

The Impact of Parametric Thought on Changing Urban Formulations.

(Towards creating an integrated parametric urban framework).

Main Author:

Rania Hisham Ahmed Mohamed Ayad.
Architecture Department, Helwan University, Egypt.
Email Addresses: raniaayad6100@gmail.com
raniad01229@m-eng.helwan.edu.eg

Co-Authors:

Prof. Mahmoud Taha Mahmoud Selim.
Prof. at Architecture Department, Helwan University, Egypt.
artyarch_artyarch@yahoo.com.

Assistant Prof. Marwa Kamal Fahmy
Assistant Prof. at Architecture Department, Helwan University, Egypt.
Marwa_fakhry@m-eng.helwan.edu.eg.

Abstract.

Undoubtedly, the evolution and innovation in architecture and urban design are closely tied to the advancement and growth of technology. In this context, it is evident that the incorporation of contemporary parametric technological design tools in urban design has led to a transformation in the traditional urban formulations and patterns of city blocks, standards, and morphology. This paper focuses on the concept of Parametric Urbanism, delving into the exploration and questioning of the various types of urban formulations and the impact of parametric thought on changing these formulations. It also examines how this approach can influence traditional urban patterns and contribute to the emergence of new architectural methodologies. Additionally, the paper addresses the factors that have contributed to the rise of parametric urbanism and seeks to determine the benefits and potential drawbacks of

this approach in urban planning. Furthermore, it aims to establish an integrated parametric urban framework that can be effectively applied during the different phases of urban design. The paper includes a concise literature review that concentrates on typical urban formulations, parametric urbanism, and parametric thought. It then presents a practical integrated parametric urban framework, showcasing its application through case studies of parametric projects. This framework explains the fundamental principles of parametric design and highlights the impact of this approach on both the form and function of design decisions in those case studies. Moreover, it elucidates the urban formulations employed in those projects and concludes by discussing the influence of parametric thinking on changing urban patterns.

Keywords:

Urban Parametricism, Algorithmic design, Urban formulation, Parametric modeling, Parametric analysis, Urban environmental assessment.

1. Introduction

When we discuss the impact of parametric thinking nowadays, it is evident that parametric thinking has played a crucial role in shaping modern building materials and sophisticated digital design tools, facilitating the generation of urban scenarios and prototypes through the analysis of various site information such as built-up area, construction ratio, weather conditions, site characteristics, and neighboring urban block patterns. This methodology strives to achieve urban and humanitarian designs and identify optimal urban scenarios for specific designs while acknowledging the influence of parametric thinking on urban formulations. This, in turn, leads to the development of diverse planning solutions and a departure from conventional urban formulations and block patterns based on the site parameters. Consequently, meticulously planned prototypes will be formulated to ensure thermal comfort and appropriate urban design for the given location (Abdulmawla et al., 2018)(Konieva, 2018).

In the beginning, it is crucial to establish the definition of urban formulations. The urban formulation is designing and shaping the physical forms of cities, towns, and suburbs, considering urban ecosystems characterized by complex interactions between social, economic, institutional, and environmental variables to ensure human comfort. (R. C. Da Silva & Morim, 2010, pp. 3–5) (Burry, 2004, pp. 9–11)(Zhang & Liu, 2021, p. 1:3), It is the collaboration between urban design - the design of towns and cities, streets and spaces, and human needs and also it is the collaborative and multidisciplinary process of shaping the physical setting for life, (the art of making places), the technical and political process, concerning the use of land and design of the urban environment, considering air, water, and the infrastructure passing into and out of urban areas such as transportation and distribution networks aiming to obtaining human comfort and creating an ecological environment. it answers questions about

how people will live, work, and play in a given area and thus, guides orderly development in urban, suburban, and rural areas. The urban formulation contains urban settlement patterns, which refer to how cities and towns are organized and distributed across a landscape, generally shaped by several factors, including physical geography, historical development, economic activity, and social and cultural factors. (Eisner et al., 1993, p. 22:38). Then Patrik Schumacher introduced the concept of `parametricism` as an innovative design theory and started to define the principles of parametric design, which had not been applied to tackle the issues prevalent in modern cities at that time. Nevertheless, parametricism has now emerged as a valuable operational instrument for urban design endeavors of all sizes(Çalışkan et al., 2021)(Steinø, Nicolai & Obeling, 2013) and many researchers and urban design schools have been interested in urban parametricism in their publications and workshops. Since then, parametric thinking has evolved in the fields of architecture, urban planning, construction, and engineering(Wooff, 2016, p. 13:15). The computational tools of parametric thinking have redefined the relationship between architectural design and the shaping of urban morphology. They have also impacted human and environmental generation and regeneration, and ultimately clearly had their impact on urban formulation and planning of urban patterns. For example, Zaha Hadid's designs for the Kartal Masterplan and Singapore One-North revolutionized how people perceive urban spaces. (Yes, the avant-garde forms caused some controversy.) Consequently, the realization of the potential use of parametric tools has intensified technological investments in this area over the last decade(Zhang & Liu, 2021, pp. 1–2) (R. C. Da Silva & Morim, 2010; Zhang & Liu, 2021). Based on the characteristics of cities as hybrid territories, urban design methods use parametric tools to optimize urban-scale design models and manipulate the dynamics of urban morphology. Architects and planners can optimize urban forms and spatial constructions through parameters. Parameters are variables within a system that can control design performance, from the smallest architectural details to large-scale developments, and use parametric principles to create parametric forms.(Eisner et al., 1993; Marwa Kamal, 2020; Nagy, 2009; Zhang & Liu, 2021). Having said all this, it is clear that parametric design is becoming increasingly popular in urban design as it involves the use of algorithms and digital tools to create complex and dynamic designs that can adapt to changing conditions and requirements. Parametric thinking allows urban planners to create more flexible and responsive designs that better meet the needs of those who use them. Parametric design can also help urban planners optimize their designs for various factors such as energy efficiency, sustainability, and cost-effectiveness. By using digital tools to simulate different scenarios and test different design options, designers can determine the best solutions for a given project to achieve the required urban formulation (Schnabel, 2008).

Therefore, this study discusses urban structures and the factors affecting them, whether natural or human, as well as the urban patterns that form them. It then moves on to

study parametric thinking, the history of its origins, and the functional and formal principles of this thinking. Then, the effect of parametric thinking in changing typical urban formulations is clarified by applying them to realistic examples. The study concludes by deriving an integrative parametric urban framework that can be applied later in urban planning in the future to determine the best and fastest solutions, including all the factors that would lead to a design that aims for The comfort of its users and takes into account future solutions as well as natural and human factors This framework elucidates the fundamental principles of parametric design and underscores the impact of this methodology on the form and intent of design decisions in diverse case studies. Furthermore, it elucidates the urban formulations employed in these projects and culminates by analyzing the evolution of urban patterns.

2. Research Method

The paper is focused on developing a comprehensive and efficient parametric framework that explores the impact of parametric design on changing urban patterns. It is structured into three key phases:

The initial phase involves theoretical analysis, delving into common urban configurations: their definitions, classifications, and influencing factors. This phase culminates in identifying typical urban patterns, followed by exploring parametric thought, the principles of parametric urbanism, the factors shaping it, and establishing a structured research framework for parametric urban patterns. Additionally, it discusses the fundamental principles of parametric design in practical and operational terms.

The subsequent phase leads to exploring the integrated parametric urban framework and applying this framework to some parametric projects, this framework explains the core principles of parametric design and emphasizes the influence of this approach on the shape and purpose of design choices in various case studies. Additionally, it clarifies the urban strategies utilized in these projects and concludes by examining the impact of parametric thinking on the transformation of urban patterns.

The research paper deals with the following urban scales:

It starts with the individual building scale and its urban spaces, followed by the Marco quarter scale such as neighborhood, and ends with the city quarter and design.

