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THE INFLUENCE OF ADVANCED TECHNOLOGY ON ARCHITECTURAL FORM IN HIGH-RISE HOUSING PROJECTS IN SULAYMANIYAH CITY/KRG-IRQ

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ABSTRACT

The accelerated urban growth of Sulaymaniyah city in the Kurdistan Region of Iraq has generated an unprecedented surge in high-rise residential development. Running in parallel, advanced technologies such as BIM, AI and parametric design, adaptive façades, high-performance materials, and life cycle analysis are rewriting architectural practice. This paper collates global and local literature with the aim of understanding the impacts of such technologies on architectural form at the levels of massing, plan geometry, façade articulation, fenestration, orientation among others, identifies the gaps with respect to Sulaymaniyah, defines variables, and develops hypotheses. The empirical part—building on the above—is an analysis of eight high-rise residential projects in Sulaymaniyah. This paper will contribute to the bridging of theory and practice in a transitional economy context with wider implications for sustainable design policy and architectural form.

KEYWORDS: Advanced Technology; Architectural Form; High-Rise Housing; BIM; Parametric Design.

1. RESEARCH METHODOLOGY

This research adopts a mixed-methods qualitative–quantitative approach that combines theoretical analysis, a literature review of more than 12 international and regional Literatures, and empirical investigation of eight purposively sampled high rise residential projects in Sulaymaniyah in order to investigate how advanced technologies like BIM, parametric design, and responsive envelopes influence architectural form, facade design, and sustainability. Key variables—technological (BIM, parametric tools, kinetic façades, smart materials), architectural form (massing, façade articulation, volumetric geometry), and environmental (solar access and shading,)—were identified from the literature and used to evaluate the cases. Data were collected from architectural drawings and BIM models, site visits, interviews with architects/planners, and local climate data. Analysis combined qualitative morphological and façade-typology assessments (plan, section, elevation, materials, aesthetic/perceptual qualities) with quantitative measures (shading devices, orientation) and cross-project comparisons to identify form–environment relationships and the technological tools applied. Results were synthesized to determine where and how technologies altered form, to reveal patterns linking technology to urban image and sustainability, and to highlight barriers and opportunities for sustainable form-making in Sulaymaniyah; all interviews obtained informed consent and project data were used with permission, with anonymization applied where necessary. **Figure.1**

