Journal of Modern Technology
Vol. 02, No. 02, August 2025, pp. 327-345.
DOI: https://doi.org/10.71426/jmt.v2.i2.pp327-345 , E-ISSN: 3049-3102
Homepage: https://review.journal-of-moden-technology.com/index.php/jmt/index

Re-Evaluating the Functionalist Approach of Urban Management towards Sustainable Architecture and Urban Layout with Emphasis on the Role of Digital Technologies

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Article Info

Article history:

Received: July 17, 2025
Revised: August 13, 2025
Accepted: August 18, 2025
First Online: August 20, 2025

Keywords:

Urban management
Sustainable architecture
Urban layout
Artificial Intelligence (AI)
Digital technologies

ABSTRACT

Urban management's persistent reliance on purely functionalist approaches often sidelines aesthetics and social vitality, particularly in sustainable architecture and urban layout. This tension between sociologists prioritizing citizen-centered social functions and architects championing environmental, aesthetic, and symbolic roles undermines holistic urban development. Focusing on Tehran's District 6, this research interrogates how digital technologies can reconcile these perspectives to foster spaces that are efficient, sustainable, and culturally resonant. Through critical literature review and qualitative case analysis, we reveal how decades of functionalist management eroded District 6's visual coherence, social equity, and historical identity. The area's haphazard development, driven by ad-hoc construction and weak oversight, exemplifies the costs of neglecting integrated design. Yet, our findings propose a transformative pathway: strategically embedding digital tools (e.g., geographic information systems (GIS) mapping, Artificial intelligence (AI)-assisted restoration, augmented reality/virtual reality (AR/VR) placemaking, and participatory platforms) within sustainable architecture principles can revitalize urban fabric. We demonstrate that digital integration enables more than technical efficiency—it re-centers human experience. Interactive public spaces, digitally enhanced heritage conservation, and real-time civic co-design tools strengthen belonging while optimizing resource use. However, success hinges on transcending institutional silos and empowering communities. Ultimately, this study argues for an aesthetic-functional hybrid model where digital technology mediates between sociological needs and architectural innovation. For cities like Tehran, this approach isn't optional; it's vital for crafting resilient, identity-rich neighborhoods that honor both people and place.

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1. INTRODUCTION

The debate between urban sociologists and architectural theorists/researchers regarding the use of functionalist approaches in urban management particularly concerning sustainable architecture and urban layout persists to this day. To understand this tension, it's crucial to first define the functionalist approach in urban management. Historically, functionalism, often rooted in modernism, emphasizes efficiency, utility, and rational organization as

primary drivers for urban planning and design. This approach views the city as a machine or a system, where each part serves a specific purpose to ensure the smooth operation of the whole. For urban management, this often translated into policies focused on optimizing infrastructure, maximizing economic output, streamlining transportation networks, and providing basic services in the most direct and pragmatic way. The underlying assumption was that by fulfilling these core functions, a city would inherently be successful and serve its inhabitants effectively.

Most urban sociologists, emphasizing the importance of vital societal functions (especially maintaining intra-urban interactions, communicative spaces, etc.), strive to address these issues primarily from a citizen-centered perspective. This sociological functionalism, while also concerned with meeting needs, focuses more on the social structures and processes that enable community life, interaction, and well-being. Conversely, urban architectural theorists and researchers argue that a city's visual image—or more plainly, its aesthetic and visual approach—not only enhances citizens' urban interactions but also frames the city as a natural construct rather than an artificial one. It is here that attention to components like sustainable architecture and preserving the visual aesthetics of urban layout will be far better able to reinforce the city's natural function.

At the heart of this debate lies the differing weight and value each group assigns to "function." For sociologists, function typically means the capacity to address citizens' social, economic, and cultural needs. Architects, however, view function as encompassing environmental, aesthetic, and even symbolic dimensions. In other words, sociologists emphasize the social function of the city, whereas urban architects consider the scope of function more broadly, seeking to create synergy among diverse functions. This disagreement becomes especially pronounced in the context of sustainable architecture. Sociologists might evaluate sustainable architecture by asking: Does it ensure equitable access to resources, reduce social inequalities, and create accessible green spaces for all citizens? Architects, conversely, may focus more on the technical and environmental aspects of sustainable architecture such as reducing energy consumption, using locally sourced materials, and designing buildings compatible with the local climate.

Resolving this challenge appears to require a hybrid approach that incorporates both perspectives. An ideal city must not only be socially and economically efficient but also environmentally sustainable and aesthetically pleasing. Achieving this demands ongoing, constructive dialogue between sociologists, architects, and other urban specialists. Additionally, active citizen participation in urban design and planning processes can help identify and address a community's genuine needs, preventing spaces that only serve specific groups. Ultimately, it is crucial to recognize that a city is a living, dynamic entity, and all management and design efforts must account for this reality.

Accordingly, this recent research seeks to revisit the functionalist approach of urban management toward sustainable architecture and urban layout particularly the use of digital technologies. It also addresses the neglect of aesthetics in large-scale urban environments like Tehran as a vital element that enhances civic vitality and social interactions, all while pursuing improved quality of life and urban sustainability. The primary goal is to move beyond mere efficiency and achieve spaces that not only meet citizens' essential needs but also strengthen their sense of belonging, identity, and vibrancy. To this end, through theoretical studies and case analyses within Tehran's urban fabric, this research identifies strengths and weaknesses in current approaches. It then proposes innovative strategies for optimally integrating digital technologies with principles of sustainable architecture and human-centered urban design. The core question is: How can new digital technologies be leveraged to create urban spaces that are both efficient and sustainable, while also possessing aesthetic value—spaces that enhance social interactions and strengthen citizens' sense of place? Toward this goal, while recognizing the critical role of citizen participation in urban design and planning processes, emphasis will be placed on educating and raising awareness about the benefits of sustainable architecture and human-centered urban spaces.

2. LITERATURE REVIEW

2. 1. Urban management

A city is a space that fulfills people's needs and desires particularly regarding health, safety, and welfare through its internal structures and urban infrastructure. In the modern era, a city is regarded as a living organism requiring constant attention. Service-distributing institutions must consider all areas of the city as places needed by citizens. Consequently, equitable distribution of urban services is a primary duty of municipalities, ensuring citizens feel acknowledged in their urban environment. This perspective of cities as living organisms necessitates the principle that the purpose of a city is to enhance citizens' quality of life. Most theorists and researchers in sustainable urban development believe establishing a city serves no objective other than increasing citizen satisfaction and quality of life [1].

Expecting a vibrant, dynamic city is meaningless without robust and intelligent urban management. Management is a hierarchical process involving planning, organizing, and decision-making to achieve organizational goals [2], coordinating individual and collective efforts toward defined objectives. Urban management extends beyond municipalities, encompassing all formal and informal institutions involved in city governance [3],[4], including their policy-making and decision-making processes. Today, urban management is viewed as a democratic approach for better city administration, emphasizing the pivotal role of municipalities as direct representatives of citizens in improving urban quality of life [5].

2. 2. The functionalist approach in urban management: A deeper look

Historically, the functionalist approach in urban management gained prominence with the rise of industrial cities and the need for efficient infrastructure and services. This approach primarily emphasizes the city's role in fulfilling practical, measurable needs, often prioritizing economic development, logistical efficiency, and public health. Key characteristics of this approach include:

A) Zoning and Segregation of Functions: A hallmark of functionalist planning is the separation of urban activities into distinct zones (residential, commercial, industrial, recreational). The idea was to minimize conflicts between different uses and optimize the flow of people and goods. While intended for efficiency, this often led to monotonous urban landscapes and a lack of mixed-use vitality.