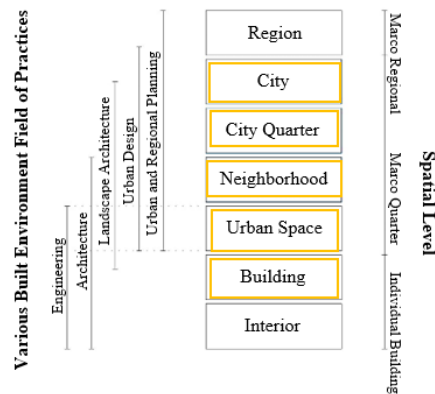


Figure 1 The Researcher Urban Scale (By the Researcher).

1.1 Typical Urban Formulations and Factors Affecting Them.

Urban Formulation is a multidisciplinary thought involving the design, regulation, and management of urban areas' physical, social, and economic aspects. Urban planning aims to create sustainable, functional, and aesthetically pleasing environments for people to live, work, and play. (Maccowan, 2012)

Here are some key aspects of urban formulations:(Sharma, 2014)(Raven et al., 2018)(Rezaei, 2023).

- Political Strategic Formulation.
- Social and Recreational Formulation
- Infrastructure Formulation
- Environmental and Sustainable Formulation.
- Economic and Land Uses Formulation.
- Urbanization Formulation.

Each urban formulation has its regulations and goals that define it and create its urban patterns, the following urban formulations:(Sharma, 2014)(Raven et al., 2018)(Rezaei, 2023).

Types of Urban formulations



Political Strategic Formulation.

Involves creating policies and laws related to safety and security.

Walls are built high to resist external threats such as animals and intruders.

Creating a network layer is the easiest to understand, which is functionally easy to see and implement.

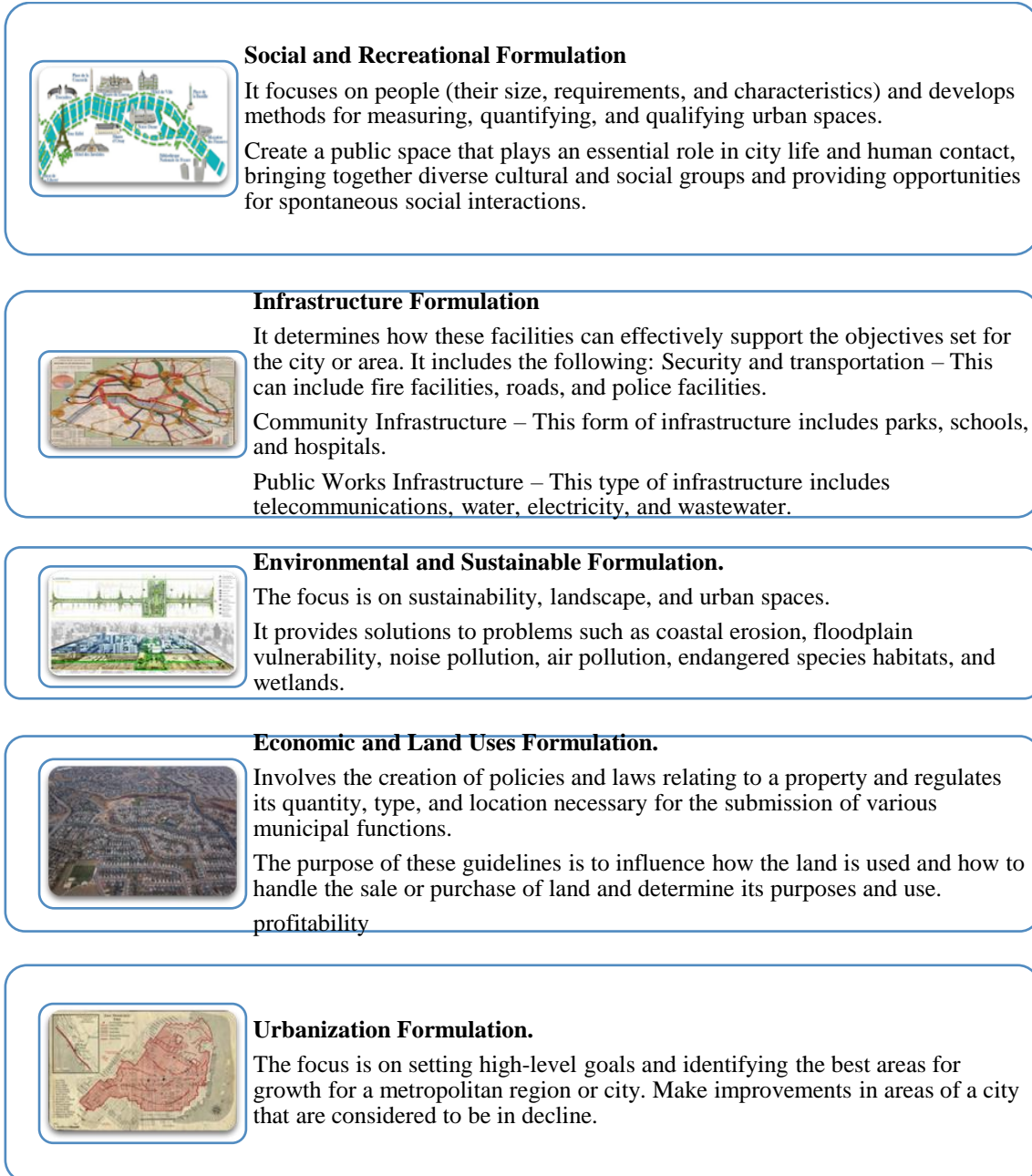


Figure 2 Determining urban formulations' regulations and goals (By the researcher).

As mentioned above, the Urban formulation is the collaboration between urban development – i.e. the design of cities, streets, and spaces – and human needs. It is the collaborative and multidisciplinary process of designing the physical environment for life (the art of making places), the technical and political process concerned with the use of land and the design of the urban environment, taking into account air, water, and Infrastructure deals with traffic in and out of urban areas such as transportation and distribution networks to ensure human well-being and create an ecological environment. (Researcher, 2023).

1.2 Parametric Thinking, parametric urbanism, and Factors Affecting it.

Parametric design has recently been recognized as one of the most significant influences in the fields of manufacturing and engineering, particularly architecture. For this reason, it was seen as a way to innovate and create new designs based on digital designs and analysis of available information, using logarithms and parameters as a means of developing planning and urban scenarios and creating innovative urban solutions. It was accordingly a need to know its concepts, history, factors, and the consequent changes in various scientific fields. (Coyne, 2014).

➤ **The Definition of Parametric Design and Parametric Urbanism:**

Parametricism is a style within contemporary avant-garde architecture, promoted as a successor to modern and postmodern architecture. The term was coined by Patrik Schumacher in 2008. Parametricism has its origins in parametric design, which is based on the constraints in a parametric equation and relies on programs, algorithms, and computers to manipulate equations for design purposes. (Schumacher, 2011)(Coyne, 2014).

Parametric design is a method in which features (e.g., building elements and technical components) are shaped using algorithmic processes instead of direct design. In this method, parameters and rules determine the relationship between design intent and design response. Aspects of parametricism have been used in urban planning, architectural design, interior design, and furniture design. Proponents of parametricism have stated that one of the defining characteristics is that "parametricism implies that all elements of the design become parametrically variable and adapt to one another. (Schumacher, 2011).

Parametric Urbanism: A Digital Methodology for Manipulating Typological Forms of Density in 21st Century Urbanism. It's the ability to quickly visualize the impact of changes to bylaws or density targets that could in theory enable planners to make more informed choices among a variety of alternatives. As such, the goal is to incorporate a multitude of variables into a cohesive system to evaluate the dynamic effects of different parameters on each other and the form of cities. (Schumacher, 2011).