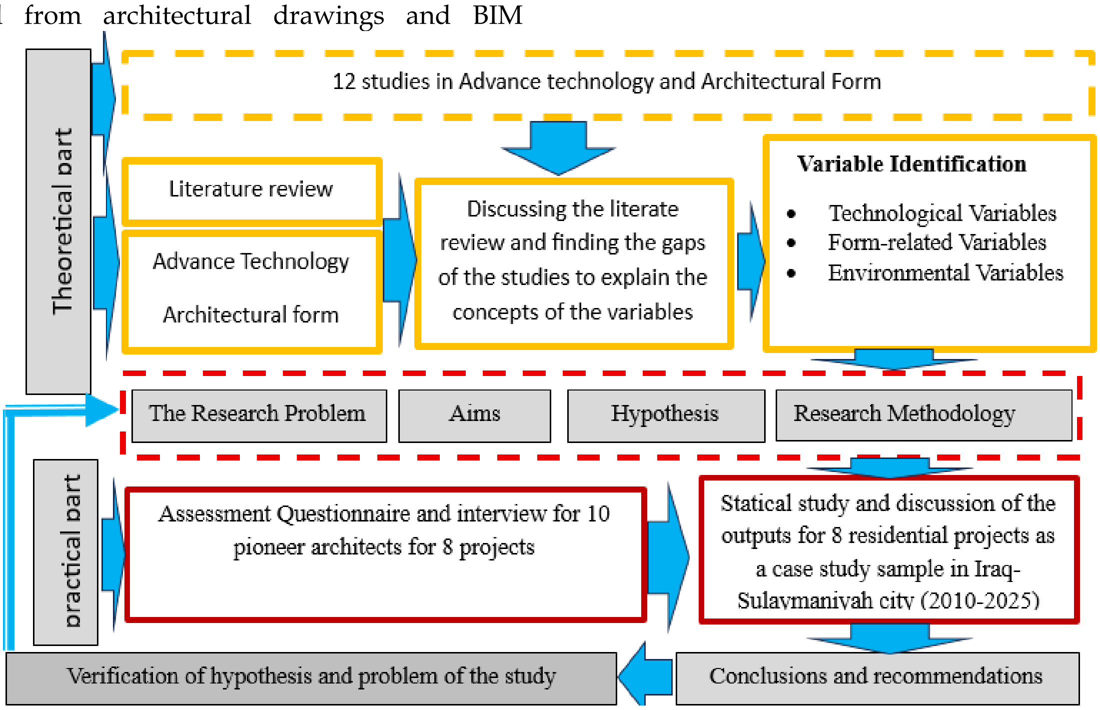


Figure.1: Research plan and methodology

2. INTRODUCTION

Sulaymaniyah is undergoing rapid transformation: increasing population, land scarcity, and rising expectations for modern, comfortable housing lead developers toward high-rise residential towers. Meanwhile, architectural and construction technologies globally allow more formal flexibility and performance optimization. These include Building Information Modeling (BIM), artificial intelligence (AI), parametric and generative design, adaptive or kinetic façades, modular or prefabricated components, advanced structural systems, high-performance glazing and insulation, energy simulation, and life cycle assessment (Assadimoghadam et al., 2025).

Architectural form—defined here as massing (plan shape, volume), orientation, envelope geometry and articulation (projections, overhangs, depth), façade composition (fenestration, openings, rhythm), and visual/aesthetic identity is shaped by both technological affordances and local constraints (Nuñez,2025). These factors such as climate, regulation, cost, materials, skills, and culture (Soltani & Atashi, 2023). In Sulaymaniyah, however, it is not yet clear which of these advanced technologies are actually being used in high-rise residential projects, how far they influence architectural form, and what contextual constraints temper that influence (Sleman & Atakara, 2024).

1. Review theoretical and empirical literature (global + local) on advanced technology and form in high-rise housing.
2. Identify gaps, especially in Sulaymaniyah / Kurdistan context.
3. Define and operationalize variables (technological, contextual, formal) for empirical analysis.
4. Propose hypotheses about how technology relates to form.

Figure.2: Tulib Towers, Var Park Towers, Empire -Erbil – Erbil Housing projects/ high-rise

Figure.3: Barzayakany sulaimani project, Parck 77, Dayk Project- Sulaymanayah Housing projects /high-rise

3. LITERATURE REVIEW

Below is a synthesis of studies (global and regional) on how advanced technologies affect architectural form, followed by critique and gap identification. **(Table.1)**

1. Adaptive façades for high-rise residential buildings: A qualitative analysis of the design parameters and methods, examine adaptive façades in high-rise residential buildings, identifying key design parameters (material, shading, simulation tools) and constraints (cost, maintenance, regulation) (Assadimoghadam et al., 2025). While the study strongly links façade tech to envelope performance, it does not deeply explore the resulting massing/plan geometry and is mostly theoretical/qualitative (Assadimoghadam et al., 2025), (Alsofiani,2024).
2. Influence of Building Information Modeling (BIM) implementation in high-rise buildings towards sustainability, used surveys and modeling to connect BIM implementation in high-rise buildings with sustainability outcomes: improved coordination, visualization, energy savings, safety (Manzoor et al., 2021). But formal architectural attributes (façade depth, shape curves, non-orthogonal massing) are discussed less (Manzoor et al., 2021) (bagasse,2025).
3. BIM-based life cycle assessment of the embodied carbon and environmental impacts of high-rise building structures: A case study, perform a BIM-based life-cycle assessment of embodied carbon in high-rise building structures, comparing structural systems (steel vs concrete) (Ma et al., 2024). They show material choices affect environmental performance, but again less attention paid to how these material + structural decisions manifest in external architectural form (Ma et al., 2024).
4. BIM-Based Energy Optimization – Case study of High-Rise Building in Pakistan, modeled high-rise buildings in Pakistan using BIM for energy optimization, exploring form, orientation,

façade, envelope alternatives (Hasan et al., 2021). This shows that early technology use allows comparing form alternatives, but local budget, building practices often limit what is built (Hasan et al., 2021).