B) Infrastructure-Centric Development: Functionalism heavily invests in large-scale infrastructure projects such as extensive road networks, public transportation systems, utilities (water, sewage, electricity), and housing complexes designed for mass accommodation. The focus is on providing universal access to these essential services.

C) Rational Planning and Top-Down Implementation: Decisions are typically made by experts (planners, engineers) based on data-driven analysis and projected needs. Public participation, if present, is often limited to formal consultation rather than collaborative co-design, reinforcing a hierarchical, top-down model of governance.

D) Standardization and Reproducibility: Functionalist approaches often favor standardized designs and mass-produced solutions to achieve efficiency and cost-effectiveness. This can result in a loss of local character, historical identity, and architectural diversity.

F) Emphasis on Measurable Outcomes: Success is often gauged by quantifiable metrics like traffic flow, housing units constructed, economic growth rates, and service delivery efficiency. Less tangible aspects, such as community cohesion, aesthetic appeal, or cultural vibrancy, are often secondary or overlooked.

While functionalism has contributed to the development of modern cities by providing essential services and infrastructure, its limitations have become increasingly apparent. Its rigid adherence to efficiency and separation often neglects the complex social, cultural, and aesthetic dimensions that contribute to a truly livable and sustainable urban environment. The "build-and-sell" or density-trading approach, as mentioned later in this section, is a contemporary manifestation of a purely functionalist, market-driven logic that can disregard environmental and social consequences.

Furthermore, insights from customer relationship management systems in online retailing highlight the critical role of understanding user needs and optimizing interactions [6], principles equally vital for citizen-centric urban service delivery and engagement platforms within smart urban management frameworks. Extending this to knowledge management, Saremi et al. [7] demonstrate how digital marketing models leveraging customer participation can be optimized through effective knowledge management systems, highlighting the potential for structured digital platforms to enhance civic co-creation in urban planning. This aligns with emerging natural language processing (NLP)-enabled assessment tools that mitigate linguistic discrimination in civic feedback systems, ensuring equitable inclusion of diverse socio-economic and educational backgrounds in participatory processes [8]. Indeed, efficient urban management guarantees sustainable and balanced urban development. In the absence of an effective management system, cities face challenges such as traffic congestion, air pollution, socioeconomic inequalities, inadequate urban services, and neglect of sustainable architecture and urban layout. As such, strengthening and developing managerial capacities in cities is both vital and inevitable.

Smart urban management uses modern technologies and analytical data to not only address the current needs of citizens but also to anticipate future developments. It's a knowledge- and technology-based approach that aims to improve citizens' quality of life and enhance urban sustainability through informed decision-making and strategic planning. Furthermore, effective urban management requires close interaction and cooperation among all urban stakeholders, including citizens, governmental and non-governmental organizations, and the private sector. Citizen participation in the decision-making process ensures their needs and desires are considered in urban policymaking. Similarly, cooperation between different organizations prevents duplication and overlapping of duties, fostering greater coordination and cohesion in city administration [9]-[10]. Furthermore, insights from economic policy

research underscore that uncertainty in decision-making frameworks (such as monetary policy) can destabilize planning outcomes and public trust [11], reinforcing the need for transparent governance. Robust methodologies for evaluating causal impacts, such as those reviewed by Mahdavi and Ehsani [12], are essential for urban managers to credibly assess the effectiveness of digital interventions and policy choices on social equity and environmental outcomes. Therefore, successful urban management is responsive and transparent management. This means city managers must be accountable to citizens for their performance and publicly disclose information regarding urban decision-making and projects. Transparency and accountability increase citizens' trust in urban management and encourage their more active participation in city affairs. Systematic evaluation frameworks like the validated Persian Individual Work Performance Questionnaire (IWPQ) [13] could strengthen accountability by measuring municipal staff effectiveness across task execution, contextual contributions, and counterproductive behaviors directly linking performance metrics to sustainable urban outcomes. Citizens should not remain distant from the urban sphere or refrain from criticizing city-wide policies and decisions, as every decision leads to small or large changes in urban spaces and citizens' daily lives. Consequently, in urban management, citizens must assume an active role to protect their shared, collective urban spaces and prevent actions decided and executed by the municipality that are supposedly meant to meet collective demands. This is undoubtedly the best method for overseeing urban management [14].

Undoubtedly, the success of urban management is directly linked to the legal and social legitimacy of municipalities. Success in urban policymaking and decision-making requires citizen participation in project implementation. Urban management must create spaces that sustain urban life by formulating short-term and medium-term plans based on specific data. The current "build-and-sell" or density-trading approach is less urban management and more the deliberate destruction of a city's social, cultural, and spiritual fabric. This type of management, disregarding environmental, demographic, and social consequences, destroys the authentic fabric of old neighborhoods and replaces them with towers that bear no relation to the city's geography or its citizens' way of life [15],[16]. Furthermore, research highlights how neglecting diverse neighborhood subcultures within urban management frameworks can exacerbate social issues and hinder cohesive community development, undermining the very social fabric functionalist approaches claim to serve [17].

Urban management, while responsible for a set of decisions and policies, is not only consistently accountable to the city's residents but also attentive to citizens' genuine needs regarding the city's visual and aesthetic dimension. By creating urban spaces, urban management not only expands the city's living facilities and enhances people's quality of life, but most importantly, through citizen participation, it both establishes social justice and considers the city's visual atmosphere, especially in architecture and urban layout. In other words, modern urban management is not limited to merely addressing basic needs like transportation, housing, and health services; it also seeks to improve quality of life by creating attractive and inspiring public spaces. This requires careful attention to the city's aesthetic details, from the design of buildings and street furniture to tree planting and street lighting. A well-designed urban space not only strengthens citizens' sense of belonging and identity but also contributes to their mental and physical well-being [18].

Furthermore, citizen participation in the process of designing and developing urban spaces plays a vital role in achieving urban management goals. Emerging research on automated formative assessment tools suggests that structured digital platforms can significantly enhance the clarity and impact of civic feedback, ensuring diverse voices are effectively articulated and integrated into planning processes [19]. Furthermore, the efficacy of such platforms in fostering genuine empowerment and sustained engagement may depend on underlying psychological factors; research indicates that financial self-efficacy acts as a critical mediator between financial literacy and positive financial behaviors/resilience proposed by Moazezi Khah Tehran, Hassani et al. [59], suggesting that digital participation tools must also aim to build citizens' confidence and perceived agency in shaping their urban environment for optimal impact. These platforms must prioritize user experience, as studies in other digital service sectors, such as crypto wallets, demonstrate that e-service quality and user satisfaction are critically linked to factors like security, trust, privacy, and ease of use [61]. Insights from evaluating the effectiveness of pedagogical programs, such as those for engineering students [20], underscore the importance of robust assessment frameworks for designing successful citizen education and engagement initiatives aimed at fostering understanding of sustainable urban principles. Extending this, the 'Convince, Understand, Teach' framework [21] originally developed for mathematical proof instruction offers a transferable pedagogical model for urban planners to structure public consultations: first convincing citizens of sustainability benefits, then deepening conceptual understanding through participatory simulations, and finally co-teaching neighborhood-specific implementation strategies. When citizens feel they have a share in shaping their living environment, they are more likely to care for public spaces and actively participate in the city's social and cultural activities. This participation can occur through consultative meetings,

surveys, and educational workshops. It can be said that successful urban management is one that can creatively integrate the views of experts, the needs of citizens, and environmental requirements to create sustainable urban spaces that are both functionally efficient and visually attractive and inspiring. Such spaces not only help improve citizens' quality of life but also lead to the city's economic and cultural prosperity. Essentially, healthy urban management never contributes to class divisions by creating and equipping luxury urban spaces in wealthy neighborhoods. Instead, it always values social justice, economic efficiency, and environmental sustainability [22]. Consequently, urban management is the vital framework of the city through which citizens experience a sense of security and participation in their urban community.