➤ **What is the Parametric Manifesto: The Dogmas and Taboos of Parametric Design?**

The parametricism notion was first presented as a part of the "Parametricism Manifesto, " written by Patrik Schumacher in 2008. It was asserted in this presentation that "Parametricism would be the great new style after Modernism". (Oktan, 2017)

Schumacher introduced paths to pursue and paths to avoid within the context of his manifest, dated 2008, for the first time. He then reawakened these principles in his article dated 2009 and book dated 2011. He described the paths to pursue as "dogmas" and the paths to avoid as "taboos."(Oktan, 2017)

In *Parametricism as Style - Parametricism Manifesto* (Schumacher, 2008), dogmas are defined as inarticulate, hybridize, morph, deterritorialize, deform, use splines and NURBS, generative components, and scripts rather than models. Taboos are defined as familiar typologies, platonic/hermetic objects, clear-cut zones, straight lines, right angles, and corners, and they do not add or subtract without elaborate inner articulation. (Oktan, 2017)

In *Parametricism: A New Global Style for Architecture and Urban Design* (Schumacher, 2009), dogmas are defined as follows: all forms must be parametrically malleable, differentiate gradually, inflect, or correlate systematically. Taboos are defined as hermetic forms, simple repetitions, and juxtapositions of unrelated elements/systems. (Oktan, 2017)

Finally, in the book *Autopoiesis of Architecture* (Schumacher, 2011), dogmas are defined as follows: all forms must be parametrically malleable, all systems must be lawfully differentiated, and all systems must be correlated. Taboos are defined as rigid geometric primitives, simple repetition of elements, and collages of unrelated elements.

The three studies presented by Schumacher are analyzed, and it is seen that some of the dogmas and taboos of Parametricism state similar situations. To summarize the manifesto and determine the evaluation criteria, taboos, and dogmas were collected under titles. These criteria form a systematic framework for analyzing parametric design samples.

The summarized principles are given in the following points:

▪ Operational definition of Parametricism:

Negative principles (taboos):

- Avoid rigid forms (lack of malleability and complexity).
- Avoid simple repetition (lack of variety)
- Avoid collage of isolated, unrelated elements (lack of order)
- Avoid Pure Difference (modernism is all about simple forms, separating and repeating).

Positive principles (dogmas):

- All forms must be soft (intelligent: deformation = information)
- all systems must be differentiated (gradients)
- All systems must be interdependent (correlations or coherence).

▪ Functional heuristics:

Negative principles (taboos):

- Avoid rigid functional stereotypes.
- Avoid segregation functional zoning.

Positive principles (dogmas):

- All functions are parametric activity/event scenarios.
- All activities/events communicate with each other.

The avoidance of taboos and the adherence to dogmas delivers complex, variegated order for complex social institutions. These principles outline pathways for the continuous critique and improvement of the design.(Coyne, 2014; Oktan, 2017; Schumacher, 2011).

**1.3 The impact of parametric thought in changing urban formulations.
(Towards creating an integrated parametric urban framework).**

Parametric thinking has made a difference in urban formulations and patterns as it integrates modern technology in the development of urban ideas and the use of the components of the site as input to the programs and subsequently in the work of their prototypes through analysis and to coordinate this information together and create urban and human forms and find the best scenarios. However, this thought has led to some functions between the different activities of the buildings being grouped under one building or area, rather than separating them as long as they are similar in form and concept, and by eliminating some other spaces and even the buildings in contact with them, a formative and functional framework has been created, integrated into the environment and offering, in addition to human comfort, elements of wealth and luxury, and this must require thinking about the impact of this thought on the changing urban patterns and understand what its framework is. (Wooff, 2016)(Schumacher, 2011).

Recently the urban pattern has been chosen to be integrated with a similar parametric pattern. The similarity is clarified. After that, a new pattern or technique categorization has been extracted to be used in the generation processes of urban parametricism. (Marwa Kamal, 2020).








Parametric Patterns And Urban Parametricism Patterns		
Patterns	Similarities	Parametric Patterns & Urban Parametricism Patterns
Controller	Rig	
Increment	Force field / spilling (The force field gives an incremental effect according to the attractor object).	
Reactor	Force field/ blending (force field attracts the objects within the attraction field, and blending establishes an infinite number of sub-states that are related to mathematical logic).	
Recursion	Branching or tree/ repetition. (The Woodbury recursion pattern includes many techniques that should have a motif and rule of repetition).	
Tiling	Topology/ tiling (Some theorists differentiate between tiling, and subdivision through the principles of topologies. They include tiling in topographical classification, while others separate them as two different techniques).	
Packing	Subdivision (Subdivision can be considered as a topological pattern type, a packing pattern, or can be classified as a separate technique).	
	Projection/ Lacunary pattern. Packing and tiling. (All terms have the same idea of formation technique, which is called packing).	

Figure 3 Parametric Patterns and Urban Parametricism Patterns are used to create parametric urban.

By referring to the results of the previous parts specifically in figures 2 and 3, it is possible to discuss the extent of the impact of these parametric ideas on the urban formulations described in part 1 and to use the developed urban parametric framework which consists mainly of those figures mentioned above to disengage the impact of these ideas on generating different parametric urban patterns through the following figure

- **The integrated Parametric framework that will be applied in the traditional urban formulation:**

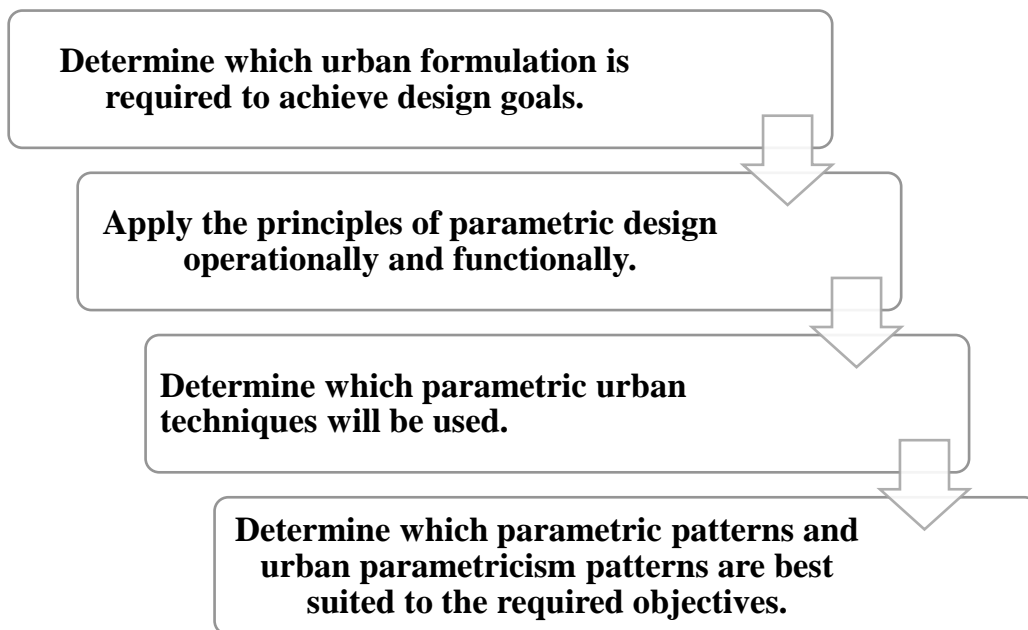


Figure 4 The methodology of how to apply the derived framework to your urban design

➤ Finally: Obstacles to applying parametric urban thought.

Parametric urban formulation refers to the use of parameters and algorithms to generate and analyze urban forms and spaces and provide a better life for residents. While parametric thought offers numerous advantages in terms of efficiency, flexibility, and optimization, there can be challenges and shortcomings associated with its implementation in the context of urban design and achievement in urban formulations. Some of these challenges include the following:

1. Integration with Traditional Design Processes:

Integrating parametric design into traditional urban design processes can be challenging. There may be resistance to change or a lack of understanding among stakeholders regarding the benefits of parametric approaches.