5. Energy analysis of high-rise building integrated with BIM, in India compared different architectural shapes of high-rise buildings using BIM, assessing energy relative to shape, solar exposure, occupancy (Mishra & Goel, 2019). Their findings link form (mass, façade, orientation) and energy, and show technology (BIM) can enable evaluating trade-offs (Mishra & Goel, 2019) (Ahmed ,2025).
6. Temperate climate: An assessment of energy saving solutions for the envelope design of high-rise buildings, examine envelope design for energy savings in temperate climates, focusing on variables such as window-wall ratio (WWR), glazing, shading, orientation. Their simulations show significant savings but do not cover many real built residential forms under constrained contexts (Raji et al., 2018).
7. The Effect of Architectural Standards on Energy Consumption in High-Rise Residential Buildings in Northern Iraq (2022-2023), explores how adherence to architectural standards (insulation, orientation, ventilation, window design) affects energy consumption in high-rise residential buildings in Northern Iraq. It finds that except for window design, many standards are weakly followed, negatively impacting efficiency (Sleman & Atakara, 2024).
8. Feasibility Study of Concrete Louvers for High-Rise Residential Buildings in Terms of Cooling Energy Requirements, investigates fixed external shading devices—horizontal & vertical louvers—on a 13-storey building in Sulaimani City. It finds that certain sizes and configurations of horizontal louvers significantly reduce cooling loads; vertical shading devices are less effective in some configurations. This directly links façade shading design to form (façade depth, projection) and performance (Bahaadin et al., 2022).
9. Motivation Factors for Adopting BIM in Iraq, surveys key drivers for BIM adoption in Iraq, including educational curricula, awareness, contracting with experienced experts. While not directly about architectural form, the study informs how ready the environment is for technology that could change form (Hatem et al., 2018).
10. Using BIM to Propose Building Alternatives Towards Lower Consumption of Electric Power in Iraq, models' alternative materials (walls, roofs) via BIM for houses in Iraq, comparing with actual consumption. It shows that envelope material choices and orientation have measurable impacts, and technology (BIM) allows testing these alternative forms (Naji et al., 2019).
11. Exploring the Challenges and Opportunities of BIM Implementation in Major Architectural Projects in Iraq, interviews practitioners (clients, contractors, consultants) to assess BIM status, obstacles (lack of mandates, awareness, cost) in Iraq major projects. This gives context for whether form-reshaping tools are likely to be adopted (Hassan & Al-Kindy, 2023).
12. Comfort and Functional Design in High-Rise Residential Buildings: A Case Study of Penthouse Units in Iraq, examines a penthouse in Grand Boulevard Tower Tulip, Sulaymaniyah. It focuses on user comfort and spatial organization, large glazing, open plan, aesthetic lines. It offers insight into form choices (window surfaces, plan layouts) in luxury residential high-rise in Sulaymaniyah (İslamoğlu, 2025).

Table 1: Literature Review studies analyzing

	Author(s) & Year	Focus of Study	Key Findings	Critique / Gap
1	Assadimoghadam et al. (2025)	Adaptive façades in high-rise housing	Identifies material, geometry, and control systems for adaptive façades	Does not examine effect on overall building form or massing
2	Manzoor et al. (2021)	BIM and sustainability in high-rise buildings	BIM improves coordination, visualization, and energy efficiency	Lacks in-depth analysis of how BIM affects formal design (façade, shape)
3	Ma et al. (2024)	Embodied carbon in high-rise building structures via BIM	Shows BIM can help assess embodied energy in materials	Focuses on structure and materials, not explicitly on architectural form
4	Hasan et al. (2021)	BIM-based energy simulation in high-rise	Demonstrates how early-stage BIM use helps energy optimization	Form-related aspects like massing and façade not detailed
5	Mishra & Goel (2019)	Building shape and energy analysis via BIM	Establishes link between shape, orientation, and energy performance	Case-specific; not generalized or contextualized in a regional setting
6	Raji et al. (2018)	Envelope design in temperate climates	Simulations show WWR, shading, orientation influence energy use	Focused on energy, not formal or aesthetic dimensions of architecture
7	Bahaadin et al.	Concrete louvers for high-rise	Horizontal louvers significantly	Good link to façade design;