Urban management should not avoid strengthening citizens' social actions due to fear of potential protests. Expanding urban spaces related to these actions improves the city's cultural and social vitality and enables urban management to act according to citizens' needs. Modern management views collaboration with diverse social and political groups as part of engaging citizens to improve social conditions, and its primary goal is to enhance citizens' quality of life by achieving predefined organizational objectives [23], [24].

2.2. Sustainable architecture and urban layout

The application of sustainability concepts and sustainable development goals to reduce energy waste and environmental pollution in architecture has given rise to a field called sustainable architecture. Sustainable architecture is a comprehensive approach to building design that seeks to meet today's needs while reducing the negative impacts of construction on the environment and enhancing quality of life, without compromising the ability of future generations to meet their own needs. This intergenerational responsibility mirrors the core principle of sustainable development, where investments in critical areas like healthcare expenditure are recognized as foundational for long-term societal well-being and economic stability [25], just as sustainable built environments are foundational for resilient and thriving urban futures. This architecture aims to minimize energy waste and environmental pollution by employing ecological principles, optimizing the use of natural resources (such as solar energy, wind, and rainwater), selecting sustainable and recyclable building materials, and utilizing active and passive building design to reduce energy consumption [4].

Fundamentally, sustainable architecture is an approach aimed at creating buildings with lower environmental impacts that are compatible with the environment. Sustainable architects, by considering the building's full life cycle from design and construction to operation and demolition strive to minimize environmental impacts at every stage. For example, passive building design with proper orientation, use of sunshades, and natural ventilation significantly reduces the need for mechanical heating and cooling systems. This is particularly vital in climates like Tehran's; systematic reviews confirm that integrating traditional passive cooling wisdom (e.g., windcatchers, courtyard design, evaporative cooling) with modern innovations offers highly effective pathways for sustainable thermal comfort in arid urban environments [60], providing locally relevant strategies that align with both environmental and cultural sustainability goals. Additionally, the use of renewable energy sources like solar panels and wind turbines minimizes dependence on fossil fuels and reduces greenhouse gas emissions [26], [27]. Furthermore, the application of advanced computational methods, such as machine learning, can enhance the long-term durability and sustainability of construction materials by predicting phenomena like concrete carbonation [62]. Moreover, integrated management frameworks such as the synergistic application of Green Supply Chain Management (GSCM) and Total Quality Management (TQM) empirically enhance energy efficiency and waste reduction in built environments, as demonstrated by SEM-ANN analyses of operational systems in resource-constrained contexts [28]. Furthermore, sustainable architecture pays special attention to indoor air quality and occupant health. Using non-toxic, low-(volatile organic compounds) VOC materials, along with proper ventilation and natural light, helps improve indoor air quality and enhances occupant health and well-being. Sustainable architecture is not merely an architectural style, but a design philosophy seeking to create healthy, comfortable, and sustainable spaces for living and working, while fulfilling its responsibility to preserve the environment and natural resources for future generations [29]. This philosophy resonates with historical Iranian vernacular practices, where master builders ('Ostads') intuitively integrated climate responsiveness, local materials, and cultural aesthetics long before the modern sustainability discourse, offering valuable lessons for contemporary approaches [30], while broader cultural framings, such as those explored in medical anthropology regarding narrative intertextuality and resource conflicts [31], underscore how deeply sustainability intersects with socio-cultural narratives and power dynamics within urban spaces.

On the other hand, one important model in urban architecture is the preservation and revitalization of the urban layout. This model means preserving the city's core structure, streets, neighborhoods, and valuable historical buildings. Revitalizing the urban layout is not limited to physical restoration; it also includes reviving social and cultural identity, appropriate land uses, and economic prosperity. This approach views the city as a living and

dynamic entity that, by preserving its roots, can step towards a sustainable and flourishing future. Preserving the urban layout keeps collective memories alive and gives citizens a sense of belonging and identity.

According to research findings, urban layout examines how spaces are arranged and how this affects their use. This concept originates from spatial configuration analysis and is applied in urban design. One important approach in this field is Space Syntax Theory, developed by researchers such as Bill Hillier and Julienne Hanson. Additionally, urban decor inspired by city life creates modern and calming spaces. Urban spatial configuration involves applying space syntax analysis to identify geometric patterns formed by buildings and cities. This method enables understanding the configuration of urban spaces and the social logic shaping them. In other words, space syntax analysis helps us comprehend how urban space functions, the presence of urban space influences movement, social interactions, and even urban economics. Using specialized algorithms and software, this analysis converts a city map into a set of lines (axial lines) or spaces (convex spaces), then examines relationships between these elements. By understanding these patterns and metrics, we gain deeper insight into city functionality and its underlying social and economic dynamics, allowing this knowledge to inform more efficient and equitable urban design [32].

The most crucial feature of urban spatial configuration is creating proportionality and a sense of belonging for citizens. Proper use of spaces and urban layouts makes the city feel like home to residents not an unfamiliar or alien environment. This sense of belonging goes beyond mere access to amenities; it depends on addressing citizens' emotional and psychological needs. A successful urban space is one where people feel security, tranquility, and identity. Designing attractive visual symbols tied to the city's culture and history, creating pleasant green spaces, and easing access to public facilities all strengthen this sense of belonging [33]. Recent empirical work further emphasizes how effective public space design such as repurposing underutilized urban areas for leisure and tourism [34] directly influences social cohesion and citizen well-being, just as critical analyses of cultural production remind us of that taste, aesthetics, and visual identity are not neutral but deeply intertwined with social categories like race and gender, shaping how spaces are perceived and experienced [35].

Urban spatial arrangement should not be purely functional; it must also address aesthetic aspects and create positive experiences for citizens. Implementing appropriate lighting, using harmonious and appealing colors, and designing spaces for pause and social interaction can enhance urban quality of life. A successful urban layout considers all citizens' needs including children, the elderly, and people with disabilities—to create an equal and fair space for everyone. A space where every individual can freely access city amenities without worry, feeling security and tranquility while taking pride in their city.

2.3. Digital Technologies

Technology is a combination of skills, knowledge, abilities, materials, machines, and tools that humans use to convert or change raw materials into valuable goods and services [36]. However, information technology is defined as "the study, design, development, implementation, support, or management of computer-based information systems, particularly application software and computer hardware." In brief, information technology deals with using electronic computers and computer software to securely convert, store, protect, process, transmit, and receive information [37]. Recently, it has become common to use a term that encompasses the field of electronic communications, which is why people tend to use the term ICT (Information and Communications Technology). Today, the application of information technologies is increasing daily. Advances in communications and computer technologies (including mainframe and personal computers) allow employees of an organization to remain connected to their organization and work for it even when outside the organization [36].