2. Functional Heuristics:

The parametric design focuses on the forms and design and can't cover all the functional heuristics

3. Data Quality and Availability:

The parametric design relies heavily on data. The lack of accurate and up-to-date urban data can hinder the effectiveness of parametric models. In some cases, data may be difficult to obtain or may not exist for certain aspects of an urban environment.

4. Skill Shortage:

Parametric design often requires high expertise in computational design tools and programming languages. There may be a shortage of professionals with the necessary skills to implement parametric urban designs effectively.

5. Complexity and Accessibility of Tools:

Parametric design tools can be complex and may require steep learning curves. The shortage of accessible and user-friendly tools can limit the adoption of parametric design approaches among a wider audience including urban planners and designers.

6. Interdisciplinary Collaboration:

Successful parametric urban design often requires collaboration among professionals from different disciplines, including architects, urban planners, data scientists, and software developers. The lack of effective interdisciplinary collaboration can impede the implementation of parametric design solutions.

7. Regulatory and Institutional Barriers:

Existing regulatory frameworks and institutional structures may not be equipped to handle the complexities introduced by parametric design. There may be a shortage of guidelines or regulations addressing the use of parametric tools in the urban design process.

8. Public Engagement and Acceptance:

Parametric design often involves complex algorithms that the general public may not easily understand. This can lead to a shortage of public acceptance and engagement in

the decision-making process as the transparency of parametric models may be a concern.

2.1 Findings and Discussions:

Part 1: Applying The Framework in Some Parametric Designed Projects:

1) **(Urban scale: Individual Buildings & its urban space): The Peak, The Rejuvenating Resort & Spa:): The Peak, The Rejuvenating Resort& Spa:(Shakeri, 2022) (India, News, Resort, 2022).**

Project Team, Design: Amit Gupta, Britta Knobel Gupta, **Project team:** (DD and Construction Stage): Associate: Kartik Misra, **Project Lead:** Aditya Kumar Sharma, **Team:** Anjan Mondal, Hasnain Alam, Apurv Jain, Arshad Achu. **the Project team (Concept Design): Associate:** Sonal Dongre Jain, Akshay Kodoori, Kartik Misra **Team:** Steven Derrick Thomas, Aditya Kumar Sharma, Anjan Mondal, Chaitanya Goyal, Hasnain Alam, Harshi Garg. (India, News, Resort, 2022).

Project Information / Site Consideration, Project name: THE PEAK, **Location:** Udaipur, India, **Scope:** Architecture | Interior | Landscape, **Site Area:** 6746 sqm, **Built-up Area:** 1987 sqm, **Program:** 8 pool villas, restaurant, reception, spa, gym, swimming pool, event space, **Status:** Planning Permission, Client: Rahul Ventures, **Consultants:** Light Practice, Sydney. (India, News, Resort, 2022)(India, News, Resort, 2022).

Urban Formulation: Environmental and Sustainable Formulations.

The Peak is an opulent and rejuvenating resort and spa amidst majestic mountains. Enveloped by breathtaking natural beauty, our resort offers a serene and peaceful retreat from everyday life's fast-paced and chaotic nature. (Shakeri, 2022)(India, News, Resort, 2022).

Design concept: The design concept seamlessly blends the untouched splendor of nature that surrounds the site with the distinctive architectural style of Rajasthan. The original contours of the site have been ingeniously utilized to create a harmonious interface between the architecture and the natural landscape. (Shakeri, 2022)(India, News, Resort, 2022).

Building style: Each villa is delicately nestled within the landscape, resembling a cozy cocoon. These unique villas have been meticulously crafted by excavating the earth, utilizing the undulating terrain of the site to integrate the dwellings into the topography seamlessly. Locally sourced stone has been employed for both the outdoor landscape and indoor finishes, further enhancing the connection to the region. (Shakeri, 2022)(India, News, Resort, 2022).

Spatial grid: Drawing inspiration from local patterns, a hexagonal foundation pattern has been replicated on the site, resulting in a landscape design approach that is driven

by a systematic and harmonious arrangement. This pattern is a unifying element, bridging the gap between nature and regional architecture. (Shakeri, 2022)(India, News, Resort, 2022).

Sustainable design solutions: To promote sustainability and reduce cooling loads within the buildings, innovative design solutions have been implemented. The prevailing wind direction from the south, which serves as the entrance to the site, has been harnessed. By strategically constructing two buildings on either side of the entryway, a wind tunnel effect is created, accelerating the breeze. This accelerated wind passes through modest water bodies in the central plaza, effectively cooling it. Additional shallow water bodies have been strategically placed along the wind's path to maintain its coolness. (Shakeri, 2022)(India, News, Resort, 2022).

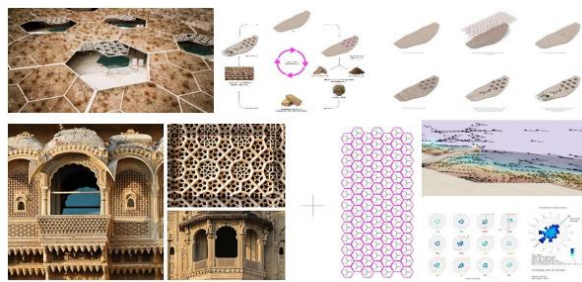


Figure 5 The Peak, The Rejuvenating Resort & Spa, Source: (Shakeri, 2022).

2) (Urban scale: Neighborhood Design) One-North Masterplan:

Project Team: Design: Zaha Hadid with Patrik Schumacher, **Project Director:** Mark Dochantschi, **Project architects (Masterplan Phase):** David Gerber, Dillon L Silvia Forlati, **Project team (Masterplan Phase):** David Mah, Gunther Koppelhuber, Rodrigo O'Malley, Kim Thornton, **Project architects (Rochester Detail Planning Phase):** Gunther Koppelhuber, **Project team (Rochester Detail Planning Phase):** Kim Thornton, Hon Kong Chee, Yael Brosilovski, Fernando Perez. **Models:** Riaan Steenkamp, Chris Dopheide, Ellen Haywood, Helena Lin, Barbara Kuit, Woody K.T. Yao, **Urban strategy:** Lawrence Barth, Architecture Feldman. **Project Information / Site Consideration: Construction time:** 2001-2021, **Location:** Singapore/ located in the peripheral east zone of the city for a mixed-use business park in Singapore, **Construction statute:** under construction, **Buildings area:** The projects include the 200-hectare (494-acre, Estimation population: 138,00.(Zaha Hadid Architects, 2019). **Urban Formulation:** Urbanization formulation.

Objectives: Address the issue posed by the competition by utilizing parametric design as the primary method in the generation process. The design team can establish and modify data such as area, density, flow, contextual, and formal constraints, allowing

for the creation of connections between these parameters. Additionally, the aim is to enhance urban interaction. (R. L. and M. Silva, 2015)(R. L. and M. Silva, 2015).

Form: A proposed morphological system consists of flexible forms that can be altered throughout the design process. This mega-urban form, resembling a smoothly undulating dune, aims to convey a sense of unity. The form establishes a distinct identity by achieving a harmonious blend of diverse elements. The resulting skyline is truly unique.(Manuel et al., 2013).

Spatial Grid: A harmonious Cartesian curvilinear pattern, created using NURBS, determines the layout of roads and seamlessly integrates with the surrounding grids. The designer explores the potential of curvature, shape deformation, and flexibility offered by parameterization. This approach effectively accommodates both the topography and areas of high activity.(Manuel et al., 2013)(Verebes, 2014).

