such as user experiences and ecological impacts. Morphological analysis transcends a linear or isolated examination of the problem. Instead, it captures a more authentic portrayal of the intricacy and interconnected inherent in design challenges. This is particularly crucial when behavioral and social considerations must be integrated 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, such as structural loads and environmental performance metrics, with "soft" qualitative insights, like aesthetic values and community engagement.

Furthermore, morphological analysis is equipped with the ability to pinpoint outliers and subtle indicators early on, as well as to anticipate both positive and negative unintended consequences. 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, morphological analysis supports a more rigorous and informed decision-making process. In essence, morphological analysis 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 are not only technically and functionally sound but also resonate with the social, cultural, and environmental contexts in which they are situated. This holistic approach to problem structuring is vital for creating sustainable, inclusive,

and aesthetically pleasing built environments that stand the test of time and meet the diverse needs of their users.

4 Discussion

The 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 evaluated^{[38][39]}. Unlike traditional approaches that rely on a fixed worldview, morphological analysis (MA) deliberately avoids universalism or prescriptive alignment with 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 morphological 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 represented and fairly considered.

A framework (shown as figure 5) demonstrates how morphological analysis 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 morphological matrix. 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, morphological analysis enables a systematic, participatory, and creative exploration of contested design scenarios, bridging social system complexity with spatial design practice.

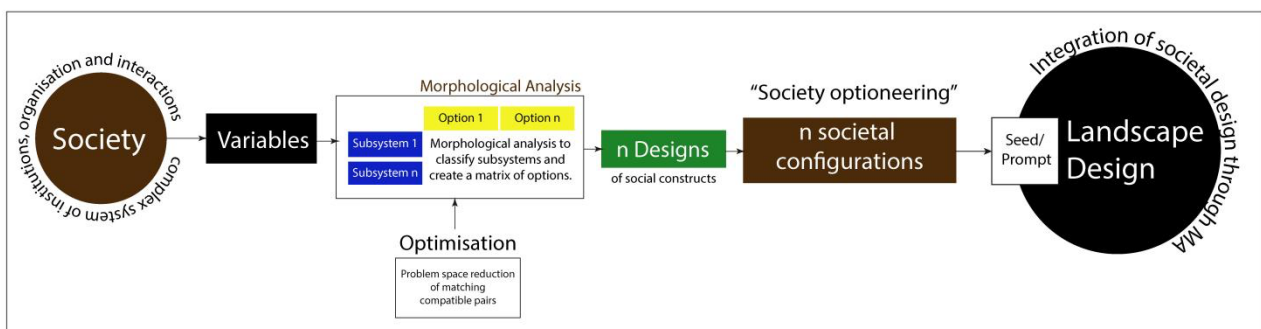


Fig. 5: How MA can support the structuring and exploration of socially contested scenarios in landscape design.

While this framework opens up 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. This tension highlights the dual role of morphological analysis, not only as a generator of pluralistic visions, but also as a critical tool for managing the inherent complexity of design and planning processes. In landscape architecture, building design, and spatial planning, MA functions as an

indispensable tool for managing complexity in sustainable and innovative design. However, the method can produce an excessive number of viable configurations. To address this challenge, the integration of morphological analysis into 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 the design cycle, thereby transforming complexity into a structured source of creativity.

When integrated into design thinking, morphological analysis can integrate each stage of the design cycle (shown in Figure 6):

- Problem understanding and variable definition: MA facilitates multi-perspective analysis of user behavior, emotional needs, functional requirements, and environmental interactions. By decomposing problems into their diverse aspects, it enables comprehensive problem analysis across social, functional, energy, technological, and cultural dimensions.

- Creative generation: Through the recombination of design elements—functionality, form, materials, technology, aesthetics—MA encourages divergent exploration and produces a wide range of novel proposals that transcend conventional approaches.

- Systematic evaluation and integration: Morphological matrices provide a structured foundation for evaluating the feasibility and merits of multiple schemes, balancing multi-objective considerations such as functionality, aesthetics, economy, and sustainability.

- Iterative optimization: With its modular and adaptive nature, MA allows for dynamic adjustment of variables, integration of user feedback, and incorporation of technical constraints. This iterative capacity enhances flexibility and adaptability, supporting continuous improvement of design outcomes.