Digital technology, however, refers to all tools, systems, devices, and resources used to produce, store, and process information digitally. This technology includes a wide range of items, from personal computers and smartphones to computer networks, the internet, software, applications, sensors, and many others. Digital technology has fundamentally changed how we live, work, and interact with each other, and it continues to evolve rapidly. This digital transformation has provided countless opportunities for individuals, businesses, institutions, and governments. From improving efficiency and productivity to creating new business models and delivering innovative services, digital technology enables us to do things that previously seemed impossible.

However, these advancements also bring challenges. Issues concerning data privacy, cybersecurity, the digital divide, and the social effects of automation are among those that need serious attention. Securing the digital infrastructure underpinning smart city functions, including citizen data and critical systems, is paramount, as vulnerabilities highlighted in domains like mobile social networks [38] pose significant risks to public trust and operational integrity. Addressing collusion threats specifically, frameworks like SERENE [39] demonstrate how resilient, replication-based verification mechanisms can enhance the trustworthiness of distributed systems essential for secure urban data management. These risks are compounded by human and organizational factors, as effective

cybersecurity implementation depends critically on individual awareness, social norms, and institutional training – determinants that shape resilience in smart city ecosystems [40]. The application of Artificial Intelligence (AI) in augmenting human decision-making for diversity and inclusivity goals, such as in K-12 teacher recruitment [41], exemplifies the potential of these technologies to address complex societal challenges beyond efficiency, underscoring the need for ethically guided implementation in urban contexts to foster equity and social cohesion. Similarly, machine learning frameworks analyzing economic factors in business districts [42] and cross-national FinTech adoption patterns [43] demonstrate how algorithmic tools can optimize resource allocation and fiscal sustainability in urban regeneration projects particularly relevant for mixed-use zones like Tehran's District 6. To fully benefit from digital technology, we must continuously upgrade our skills, develop appropriate regulations, and ensure everyone has access to this technology. Ultimately, digital technology is a powerful tool that can be used to improve human life, but it requires a responsible and informed approach to prevent misuse and mitigate its negative impacts [44].

3. RESEARCH METHODOLOGY

The methodology of this study is primarily qualitative, employing a multi-pronged approach to investigate the impact of functionalist urban management on sustainable architecture and urban layout, with an emphasis on digital technologies. The research proceeds in two main stages:

3. 1. Theoretical framework development

A comprehensive critical literature review was conducted to establish the theoretical foundation of the study. This involved examining existing scholarly works on:

A) Functionalist approaches in urban management: To understand its core tenets, historical applications, and identified limitations.

B) Sustainable architecture and urban layout: To define their principles, objectives, and contemporary challenges.

C) Digital technologies in urban planning and design: To identify relevant tools and their potential applications in fostering sustainable and human-centered urban environments.

This stage allowed for the development of a theoretical framework that highlights the tension between purely functionalist urban management and the holistic demands of sustainable urban development, particularly concerning aesthetics and social vitality.

3. 2. Qualitative case analysis

Building upon the theoretical understanding, the study then employed a qualitative case analysis focused on Tehran, with a primary focus on District 6 as shown in Figure 1. This specific district was chosen due to its observed historical development patterns, which exemplify the challenges posed by past functionalist management approaches. The primary methods for data collection were:

A) Field observation: Direct observation and documentation of the architectural fabric and urban layout within Tehran's District 6 were conducted. This involved noting visual coherence, social equity (as manifested in public spaces and access), and the extent of historical identity preservation or erosion. Specific attention was paid to identifying the consequences of ad-hoc construction and weak oversight on the urban environment.

B) Documentation and visual analysis: Relevant theoretical sources and visual documentation (e.g., photographs, urban plans, historical records) pertaining to urban architecture and development in District 6 served as key tools. This qualitative data was analyzed to identify patterns, characteristics, and impacts stemming from the functionalist approach.

3. 3. Integration of digital tools in sustainable architecture and urban layout

A key component of this methodology is to conceptually integrate the use of digital tools within sustainable architecture principles and urban layout strategies, specifically in the context of District 6. While this research does not involve the direct implementation of these tools, it proposes how they could be effectively utilized to address the identified deficiencies of functionalist approaches. By outlining the strategic application of these digital tools, the methodology illustrates a pathway for moving beyond rigid functionalism towards a more holistic, sustainable, and human-centered approach to urban management in District 6. The insights gained from the qualitative case analysis inform the specific recommendations for integrating these digital technologies to achieve improved aesthetic, environmental, and social outcomes.

3. 4. Data analysis

Data analysis in this study is qualitative and interpretive. The qualitative data gathered from the literature review, field observations, and documentation were analyzed to: Identify strengths and weaknesses in current urban management approaches in Tehran's District 6. Reveal how decades of functionalist management have contributed to the erosion of visual coherence, social equity, and historical identity in the area. Develop a practical-theoretical framework that proposes innovative strategies for optimally integrating digital technologies with principles of sustainable architecture and human-centered urban design. This framework aims to reconcile functional, aesthetic, and social dimensions to foster urban spaces that are efficient, sustainable, and culturally resonant.

The overarching aim is to provide actionable, implementable solutions for urban policymakers and managers, empowering them to leverage modern digital technologies in creating urban environments that are not only sustainable and efficient but also foster citizens' sense of belonging, identity, and social interaction.

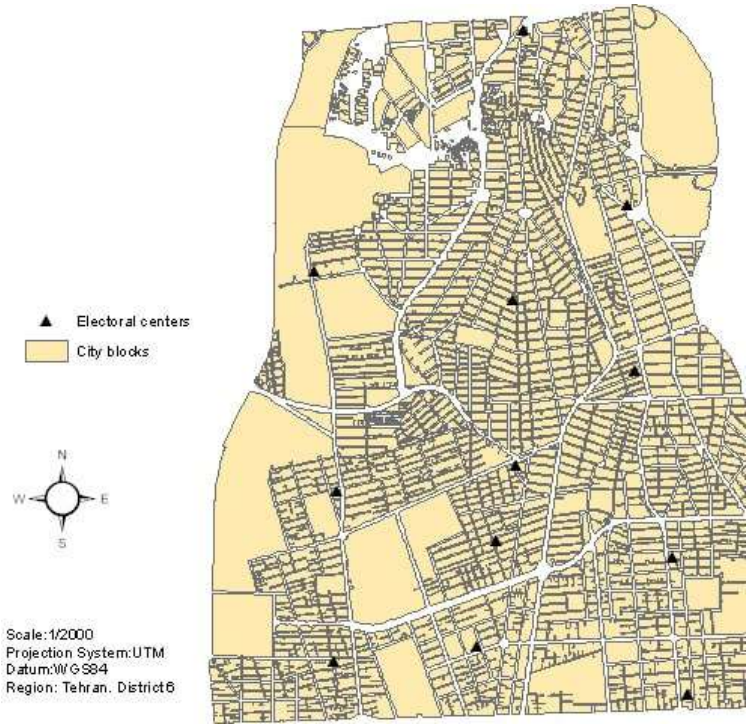

Figure 1. Development pattern of Tehran's District 6.