Streets and Paths: The contextual affliction and continuities with the various adjacent urban tissue also the internal differentiation of the urban fabric produce field logics that can be navigated along legible vectors of transformations. The street's geometry produces a great diversity of setting land division. (Verebes, 2014) (R. L. and M. Silva, 2015).

Buildings: The dynamic urban atmosphere is guided by a grid of undulating buildings and nodes of varying intensities. (Zaha Hadid Architects, 2019)(Aw, 1987).

Districts: One North consists of seven urban districts that can easily adapt to changing investment and development conditions. The division of One North into distinct districts aligns with the organic investment pattern. These districts provide appealing neighborhoods that cater to the needs of tomorrow's workforce. (Zaha Hadid Architects, 2019).

Parks and Landscapes: Zaha Hadid's Master plan incorporates a long, winding open space within the area. This park, situated at the heart of the quarter, features dramatic topography and captivating sight lines, breaking the urban form. It offers a shaded environment for strolls. (Zaha Hadid Architects, 2019).



Figure 6 One-North Masterplan, Source: (Zaha Hadid Architects, 2019).

3) (Urban scale: Neighborhood Design) Kartal Pendik Masterplan:

Project team: Design: Zaha Hadid with Patrik Schumacher, **Project Architect:** Stage 1 Bozana Komljenovic and Dea Wha Kang, **stage 2:** Bozana Komljenovic, **Project**

Team (stage 1): Sevil Yazici, Vigneswaran Ramaraju, Brian Dale, Jordan Darnell, Oznur Erboga, **Project Team (stage 2):** Amit Gupta, Marie-Perrine Placais, Susanne Lettau, Elif Erdine, Jimena Araiza.

Project information / Site consideration: Location: Kartal_Pendik Masterplan is located between the regions of Kartal and Pendik among a major international highway and the coastline in Istanbul, Turkey. **Date:** 2006. **area:** The project area covers 550 hectares of urban land. (6 million m² floor space including housing, business, and cultural facility. (Kocabas, 2010).

Urban Formulation: Urbanization formulation.

Objectives: The model aims at constructing new field logic that operates through the mutually accentuating correlation of various urban systems: fabric modulation, street systems, and a system of open spaces. The area was designed to be a new centrality for the city by offering business centers, residences, and cultural facilities like museums, opera houses, and theatres, and spaces for leisure activities, e.g., marinas and tourist hotels. (R. C. Da Silva & Morim, 2010).

Fabric modulation: The street articulation technique allows the rhythm of urban peaks to index the rhythm of the widening and narrowing of the urban field. The rhythmic flow of the urban fabric gives a sense of organic cohesion. The result is a coherently differentiated cityscape that facilitates navigation through its lawful. (Kocabas, 2010).

Spatial Grid: The grid is not a Cartesian grid but a type of topographical grid that deforms to adapt to different circumstances and urban topography. (Çalışkan, 2017).

Streets and paths: The street pattern generated by the grid articulation of all elements consequently. The definition logic of the smooth grid is to connect the intersection points between the areas of interest to create the major road and network. The street grid is deformed to adapt or integrate into the surrounding context. (R. C. Da Silva & Morim, 2010)(Kocabas, 2010).

Blocks and Buildings: The Maya model features the inner articulation between cross towers and perimeter blocks, in addition to the connection to the surrounding fabric. The generation of blocks is based on fabric modulation; the concept of associative geometry of the blocks through which the formation of building block types is correlated with the properties of the cells of the urban fabric. Configuring the perimeter blocks also depends on the parcel size, orientation, and proportions. The perimeter block inversely correlates the height with the parcel area. Thus, courtyards transform into internal atria, when the sites get smaller, and blocks get higher. Thus, the correlation of the whole width to absolute height can also be observed. (Fahmy, 2019)(Lane, 2009).

Open Urban Spaces:

The blocks open up, and the public spaces flow into the private courtyard. A semi-private zone is articulated through the gradient transformation between the inner and outer formulation. Through their ground-level formulation, these tower complexes

share in the creation of a continuous urban fabric, which frames the streets and sometimes expands the street space into semi-public plazas. This is achieved while keeping complete continuity between the podium-like fabric modulation and the shafts of the towers. (Çalışkan, 2017).

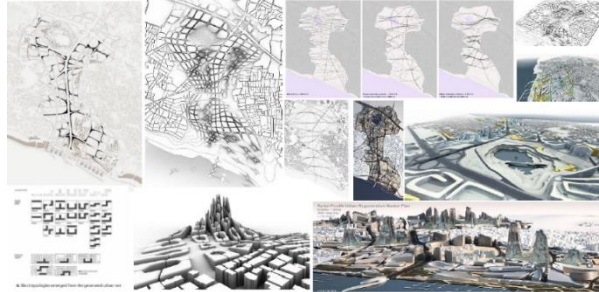


Figure 7 Kartal Pendik Masterplan, Source: (Kocabas, 2010).

4) (Urban scale: City Design) Tianjin Eco-City:

Project team: Designed by: Surbana Urban Planning Group. **Project Information / Site Consideration: Location:** The Sino-Singapore Tianjin Eco-city is located in Binhai, along Bohai Bay, Tianjin, China. **Area:** The city is approximately 10 kilometers (6.2 mi) from Binhai's core, 40 kilometers (25 mi) southeast of Tianjin's core, and 150 kilometers (93 mi) southeast of Beijing's core. **Accessibility:** The southern tip of the eco-city site is only a 10-minute drive from the Tianjin Economic-Technological Development Area (TEDA), **Construction:** Started in September 2008, **Population (2019):** 100,000, Type: City design. ((MND), 2023).

Urban Formulation: Urbanization, Economically, and Sustainable Formulations.

Objectives: The Sino-Singapore Tianjin Eco-city's vision is to be a thriving city that is socially harmonious, environmentally friendly, and resource-efficient – a model for sustainable development. This vision is underpinned by the concepts of Three Harmonies and Three Abilities. **Three Harmonies refer to:** People living in harmony with other people, i.e. social harmony; People living in harmony with economic activities, i.e. economic vibrancy; and People living in harmony with the environment, i.e. environmental sustainability. **Three Abilities refer to:** The Eco-city being Practicable: The technologies adopted in the Eco-city must be affordable and commercially viable; Replicable: The principles and models of the Eco-city could be applied to other cities in China and other countries, and Scalable: The principles and models could be adapted for another project or development of a different scale. ((MND), 2023) (The World Bank, 2009).

Form: The project is an interesting attempt to tie the necessary variety of urban buildings together by a cohesive landscaped thread. The strength of the proposal lies in the ability of the landscape itself to become a flexible entity that is also defined and shaped to offer different experiences to users. ((MND), 2023) (Sino-Singapore Tianjin Eco-City Investment and Development Co., 2023).

Spatial Grid: Square-grid pattern. Eco-Cell Construction structure (which is a basic building block for the eco-communities and measured by 0.4km*0.4km in landscape). ((MND), 2023).

Streets and paths: Users will be encouraged to take advantage of the city’s light rail system to navigate the differing sections, and the public system will help to drastically reduce the city’s carbon emissions. (MND), 2023).

Blocks and Buildings: The model places a strong emphasis on landscaping as residential towers rise amidst the parks, promenades, and valleys that create the plan’s primary network. Designed by Surbana Urban Planning Group, the scheme divides the city into seven sectors which vary in terms of landscape and programmatic offerings. ((MND), 2023)

Districts: Beginning in 2019, construction began on the city's "Central District", which will serve as the city's urban core. ("The Latest Progress, Retrieved 20 December 2021). The Central District will span an area of 4.5 square kilometers (1.7 sq. mi) and is planned to house a population of 58,000. The construction focuses now shift to the development of the central district; Designing a space where work, leisure, and sustainability can intersect through a "Green Smart Hub" and Friendship Garden. ((MND), 2023) (Sino-Singapore Tianjin Eco-City Investment and Development Co., 2023).