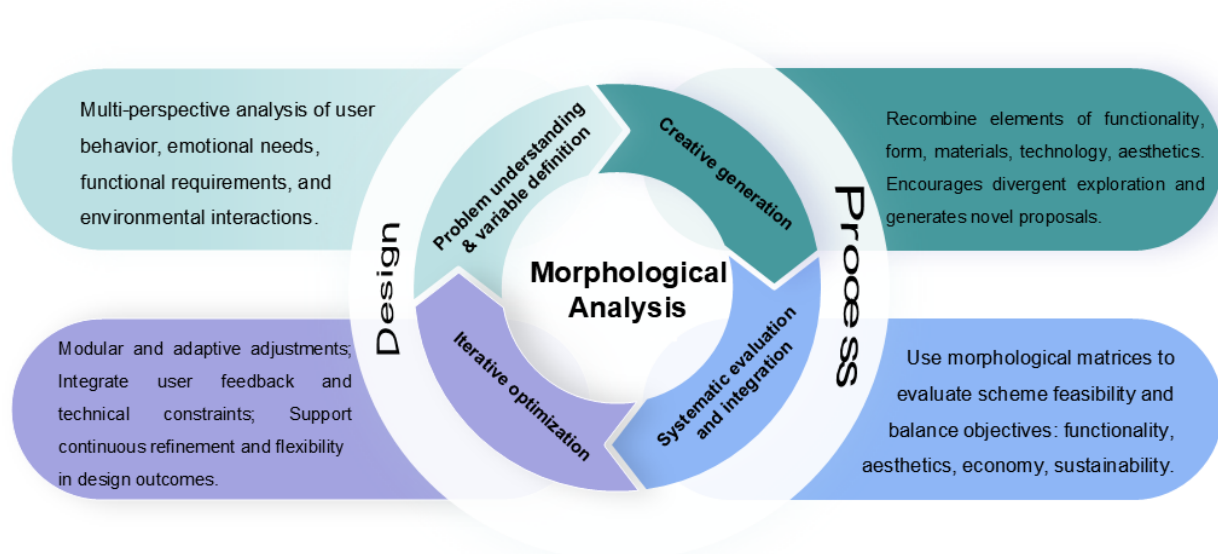


Fig. 6 How MA integrates with design process.

Beyond its methodological role, morphological analysis underscores the interplay between technology, economy, and social structures. Manuel Castells^[41] in 2011 has highlighted how information technology reshapes social forms, while Ezio Manzini^[42] emphasized design's central role in collaboration, community building, and driving social innovation. 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 morphological analysis 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, morphological analysis 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.

5 Conclusions

This paper introduces the application of a structured, options-based methodology - morphological analysis (MA) for addressing the complexities of societal design in the context of contemporary challenges. The morphological charts presented here 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 planning and landscape architecture, enabling more transparent and participatory processes in projects such as green infrastructure, community space design, and sustainable city transformation. (3) Technological Integration: It identifies pathways for combining MA with AI-generated content (AIGC) and visualization tools, 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: (1) further integrate MA with artificial intelligence (AI) and advanced visualization tools to improve efficiency, automation, and interpretability; and (2) 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 research contributes to design theory by enriching methodological approaches and 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 enhances 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, urban planners, and spatial designers, promoting both methodological innovation and sustainable practice.

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社会未来形貌构建：通过形态分析设计替代性社会图景

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摘要

在城市规划、景观与建筑设计中, 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。形态分析通过构建“子系统—选项”矩阵, 让设计师能够在项目早期阶段, 运用该方法对问题的确定性与不确定性进行评估和厘清, 同时兼顾定量因素与定性因素。本研究进一步将形态分析与人工智能生成内容(AIGC)进行深度融合。通过借助 AIGC 技术, 在设计初始阶段能够迅速生成多样化的设计提案, 提升设计流程的创新效能与实用价值。在这一整合框架下, 设计师能够多视角审视设计问题, 发现更广阔的解决方案谱系。依托系统化的评估工具, 设计者可以对设计方案进行有效评估, 提升了设计过程的理性科学性与动态适应性, 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

城市规划; 景观设计; 设计; 形态分析; AIGC; 环境; 可持续性

文章亮点

- 引入形态分析法作为应对城市与景观设计中社会复杂性与不确定性的结构化工具。
- 提出“社会形态学”概念, 将文化、制度、组织与空间系统纳入可持续设计的整体关联框架。
- 将形态分析与人工智能生成内容融合, 实现快速场景构建与参与式可视化设计。
- 该研究将形态分析融入迭代设计思维之中, 将复杂性和不确定性转化为有条理的创造性思维流程, 为面向包容性和可持续性的城市与景观设计提供多样性方案并提高了系统性评估能力。