4. RESEARCH FINDINGS

4. 1. Sustainable architecture patterns in Tehran's District 6

It can be said that modern architects are not merely seeking to beautify urban spaces. Rather, architects and urban researchers have strived to develop a model in Tehran using the principles and objectives of sustainable architecture, one that is both functionally cost-effective and soundly aligned with urban planning principles, while also being visually deserving of the term "beautiful." The architectural fabric of Tehran's District 6, in terms of its urban feel and phenomenological perception, is a region of stark contradictions. Visually, it is complex, largely ambiguous, and somewhat indigestible. Sustainable architecture in this area can not only introduce novel methods of modern architecture aimed at reducing energy waste and environmental pollution but can also achieve a level of beauty that fulfills citizens' desire to reside in this crowded and dense district. In this regard, sustainable architecture, as a comprehensive approach, can act as a catalyst for redefining the visual and functional identity of District 6. Imagine renovation and reconstruction projects inspired by nature, utilizing local materials and new technologies. These would not only minimize energy consumption but also inject green and open spaces into the urban fabric. Green roofs, vegetated walls, and the use of natural light are all elements that can contribute to creating a pleasant, environmentally centered habitat.

Beyond environmental aspects, sustainable architecture in District 6 can also help improve residents' quality of life. Designing flexible and interactive public spaces, creating safe pedestrian and cycling paths, and establishing cultural and artistic spaces can strengthen citizens' sense of belonging and social participation. Ultimately, the goal

is for District 6 to transform not only into a sustainable and eco-centric area but also into an inspiring model for other urban districts – a place where beauty, efficiency, and sustainability flourish together. Such a transformation requires a systemic mindset and interdisciplinary collaboration. Architects, urban planners, engineers, and environmental specialists must interact to propose innovative solutions suited to District 6's specific context. This collaboration must extend beyond design and execution to include the active participation of the local community. District residents, with their deep understanding of the needs and challenges of their living environment, can play a vital role in shaping sustainable architectural projects. For example, the potential within the worn-out fabric of this district—particularly around Engh lab Square and Keshavarz Boulevard, which is filled with academic, administrative, and residential buildings—can be leveraged for sustainable renovation projects. Encouraging property owners to renovate old buildings using sustainable materials and new technologies not only improves residents' quality of life but also helps preserve the area's historical and cultural identity. Additionally, creating small green spaces in neighborhoods and alleyways can help reduce heat island effects and improve air quality.

Tehran's District 6 has developed so haphazardly over the years, both pre- and post-revolution, due to the merging of unrelated spaces that a single, uniform model for revitalizing its architecture cannot be adopted. Residential areas juxtaposed with zones of entirely different character (academic/scientific) have resulted in a complete departure from environmental considerations and core sustainable architecture principles—especially reducing consumption of non-renewable resources, using natural, local, and durable materials, proper lighting, thermal insulation in structures, and many other aspects. This spatial disorder presents numerous challenges for urban planners and architects. Positive transformation in this district can no longer be expected through top-down approaches relying solely on master plans. Reviving District 6's architecture requires a multifaceted process based on deep understanding of the area's social, economic, and cultural dynamics.

It should be noted that District 6 residents encompass a wide spectrum of social strata, from university students and professors to employees, shopkeepers, and long-term residents. Each group has different needs and expectations for urban space and architecture. Therefore, any intervention in this area must consider these differences and involve active resident participation. For instance, in older residential zones, techniques for renovating and renewing worn-out fabric can enhance residents' quality of life while preserving the neighborhood's historical and cultural identity. Here, local natural materials can be used, and green/open spaces designed to improve the environment. Residents can also be encouraged to adopt renewable energy and optimize building energy consumption to reduce the area's environmental impact. In academic and scientific zones, creating public and interactive spaces can foster idea and knowledge exchange among students, professors, and researchers. Additionally, designing green spaces and parks can improve air quality and reduce noise pollution in these areas. Ultimately, revitalizing District 6's architecture requires a comprehensive, integrated approach that considers all economic, social, cultural, and environmental aspects. This process must involve active participation from all stakeholders, aiming to enhance residents' quality of life and create a sustainable, dynamic urban environment. Achieving this demands meticulous planning, adequate resource allocation, and continuous monitoring to prevent resource waste and avoid new problems. Beyond this, District 6 holds immense cultural and historical significance. Pivotal moments in Iran’s contemporary history unfolded here, making preservation of its architectural fabric crucial. Therefore, revitalization cannot rely solely on a functionalist approach. Instead, through an aesthetic lens and targeted strategy, the cultural traditions and patterns embedded in this area’s architecture can be preserved and revitalized using sustainable design. This revival not only safeguards the district’s authenticity and identity but can also foster new models of modern living within its historic fabric. Effectively, revitalizing District 6 demands an integrated approach—one blending functionality, aesthetics, and respect for cultural-historical values. Crucially, District 6 is not merely a collection of buildings and streets; it is a dynamic cultural and social ecosystem shaped over time. Consequently, any intervention must stem from a deep understanding of this ecosystem, aiming to enhance residents' quality of life while preserving its cultural heritage. In essence, revitalization must both meet current residents' needs and honor yesterday’s values. This is achievable only through a comprehensive, multifaceted strategy. Of course, sustainable architecture in District 6 shouldn’t be limited to large-scale projects and extensive redevelopment. Small, incremental actions can also yield significant impact. Promoting renewable energy in buildings, waste recycling, and public transport use are all steps toward a more sustainable, eco-centric city. Sustainable architecture in District 6 presents a unique opportunity to create a model for other urban areas. By integrating beauty, efficiency, and sustainability, we can create spaces that not only address today’s needs but also forge a brighter, more sustainable future for generations to come. This approach is less a technical solution and more a design and life philosophy grounded in human values, interaction with nature, and environmental responsibility.

The two images in Figure 2 clearly show that population pressure since the 1990s (Solar Hijri), combined with insufficient oversight of urban construction and the lack of a cohesive, integrated urban management system, has

caused a disruption in the architectural order of urban space. This was far less evident in the 1960s (Solar Hijri). This disorder has not only compromised, or more accurately, ruined the visual beauty of a metropolis like Tehran, but has also caused numerous other problems. These range from overwhelming traffic congestion and lack of green spaces to reduced quality of life and the creation of social inequalities. In the 1340s (1960s), the city of Tehran still maintained its human scale, and its architecture was more harmonious with the historical and cultural fabric. However, with the uncontrolled growth of urbanization, these principles were gradually abandoned. We witnessed rampant, low-quality construction that often lacks identity and authenticity. It appears that the absence of a comprehensive and codified urban plan, coupled with weak enforcement of laws and regulations, has exacerbated this situation.

(a) (b)

Figure 2. Example of two residential buildings designs from the (a) 1950s and (b) 2020s.

Therefore, it is essential to seriously and responsibly re-examine urban development policies. We must seek to restore the identity and authenticity of our cities by establishing an effective and accountable urban management system. Of course, it is important to note that this issue is not limited to metropolises like Tehran. Today, we observe the same spatial chaos and poor urban layout in many small and medium-sized cities, even in the most remote villages of the country. In these cities, limited economic opportunities and uncontrolled migration from villages have led to the spread of unauthorized construction and marginalization. These peripheral areas often lack adequate infrastructure, and their residents struggle with numerous problems. This situation has pushed sustainable architecture – which aims to enhance the quality of citizens' lives – completely to the margins. Undoubtedly, a large part of this disorder stems from the functionalist approach that urban management has adopted in recent decades. For instance, we see the same situation in a metropolis like Shiraz. The urban management there also mistakenly believed that merely through rampant construction, destruction of green spaces, disregard for architecture and urban layout, and crucially, ignoring citizens' needs especially participation and social interaction, it could curb or eliminate the urgent demand for housing [45].