Open Urban Spaces: Landscape: Organized into seven parts, the plan will boast a Life scape, an Eco-Valley, a Solar scape, an Urban scape, a Wind scape, an Earth scape, and Eco-Corridors that will offer residents a different landscape ranging from the stepped, terraced greenery of the Earth scape to the more futuristic soil-shaped mounds of the Life scape. In addition to the extensive use of landscaping, the project also incorporates sustainable technologies – solar and wind power, rainwater harvesting, and desalination, to name a few. **Parks:** The China-Singapore Friendship Garden serves as the city's main park, spanning an area of 41 hectares (0.16 sq. mi) along the Ji Canal. ((MND), 2023) (Sino-Singapore Tianjin Eco-City Investment and Development Co., 2023).



Figure 8 Tianjin Eco-City, Source: ((MND), 2023).

5) (Urban scale: City Design) Tanjong Pagar Waterfront City:

Project team: Architect: Wallich Residence, **Interior Designer:** Wilson Associates. **The leading design architect of the integrated development:** is Skidmore, Owings, and Merrill (SOM) **LLP—developer:** Guoco Land. **Project Information / Site Consideration: Designed by: Wallich Residence/ Brought to you by** Guoco Land | **Date:** May 29, 2016. **Location:** Bukit Merah, Singapore. (Konieva, 2018).

Urban Formulation: Urbanization, Economically, Political and Sustainable Formulations.

Objectives: The Master Plan is a statutory land use plan that guides Singapore's development in the medium term over the next 10 to 15 years, the Master Plan translates the broad long-term strategies of the Concept Plan into detailed plans to guide the development of land and property. The Greater Southern Waterfront, which extends from Pasir Panjang to Marina East, will be transformed into a new major gateway and location for urban living along Singapore's southern coast. (Blossoms, 2023) (OSINTSEVA, 2017).

Form: The form is derived through an extensive analysis, starting from the macro level of street networks and land uses, and gradually delving into finer details such as building heights and road setbacks. The parametric variations were not intended to accommodate multiple sites, but rather to capture the potential within a single defined boundary. The objective was to generate multiple proposals based on diverse conceptual ideas for the site. This case study reveals occasional underlying similarities with the traditional design process and highlights the interconnectedness between these approaches. Additionally, the project consisted of five modules: street network, shoreline, land uses transportation, and buildings. (OSINTSEVA, 2017).

Spatial Grid: Both Rectilinear Pattern and Curvilinear Pattern. (Maccowan, 2012).

Street Network and Shoreline Modules: The streets, which delineate expansive districts, were pre-established as an expansion of existing ones, while the secondary street grid was automatically generated. To initiate this process, the desired dimensions of the street block and its ratios were specified. Additionally, the overall contour of the shoreline was manually sketched by the conceptual proposal, whether it entailed maintaining the same land area or reclaiming additional sections to achieve a lower density and adhering to a design concept aimed at establishing a stronger visual connection to the water, urban elements known as fjords were created. These fjords played a crucial role in finalizing the formation of the street network, as they carved out small channels that radiated from the waterfront, accompanied by pedestrian walkways. However, the inclusion of these fjords could potentially become a subject of negotiation with the customer due to cost considerations or with engineers due to dimensional constraints. Consequently, the size, proportion, number, and location of the fjords remained flexible inputs, allowing for adjustments to be made at a later stage if necessary. (OSINTSEVA, 2017).

Land Uses and Transportation Modules: The modules focused on the distribution of functions across the area and transportation. One of the key factors considered was the

relationship between the expected and current demographic structure, which influenced the change in functional demand. Each specific function had its principle or rule of distribution. By establishing a database with energy-efficient functional templates, the most optimal option could be determined from various possibilities. With information on the distribution of land uses, density, and street network, a calculation method based on an activity-based approach was used to simulate traffic flow. This method was simplified into trip generation tables. (Konieva, 2018).

City Design, Gateways, and Land Plot Division: In the future, approximately 1,000 hectares of land will become available for development. An underground substation, integrated with a commercial building, will be constructed next to the Labrador Park MRT station, making it Singapore's first 230 kV underground substation. the Pasir Panjang Power District can capitalize on its unique industrial heritage and be transformed into a lifestyle and heritage destination. Various strategies are being explored by agencies to achieve this, such as repurposing the former power station buildings and opening up the grounds for public access. The new uses will be considerate of the adjacent Labrador Nature Reserve. The Power District will be connected to the rest of the Greater Southern Waterfront through the new Pasir Panjang Linear Park. (OSINTSEVA, 2017)

Parks and landscape: Residential precincts of the future will continue to be sustainable, green, community-centric, and car-lite, with easy access to a wide range of public spaces and amenities to meet residents' needs.(Konieva, 2018).

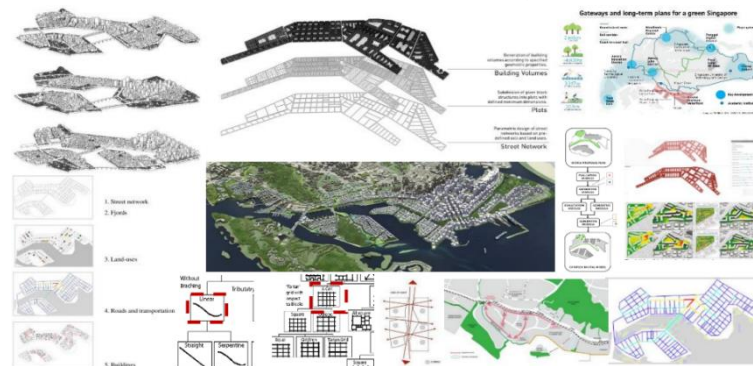


Figure 9 Tanjong Pagar Waterfront City, Source: (OSINTSEVA, 2017).

Applying the framework in some parametric projects:						
THE FRAMEWORK	PROJECT NAMES:					
Urban Formulation	The Peak, The Rejuvenating Resort & Spa	One-North Masterplan	Kartal Pendik Masterplan	Tianjin Eco-City	Tanjong Pagar Waterfront City	
	Environmental and sustainable Formulations	Urbanization formulations	Urbanization formulations	Urbanization, Economic, land uses, and Sustainable Formulation	Urbanization, Political, and Sustainable Formulation	

Operational Definition of Parametricism	Dogmas	All forms must be soft (intelligent: deformation)	The concept embodies a closed-loop approach to civil construction, where materials are extracted from the earth and returned to the site in a transformed state.	" One-north is also free-form and "malleable at any stage of its development."	The integration of the lateral connections with the main longitudinal axis creates a soft grid		The designers were unable to accomplish it.
		All systems must be different (gradients)		The proposed morphological system incorporates free forms that are susceptible to deformation and can be altered at any point during the design phase. This system takes the shape of a grand urban structure, resembling the smooth undulations of a dune, to foster a sense of unity.	In specific regions, the mesh structure elevates to create a cluster of towers in a vast terrain, whereas in other regions it transforms into a more compact pattern intersected by streets, and occasionally disappears entirely to give rise to parks and open areas. Certain regions protrude into the water, resulting in a grid of floating marinas, shops, and eateries.	The skyline of the city showcases a variety of heights, which mirror the wide array of functions within.	The city's skyline displays a range of heights, reflecting the diverse functions of its buildings.

Operational definition of Parametricism	Taboos	Avoid rigid forms (lack of malleability and complexity).	This hexagonal base pattern has been grafted on the site to create a system-driven sense of harmony and symbiosis in the design.	One-north was designed to create a park that can continuously transform over time, a concept referred to as its "malleability."	The calligraphic style of writing establishes an environment that allows for flexible transformations, ranging from standalone structures to interconnected blocks, and eventually evolving into hybrid systems. These systems have the potential to form a network of interconnected open spaces that weave through the city.	The emphasis was placed on dividing neighborhoods and allocating residential blocks rather than focusing on the external layout of buildings. Unfortunately, flexibility in design was not attained, resulting in the creation of rigid blocks.	Partially accomplished through the utilization of bridges, connections, and eco-corridors, despite the continuity of employing the block style.
		Avoid simple repetition (lack of variety)	By using parametric patterns and scaling in the forms	The clear representation of spatial depths in the urban landscape is enhanced by the variation in size among urban blocks and the relationship between block heights and plot sizes.		This principle was not achieved properly as the need to increase the proportion of affordable public housing to at least 20%, addressing the housing needs of the community.	The lack of clarity in achieving the goal was attributed to the urban division and the clustered layout.

		<p>Avoid collage of isolated, unrelated elements (lack of order).</p>	<p>The natural terrain of the site has been used as a design driver.</p>	<p>This is a key aspect of the Master plan, as it brings together numerous elements in a cohesive manner.</p>	<p>The calligraphic script creates open conditions that can transform from detached buildings to perimeter blocks, and ultimately into hybrid systems that can create a porous, interconnected network of open spaces that meanders throughout the city. Through subtle transformations and gradations from one part of the site to the other, the scripted fabric can create a smooth transition from the surrounding context to the new, higher-density development on the site.</p>	<p>the entire city will be linked together through the Z4 Light Rail Line</p>	<p>The division of all zones has been implemented based on the respective functions, not forms.</p>
		<p>Avoid Pure Difference (modernism is all about simple forms, separating and repeating).</p>	<p>The “Hexagonal” pattern which is a common denominator in nature as well as the regional architecture has been used as a unifying element for the design.</p>	<p>The urban environment is characterized by a dynamic atmosphere that is shaped by a grid of undulating buildings and nodes of varying intensities. These two forces, the smooth grid, and the waved roof surface serve as unifying elements for the diverse range of built structures.</p>	<p>The city park comprises five glass biomes, which house tropical plant collections and water gardens, resulting in an organic landscape design.</p>	<p>The designers were unable to accomplish it.</p>	

Functional Heuristics	Dogmas	<p>All functions are parametric activity/event scenarios.</p>	<p>The sloping part of the site has been used as an opportunity to excavate earth and nest villas within the topography.</p>	<p>the first application of the concept of "artificial landscape formation to an entire urban quarter."</p>	<p>The masterplan is thus a dynamic system that generates an adaptable framework for urban form, balancing the need for a recognizable image and a new environment with a sensitive integration of the new city with the existing surroundings</p>	<p>The vision of Tianjin Eco-city is to become a prosperous city that prioritizes social harmony, environmental sustainability, and resource efficiency, serving as a blueprint for sustainable development.</p>	<p>By implementing the urban strategies that encompassed six overarching concepts in urban planning.</p>
		<p>All activities/events communicate with each other.</p>	<p>Half of the site terrain is used as the flat part of the site that is adjacent to the approach road has been used for Drop-off, Reception, day dining, and Spa and then further on an open event space.</p>	<p>The one-north IT master plan has been designed to create a fully connected environment, providing wired, wireless, and high-speed fiber broadband access.</p>	<p>The objective of the project is to revitalize the region by introducing urban and programmatic suggestions that will address the centralized nature of Istanbul and establish itself as a viable</p>	<p>The city's rise as a prominent economic center can be attributed to its dedication to sustainable growth and strategic collaborations. As a result, a comprehensive and interconnected industry</p>	<p>By enlarging the Network of Public Spaces and creating additional possibilities for residential, commercial, and recreational facilities.</p>

					economic and service hub, thereby eliminating the existing imbalance between the two sides of the Istanbul Metropolitan Area.	network has been established, encompassing various sectors such as manufacturing, education, research, and practical implementation	
--	--	--	--	--	---	---	--

Functional Heuristics	Taboos	Avoid rigid functional stereotypes	Solved by using the architecture of Rajasthan boasts of intricate carving and Jharok has (Semi-covered balconies with perforated windows all around).	The one-north master plan establishes an intricate system of public spaces within the development area, creating a comprehensive structure for community engagement	The grid employed in this scenario is not a typical Cartesian grid, but instead a distinctive topographical grid that can adjust and change shape based on different situations and the city's topography.	The Eco-City is dedicated to building a smart city while also promoting the integration of intelligent enterprises, setting up training centers for intelligent industries, nurturing skilled professionals in the field, designing innovative intelligent applications, and advancing the development of independently created intelligent products.	The city remains segregated based on its function, thus failing to accomplish this principle.
		Avoid segregation functional zoning.	By integrating all the features the wind movement has been channeled by creating two buildings flanking either side of the entrance that create a wind tunnel effect and compress and accelerate the wind	The formulation of the one-north master plan involved the implementation of four essential planning strategies: Mixed use, Connectivity, Rejuvenation, and Identity.			The residents of Tanjong Pagar district will experience a positive transformation in their lifestyle, economic value, and extending the City to the Greater Southern Waterfront
Mostly Applied Urban Patterns			Hexagonal pattern.	Cartesian curvilinear pattern	smooth grid	Eco-Cell Construction structure	Rectilinear Pattern and Curvilinear Pattern

Part 2: Discussion and Findings:

Discussion:

Based on the analysis of the samples, the paper examines a parametric framework that explains the fundamental principles of parametric design and highlights the impact of this approach on both the form and function of design decisions in the projects' case studies, especially the urban projects, finding inconsistencies in its application due to the lack of universal acceptance and understanding of the Parametricism concept. It points out that parametric urbanism encompasses a multidisciplinary approach involving design, regulation, and management of urban areas, not solely focused on forms. The study emphasizes the disconnect between theory and practice in the computational design process on a large urban scale, indicating the need for a solid theoretical foundation. It suggests that Parametric design principles being applied to

the forms should be viewed as only a fraction of the entire design process, and the framework itself should be applied comprehensively in all design stages.

The article highlights that Parametricism faces limitations in design, as some perceive the utilization of parametric tools as shallow and lacking in aesthetics. Furthermore, urban design is not solely dependent on the suggested form, but also on urban and social components. The article reveals these constraints by exploring their origins, as urbanism not only prioritizes formal and aesthetic aspects, but also emphasizes the development of intricate geometries through parameterization, the ability to create a wide range of geometric shapes, from straight lines and platonic solids to highly free and complex forms as well as crucial concepts such as social, economic, and political factors. In addition to giving special attention to utilizing parameters for managing and altering variations enables architecture to create designs consisting of individual elements while maintaining unity and coherence, this approach makes manufacturing parts cost-effective and simple to produce, while also providing the flexibility to create forms that are readily accessible.

Findings:

Understanding the urban concepts utilized in shaping urban environments and urban formulations of cities, along with comprehending the rationale behind each concept and the potential for integrating them to accomplish the desired urban design objective.

Familiarity with parametric principles in functional and formal dimensions that can be implemented to realize the envisioned parametric urban design.

Developing an inclusive **parametric urban framework** that can be utilized to achieve a parametric urban design that meets its needs. This **framework** serves as a tool to identify the specific urban formulations utilized in the proposed project or under design, based on the conclusions drawn from the methodology. Furthermore, it aims to assess the degree to which parametric design principles are incorporated into the project's functional and formal aspects. This comprehensive framework encompasses all the dogmas and taboos put forth by the researchers. It not only evaluates the project's ability to achieve a successful parametric urban design through its proposals but also examines how the project leverages the parameters during the design process, thereby confirming the application of parametric thinking in design. Acquiring knowledge of urban patterns employed in urban design, as well as understanding parametric urban patterns and their impact on urban progress.

The integrated parametric urban framework		
Type of Urban Formulation	Define the type according to the design scenario	
Operational Definition of Parametricism	Dogmas	Taboos
	All forms must be soft (intelligent: deformation = information)	Avoid rigid forms (lack of malleability and complexity).