However, this was the best-case scenario, and not only did it not happen, but even the cultural-historical credit and norms that Iran's historic cities possessed were gradually lost. Undoubtedly, a major part of the problem for Iran's young population today is the lack of housing. Therefore, it seems this approach, ignoring aesthetic and cultural elements, will not lead anywhere. Because many of the housing units built in region 6 of Tehran over the past three decades not only architecturally bear no relation to the identity and national culture of Iranians but also lack the most basic components of sustainable architecture. Certainly, tackling these challenges requires a multi-pronged strategy. First and foremost, we must strengthen the urban planning system and develop comprehensive and detailed plans to stop rampant and unauthorized construction. These plans must be formulated considering all aspects, including environmental, social, and economic issues, and have high implement ability. Furthermore, by establishing a strong and effective monitoring system, we must ensure the proper enforcement of urban development laws and regulations. Violators must be seriously punished to serve as a lesson to others. At the same time, by providing appropriate facilities and incentives, builders should be encouraged to adhere to urban planning and architectural principles.

Another important point is paying attention to the historic and cultural fabrics of cities. These fabrics constitute the identity and authenticity of cities, and we must prevent their destruction through preservation and restoration. In this regard, using modern technologies and traditional materials, we can revitalize dilapidated fabrics and transform them into attractive and vibrant places. Therefore, to solve urban problems, we need active citizen participation.

Citizens must participate in urban decision-making processes and present their opinions and suggestions to officials. Also, through education and public awareness, we should increase citizens' understanding of urban issues and encourage them to comply with urban planning laws and regulations. With a comprehensive and coordinated approach, we can hope to transform our cities into beautiful, healthy, and sustainable places to live.

4. 2. Urban Layout in Tehran's District 6

Urban layout, a sophisticated approach in urban design and architecture, addresses how the spatial configuration of cities and buildings influences how people move. Relying on a robust social theory of space, this method focuses on the concepts of 'permeability', control, and 'hierarchy'. Graph-based analyses use mathematical methods to examine the social structure of space or spatial relationships. Space Syntax theory is a tool for understanding and designing spatial configurations shaped by social factors in urban design and planning. This theory not only describes the physical characteristics of space but also investigates how these characteristics shape social behaviors and movement patterns [46]. For example, a main street with high permeability is more likely to become a busy thoroughfare, facilitating social interactions. In contrast, a cul-de-sac with low permeability might be quieter and have more limited social interaction.

Control refers to how much influence a space has over adjacent spaces, as well as its level of accessibility. Spaces with high control are typically focal points where movement concentrates and social power manifests. Spatial hierarchy, meanwhile, indicates how spaces are organized according to their importance and role within the overall system. For example, the main city square occupies a higher position in the hierarchy than a side alley. In practice, space syntax analysis is conducted using specialized software and mapping techniques. These analyses can help architects and urban designers predict the impact of their plans on movement patterns, security, social interactions, and even property values [47].

Thus, space syntax as an evidence-based approach enables the design of spaces that are not only aesthetically appealing but also socially and functionally efficient. When we examine urban layout patterns, we realize these patterns are not purely aesthetic; they also follow a functionalist logic. This is where we can analyze the urban layout of Tehran's District 6 using both aesthetic and functionalist approaches. In other words, studying District 6's urban layout offers a valuable opportunity to assess how well these two approaches converge in practice. Do the district's green spaces serve merely decorative purposes, or do they also function as the city's respiratory lungs and spaces for social interaction? Beyond facilitating vehicle traffic, do the road and street networks provide equitable access to services and amenities for all residents, especially pedestrians and cyclists? Do the area's landmark buildings and historical structures, while preserving their visual and architectural identity, contribute to improving residents' quality of life and sense of belonging? Answering these questions through scrutiny, supported by available data and field observations, can provide a clearer picture of District 6's spatial strengths and weaknesses. It can also suggest practical solutions for its improvement and optimization. The goal is to achieve a layout that is not only visually pleasing but also effectively meets residents' needs while contributing to urban sustainability and vitality. This dual analysis, focusing on aesthetics and functionalism, requires careful examination of District 6's constituent urban elements. For example, the distribution of different land uses (residential, commercial, administrative, educational, etc.) and how well they align with residents' needs must be evaluated. Building density, height regulations, and the amount of open space per block all play roles in determining the area's visual quality and spatial efficiency.

Furthermore, attention must also be paid to the role of street furniture and public amenities. Are benches, waste bins, street lighting, and signage sufficiently numerous and appropriately located? Beyond just being functional, do these elements also feature attractive designs that fit the area's identity? The quality of sidewalks, cycling paths, and green spaces directly impacts citizens' experience of the urban environment. Undoubtedly, studying the relationship between public and private spaces is also highly important. Do buildings, through their fades, show respect for public space? Are entrances and exits designed to facilitate social interaction? Do semi-open spaces (like balconies, terraces, and courtyards) contribute to creating a sense of vitality and dynamism in the area? The residential and non-residential fabrics of Tehran's District 6 require a multi-pronged approach with non-functionalist objectives at the highest level of urban management. A major part of this district's problems—such as heavy traffic, extreme car dependency, destruction of green spaces, and the construction of complexes visually discordant with Iran's historical-cultural artistic order—stems from excessive neglect of sustainable architecture in this region.

On the other hand, it's important to note that a region's spatial arrangement isn't a static or fixed phenomenon. Rather, it undergoes change over time as residents' needs evolve. Therefore, the analysis of District 6's urban layout must consider this dynamism and aim to propose solutions for adapting it to new conditions. For example, with population growth and shifting traffic patterns, we may need to reconsider the street network, increase public

transport capacity, and create new green spaces. Consequently, a forward-looking approach involving citizen participation is essential for achieving an efficient, aesthetically pleasing, and sustainable spatial arrangement.

4. 3. Digital technologies in service of architectural beautification

In tech-driven contexts, "smart digital systems" use ICT to optimize their performance by adapting to changing conditions in dynamic environments. The AI embedded in these systems essentially mimics basic human intelligence, allowing the system to make necessary "decisions." Consequently, a "smart building" is typically understood as one where optimal performance—usually measured in terms of energy efficiency, sustainability, and cost-effectiveness—is achieved through integrated physical and digital infrastructure.

In such buildings, ICT systems enable the collection, processing, and generation of information. This data is used to drive continuous optimization processes aimed at improving operational performance. Similarly, a "smart city" is often defined as one where ICT systems are extensively deployed to achieve enhanced urban functionality [48],[49]. Today, digital technologies have become not only essential for urban management processes but also a catalyst for strengthening and revitalizing sustainable architecture and urban layouts. This transformation offers unprecedented opportunities to create more efficient, livable, and environmentally harmonious cities. Key opportunities that define a smart city include:

A) Smart energy management: Sensors and smart grids can optimize energy consumption in buildings and urban infrastructure, reduce energy waste, and promote the use of renewable energy. This not only helps lower costs but also minimizes the harmful environmental impacts of energy production. The digital tools discussed, like BIM, can model and predict energy performance, offering insights for designs that would lead to energy savings.