	All systems must be differentiated (gradients)	Avoid simple repetition (lack of variety)
	All systems must be interdependent (correlations or coherence).	Avoid collage of isolated, unrelated elements (lack of order).
	-	Avoid Pure Difference (modernism is all about simple forms, separating and repeating).
Functional Heuristics	All functions are parametric activity/event scenarios.	Avoid rigid functional stereotypes
	All activities/events communicate with each other.	Avoid segregation functional zoning.
Mostly Applied Urban Patterns	Define the type according to the design scenario	

References:

1. Abdulmawla, A., Schneider, S., Bielik, M., & Koenig, R. (2018). Integrated Data Analysis for Parametric Design Environment mineR: a Grasshopper plugin based on R. *Proceedings of the International Conference on Education and Research in Computer-Aided Architectural Design in Europe*, 2, 319–326. <https://doi.org/10.52842/conf.ecaade.2018.2.319>
2. Aw, A. (1987). SINGAPORE: The One-North Project. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, 35(2), 403–420.
3. Blossoms. (2023). *Four Amazing Transformations Of The Greater Southern Waterfront*. <https://www.blossomsbythepark.condos/post/four-amazing-transformations-of-the-greater-southern-waterfront>
4. Burry, M. (2004). Between intuition and process: Parametric design and rapid prototyping. *Architecture in the Digital Age: Design and Manufacturing*, 210–229.
5. Çalışkan, O. (2017). Parametric design in urbanism: A critical reflection. *Planning Practice and Research*, 32(4), 417–443. <https://doi.org/10.1080/02697459.2017.1378862>
6. Çalışkan, O., Barut, Y. B., & Ongun, G. (2021). Parametric Urban Design Thinking: Shared Patterns in Design by Algorithm and Design by Drawing. *Journal of Planning Education and Research*, December 2021. <https://doi.org/10.1177/0739456X211053653>
7. Coyne, R. (2014). What 's wrong with parametricism? *Interfaces*, 33(5), 78.
8. Da Silva, R. C., & Morim, L. M. (2010). Parametric urbanism: emergence, limits, and perspectives of a new trend in urban design based on parametric design systems. *V! Rus*, 3. <http://www.nomads.usp.br/virus/virus03/submitted/layout.php?item=2&lang=en>
9. Eisner, S., Gallion, A., & Eisner, S. (1993). *The Urban Pattern, 6th Edition*. Wiley. <https://www.wiley.com/en-gb/The+Urban+Pattern%2C+6th+Edition-p-9780471284284>
10. Fahmy, M. (2019). *Applying Parametric Urban Design of Dynamic Neighborhoods*. Helwan University.
11. India, News, Resort, S. S. (2022). *The Peak Resort and Spa by Studio*

- Symbiosis*. AASA. <https://aasarchitecture.com/2022/04/the-peak-resort-and-spa-by-studio-symbiosis/>
12. Kocabas, A. (2010). Kartal urban regeneration project: Challenges, opportunities, and prospects for the future. *WIT Transactions on Ecology and the Environment*, 129(March), 571–582. <https://doi.org/10.2495/SC100481>
 13. Konieva, K. (2018). Parametric assistance for complex urban planning processes three examples from Africa and South-East Asia. *Proceedings of the Annual International Conference on Architecture and Civil Engineering*, 0(May). https://doi.org/10.5176/2301-394X_ACE18.58
 14. Lane, B. G. (2009). *Kartal masterplan, istanbul*.
 15. Maccowan, Richard James. (2012). *biomimicry+Urban design*. 115.
 16. Manuel, G., Pinto, M., Vieira, A. P., & Neto, P. L. (2013). Parametric Urbanism as digital methodology AN URBAN PLAN IN BEIJING. *1^o ECAADe Regional International Workshop*, 121–132.
 17. Marwa Kamal. (2020). *APPLYING URBAN PARAMETRICISM IN THE DESIGN OF DYNAMIC NEIGHBORHOODS*. July, 1–23.
 18. (MND), M. of N. D. (2023). *The Sino-Singapore Tianjin Eco-city*. <https://www.mnd.gov.sg./tianjinecocity/who-we-are>
 19. Nagy. (2009). Urban magazine: towards a collective purpose. *Urban Magazine*, 349(6250), aab3884. http://scholar.google.com/scholar_lookup?title=Global+cancer+statistics&author=A.+Jemal&author=F.+Bray&author=M.+M.+Center&author=J.+Ferlay&author=E.+Ward&author=D.+Forman&publication_year=2011%0Ahttps://anthrosourc.onlinelibrary.wiley.com/servlet/linkou
 20. Oktan, S. (2017). *Parametricism: A Style or A Method?* 12.
 21. OSINTSEVA, I. (2017). *Parametric Master Planning of the Waterfront Tanjong Pagar District in Singapore*. 1–51.
 22. Raven, J., Stone, B., Mills, G., Towers, J., Katzschner, L., Leone, M. F., Gaborit, P., Georgescu, M., Hariri, M., Lee, J., LeJava, J., Sharifi, A., Visconti, C., & Rudd, A. (2018). Urban Planning and Urban Design. *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*, 139–172. <https://doi.org/10.1017/9781316563878.012>
 23. Researcher. (2023). *Adopted by the researcher*.
 24. Rezaei, M. (2023). A Review of urban design projects and theories: types and criteria. *Journal of Historical Archaeology & Anthropological Sciences*, 8(1), 34–39. <https://doi.org/10.15406/jhaas.2023.08.00271>
 25. Schnabel, M. A. (2008). Parametric design in urban design. *Paper for ICCCBE-XII \& INCITE, June*, 16–18.
 26. Schumacher, P. (2011). Parametricism and the Autopoiesis of Architecture. *SCI-Arc, Log 21, September 2010*, 17.
 27. Shakeri, S. (2022). *Peak, The Rejuvenating Resort By Studio Symbiosis*. Parametric-Architecture. <https://parametric-architecture.com/peak-the-rejuvenating-resort-by-studio-symbiosis/>
 28. Sharma, S. N. (2014). Urban Forms in Planning and Design. *International*

- Journal of Research*, 1(2), 5–11. <https://doi.org/10.5281/zenodo.10091806>
29. Silva, R. L. and M. (2015). Parametrics applied to Urbanism. *The Next City - New Technologies and the Future of the Built Environment*, 297-303. http://papers.cumincad.org/cgi-bin/works/paper/cf2015_297%0Afiles/295/Silva - 2015 - Parametric applied to Urbanism.pdf%0Afiles/296/cf2015_297.html
 30. Sino-Singapore Tianjin Eco-City Investment and Development Co., L. (2023). *China-Singapore Tianjin Eco-City*. <http://www.tianjineco-city.com/static/web/en/singapore4.html?lang=english>
 31. Steinø, Nicolai & Obeling, E. (2013). *Parametrics in Urban Design*.
 32. The World Bank. (2009). *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China*. 168. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/01/17/000333037_20110117011432/Rendered/PDF/590120WP0P114811REPORTFINAL1EN1WEB.pdf
 33. Verebes, T. (2014). *Masterplanning the Adaptive City Computational Urbanism in the Twenty-First Century* (T. Verebes (ed.); 1st Editio). Routledge.
 34. Wooff, S. (2016). *Parametric Urbanism Parametric Urbanism Master of Architecture*.
 35. Zaha Hadid Architects. (2019). *One-North-Masterplan*. <https://www.zaha-hadid.com/masterplans/one-north-masterplan/>
 36. Zhang, Y., & Liu, C. (2021). Parametric urbanism and environment optimization: Toward a quality environmental urban morphology. *International Journal of Environmental Research and Public Health*, 18(7). <https://doi.org/10.3390/ijerph18073558>