B) Urban transport optimization: Intelligent transportation systems can optimize routes, reduce travel time, and control greenhouse gas emissions by collecting and analyzing traffic data. Additionally, developing mobile apps and online platforms for car/bike sharing helps decrease reliance on private vehicles and promotes sustainable transport.

C) Responsive urban design: Digital technologies like Building Information Modeling (BIM) and Augmented Reality (AR) enable architects and urban planners to more accurately simulate and evaluate their designs. This helps them create buildings and urban spaces that align with local climatic and cultural conditions, minimize resource consumption, and enhance citizens' quality of life.

D) Citizen participation: Online platforms and mobile apps allow citizens to participate in urban decision-making processes, share feedback on development plans, and report city issues. This boosts transparency and accountability in urban management while increasing public trust in government institutions.

Recent advances in network-based urban analytics demonstrate how digital platforms can map community needs across neighborhood boundaries, revealing latent social connections that inform equitable resource allocation [50]. Such place-sensitive networking approaches align with emerging frameworks for managing urban transitions through data-driven dashboards [51], enabling Tehran's planners to transcend physical adjacency when strengthening District 6's social fabric. However, using digital technologies in urban management of metropolises like Tehran inevitably brings challenges. These include data privacy concerns, cybersecurity risks, and the digital divide. But in sustainable architecture and urban layout, the biggest issue is the lack of adoption of these technologies in urban construction. A large portion of the architecture and urban fabric in Tehran's District 6 is aged and requires revitalization. For instance, many residential buildings in Jamalzadeh, Keshavarz Boulevard, and other areas not only suffer from structural decay which is highly concerning for an earthquake-prone metropolis like Tehran but also face more serious challenges regarding proper restoration and rehabilitation. Unfortunately, the integration of new technologies into this field hasn’t been as tangible as needed, failing to offer practical solutions for these problems. This is while leveraging precise data and advanced digital modeling could significantly accelerate and refine the renovation process for dilapidated fabrics. Undoubtedly, using Geographic Information Systems (GIS) and 3D modeling in cities like Tehran could substantially assist in identifying vulnerable areas more accurately, assessing earthquake risks, and designing optimal solutions for building reinforcement.

Furthermore, digital technologies can play a significant role in optimizing energy consumption and reducing pollution in buildings. By using sensors and smart systems, energy usage in buildings can be continuously monitored and controlled. Through optimal adjustments, energy consumption can be minimized [52]. Implementing this in both older buildings and newly constructed ones in District 6 would not only reduce residents' costs but also help preserve the environment and reduce air pollution. However, achieving these goals requires integration and coordination among various institutions, including the municipality, engineering regulatory bodies, and construction companies. Additionally, it's essential to provide necessary training to engineers and construction workers in District 6 so they can effectively use modern technologies. Of course, financial support and incentives to encourage property owners to renovate run-down buildings are crucial. Otherwise, District 6 with its aging, vulnerable fabric will remain highly

susceptible to earthquakes and other natural disasters. To fully benefit from digital technologies, policymakers and urban managers must address these challenges and implement appropriate solutions. At the same time, training and empowering citizens to use digital technologies will play a vital role in the success of urban smartification projects.

The best way to achieve sustainability in District 6's urban fabric is through digital technology. However, due to the area's dense, non-expandable nature, we can't easily use technology for physical upgrades like structural smartification, energy control, and similar applications. Instead, there's great potential in software solutions using digital tools to strengthen social interactions and communication skills among residents and workers here. Practical examples include, creating neighborhood platforms, boosting local social networks, teaching digital skills for building management, developing online civic participation tools, and employing remote focus group methodologies [53] to inclusively capture marginalized perspectives on aesthetic and functional needs in District 6's redevelopment, and promoting responsible technology use. Certainly, designing apps and websites specifically for District 6's needs would enable residents to maintain constant connection with their urban environment while addressing civic needs. These platforms could feature local business information, cultural and art events, updates on urban projects, and job opportunities.

When discussing the enhancement of local social networks, we refer to leveraging existing social media platforms to create specialized and local groups. Within these groups, residents and professionals of an area can discuss and exchange views on various issues. These groups may be formed based on neighborhood, interest, or profession. Crucially, a primary objective of establishing such social networks pertains to monitoring local architecture and preventing unauthorized or visually inappropriate construction that violates aesthetic patterns and principles. Therefore, the core issue involves engaging citizens in urban management decisions and their implementation through digital technologies. These digital technologies themselves become tools for monitoring and controlling urban management actions. Secondly, it is essential to provide digital skills training for residents of the area. This could involve implementing free or low-cost training programs for local residents and professionals on using digital tools, social media platforms, and online communication skills. These programs can help individuals participate more effectively in today's digital society. Thirdly, it involves expanding and promoting a culture of responsible technology use. Examples include launching informational and awareness campaigns about the risks and challenges of technology use, such as privacy concerns, cybersecurity, and the misuse of social networks [54].

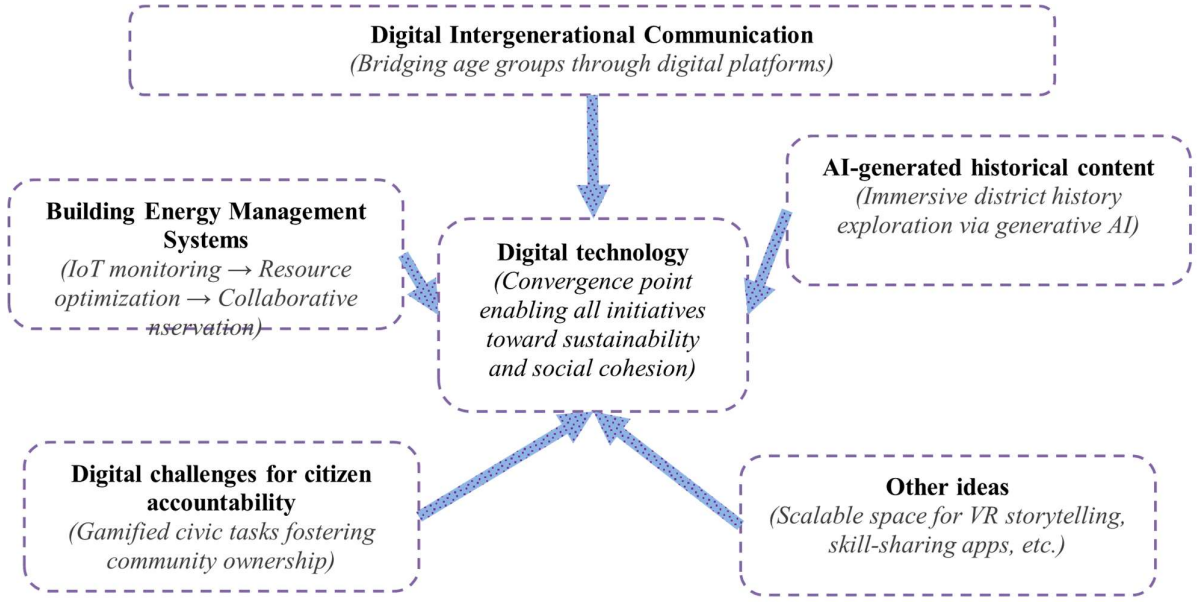

Figure 3. Modular digital ecosystem for sustainable community development in Tehran's District 6.

By focusing on these software-based initiatives, we can strengthen the social and communicative fabric of District 6 and leverage digital technology as a tool to foster sustainability and improve quality of life in this area. Given the physical constraints of the district, this approach offers an efficient and cost-effective way to harness the potential of digital technology for sustainable urban development. Beyond the mentioned points, other ideas can also be implemented to enhance social interactions and upgrade communication skills in District 6. To visualize how

software-based initiatives synergistically address District 6's physical constraints while enhancing social cohesion, sustainability, and cultural preservation, we propose a modular digital ecosystem, which is shown in Figure 3. This framework integrates core strategies intergenerational networks, energy monitoring systems, civic accountability challenges, and AI-generated historical content centered on digital technology as a unifying engine. Scalability is embedded through dedicated expansion space for future innovations, ensuring cost-effective adaptation to evolving community needs. Undoubtedly, implementing these ideas and similar actions will enable more effective use of digital technology to strengthen the social and communicative fabric of District 6, moving us toward a smart and sustainable city. The key to success in this area lies in active citizen participation, collaboration between public and private sectors, and genuine attention to the real needs and demands of residents and workers. VR-driven heritage experiences (e.g., for Jamalzadeh North) can deepen cultural identity by leveraging empirically validated quality frameworks that prioritize intuitive design and sensory immersion – key determinants of sustained user engagement [55]. Complementarily, research on categorical reasoning transfer in geometry education [56] suggests that digital tools visualizing District 6's architectural transformations should explicitly scaffold citizens' understanding of spatial relationships (e.g., showing how restored facades reintegrate with urban morphology) to bridge abstract preservation concepts with tangible community benefits.

Table 1 demonstrates how digital tools transform sustainable architecture and urban layout initiatives in District 6 into integrated strategies for architectural beautification, social cohesion, and smart-city advancement achievable through community-centric digital placemaking, culturally responsive tech integration, and cross-sector collaboration.

Table 1. Impact of applying sustainable architecture principles and urban layout with digital tools.

Dimension	Status of buildings	Sustainable architecture	Urban layout with digital tools
Building design	Deteriorated, high energy consumption, non-functional, incompatible with current urban context.	Use of local materials and energy optimization for sustainable architecture.	Digital restoration of historic buildings using 3D scanning; BIM modeling for new constructions; interactive visualization tools for tree planting layouts; energy-saving tech integrated with aesthetic design software.
Parks and public green spaces	District 6 has 66 parks (~21 million m² green space). Green space per capita falls below urban standards in areas like Yusefabad.	Design of garden-houses preserved as civic heritage and vitality factors for traffic quality improvement.	• GIS-mapped park development targeting green-deficient areas. • AR-enhanced vertical gardens with aesthetic digital displays. • IoT-monitored green roofs with automated irrigation. • Digital public art installations in parks.
Public and private transport	Heavy traffic due to administrative, educational, and commercial centers.	Development of public transport using digital technologies is essential.	• Interactive LED pavements with artistic patterns for pedestrian safety. • Solar-powered digital signage displaying real-time transit + local heritage visuals. • AR cycling lanes with embedded sensors guiding routes. • Aesthetic smart shelters with green walls + touchscreen route planners.
Energy resources	High water/energy consumption; resource wastage observed.	Use of renewable systems (solar panels, waste recycling) to reduce resource consumption.	Conceptual integration for future energy savings: • Aesthetic solar skins with customizable digital patterns on institutional rooftops. • Smart rainwater harvesting systems with artistic water features + real-time conservation data displays. • Kinetic energy pavements with LED lighting in high-traffic areas • AI-optimized waste recycling stations feature interactive public art.

			• Advanced treatment systems like algal membrane bioreactors enable wastewater reuse and resource recovery [57]. • Integrated modeling frameworks (e.g., Water Evaluation And Planning system (WEAP)- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) optimize water allocation balancing efficiency, equity, and environmental needs [58].
Social interactions	Reduced public/neighborhood spaces leading to fewer social interactions (e.g., Shafaq Park requires enhanced walkability).	Designing high-quality, accessible public spaces to increase social engagement.	• Interactive digital plazas with augmented reality (AR)-enhanced seating and projection-mapped public art. • Smart parklets featuring Wi-Fi, charging stations, and ambient lighting that adapts to gatherings. • Cultural venues with immersive tech: Digital walls in libraries, AR theater sets. • Kinetic energy floors in squares that generate light patterns when walked on. • Community kiosks display local heritage stories through touchscreens.
Cultural identity	Historic urban fabrics (e.g., Old Yusef Abad, Jamalzadeh North) require urgent preservation.	Preserving/restoring local historic architecture strengthens cultural identity.	• 3D laser scanning + AI-assisted restoration of heritage buildings • AR-enhanced fades projecting traditional patterns onto reconstructed structures • Digital pattern libraries with traditional motifs for new constructions • Immersive VR tours applying quality frameworks to optimize user engagement and contextual relevance, thereby strengthening place attachment [55]. • Interactive heritage walls with touchscreen displays of neighborhood stories.

5. CONCLUSION

Urban management classically focuses on developing urban services and infrastructure through planning, design, and implementation. Traditionally, this approach aims to improve quality of life, boost economic development, and protect the environment. However, by integrating sociological functionalism with architectural aesthetics and urban theory, we propose redefining these three pillars as enhancing citizens' quality of life, urban development that preserves aesthetic values, and environmental conservation as the cornerstone of modern cities. Tehran's District 6 presents unique architectural complexities. Our analysis shows that a dual functional-aesthetic approach offers the best path to revitalizing its significant structures. Crucially, Table 1 demonstrates how digital tools transform sustainable initiatives into comprehensive strategies for architectural beauty, social cohesion, and smart-city progress. The findings reveal that purely functional urban management has actively damaged District 6's historic fabric rather than advancing sustainability. However, combining sustainable architecture with insights from urban sociologists, architects, researchers, and local stakeholders can enable balanced development. This integrated approach creates urban spaces that meet practical needs, enrich visual and cultural experiences, and protect ecosystems. For example:

i) A functionalist building renovation might maximize space efficiency
ii) Our integrated approach (as shown in Table 1) adds:

- Digital restoration of historic features
- Sustainable materials
- Community co-designed green spaces

- Energy-saving technologies blended with aesthetic design, which facilitate optimized energy consumption

Similarly, Table 1's digital strategies from AR-enhanced public art to interactive heritage displays prove that green spaces, streetscapes, and cultural sites can simultaneously serve functional, beautiful, and sustainable purposes when managed through community-centered digital placemaking and cross-sector collaboration. While this qualitative study proposes the mechanisms and potential for enhanced sustainability, including energy efficiency, it does not present empirical measurements of energy savings. Instead, it highlights how the strategic application of digital tools enables urban managers and architects to pursue solutions that can lead to such environmental benefits. Ultimately, this evidence confirms that urban management in District 6 can evolve from a force of cultural erosion to an engine of sustainable revitalization.

DECLARATIONS

Conflict of Interest: The authors declare that there is no conflict of interest.
Funding: This research received no external funding.
Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.
Publisher's note: The Journal and Publisher remain neutral about jurisdictional claims in published maps and institutional affiliations.
Acknowledgments
The authors wish to thank the reviewers for their insightful feedback and constructive suggestions. Their contributions were instrumental in enhancing the robustness and significance of this work.

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