	(2022)	buildings (Sulaymaniyah)	reduce cooling loads	doesn't explore wider form-related consequences
8	Sleman & Atakara (2024)	Architectural standards in Northern Iraq	Weak compliance with envelope/insulation design; windows most aligned	Doesn't connect standards to formal outcomes or aesthetic implications
9	Naji et al. (2019)	BIM-based alternatives to reduce energy	Envelope material and orientation choices influence performance	No visual/formal analysis of how alternatives affect building shape
10	Hatem et al. (2018)	Drivers for BIM adoption in Iraq	Education, expertise, and awareness are key to adoption	No direct analysis of how BIM affects built form
11	Hassan & Al-Kindy, (2023)	Challenges of BIM implementation in Iraq	BIM underused due to cost, lack of mandates, and skill gaps	No formal architectural dimension discussed
12	İslamoğlu (2025)	Functional and aesthetic analysis of penthouses in Sulaymaniyah	Shows glazing, open plan, aesthetics in luxury towers	Luxury-focused; not generalizable to mid-range housing or broader city fabric

4. THE COMPREHENSION OF TECHNOLOGY AND ARCHITECTURAL FORM

Integrating global research with local case studies reveals several theoretical insights into how form, technology, and constraints intersect in the architectural context of Sulaymaniyah.

Global studies underscore that the early application of BIM and parametric tools in design allows designers to investigate several formal variants, such as massing, orientation, and façade composition, in order to arrive at optimal performance (Hasan et al., 2021; Mishra & Goel, 2019). Local studies also present how adapting national school design standards by means of a parametric model demonstrates the way in which regulatory constraints, like dimensional ranges, can be encoded into the design tools to influence form while complying with the same (Hassan & Al-Kindy, 2023). Envelope and façade design are both directly associated with building form and energy performance. A case in Sulaymaniyah with fixed louvers showed that the depth and amount of projections of the façades reduce cooling loads (Bahaadin et al., 2022). Similarly, research in Northern Iraq demonstrates that design standards related to insulation, window size, and orientation are major factors affecting energy consumption; this underlines the contribution made by façade and window form (Sleman & Atakara, 2024).

Material selection within the building envelope is critical in defining form and reducing environmental impact. A study using BIM to simulate alternative wall and roof assemblies demonstrated measurable effects on energy use and emissions, linking form to material and orientation decisions (Naji et al., 2019). The adoption of such technologies, however, is influenced by economic factors, awareness, and regulatory frameworks, which in turn influence what forms are viable or preferred in practice (Hatem et al., 2018). Conversely, high-budget developments in Sulaymaniyah, like luxury penthouses, tend to emphasize extensive glazing, open-plan layouts, and panoramic views. Such choices of form are often driven more by client expectations and aesthetic values than by performance metrics, even though thermal comfort remains a consideration. This would indicate that formal expressiveness is more feasible in contexts where budgetary constraints have been loosened (İslamoğlu, 2025).

5. THEORETICAL AND CONCEPTUAL FRAMEWORKS

Understanding how advanced technology affects form requires several theoretical lenses **(Table.2)**:

1. Technology Affordance Theory: Technologies such as BIM and parametric tools afford certain formal possibilities, for example, complex curves and precise coordination, but their use is shaped by factors such as cost, user skill, and cultural norms. (Raji et al., 2020) Form-Performance Trade-offs: Often, architectural form is determined not just by aesthetics but also by factors related to energy efficiency, structural economy, daylighting, and thermal comfort. Studies have demonstrated that performance considerations directly influence formal outcomes, (Raji et al., 2020).
2. Contextual Moderation: Local climate, regulations, materials, economic realities, and construction culture often limit how far form can be pushed by technology. While adaptive facades, for example, can have potential energy savings, their higher cost and increased maintenance requirements may make them impracticable in certain contexts (Udara,2025). Research into developing countries reveals various impediments to the use of a number of advanced systems such as modular construction (Bello et al., 2024).
3. Parametric and Algorithmic Design as Enablers: Full parametric methods, combined with optimization frameworks, can enable the rapid creation and testing of multiple design variants

for solar access, daylight, envelope performance, and material efficiency. Various studies have confirmed that these approaches result in more informed, and often higher-performing, designs (Majd et al., 2021).

4. Envelope and Façade as Formal Mediators: The building envelope is the interface between interior and exterior; it is visual, material, and environmental (Bagasi,2025) Design decisions related to shading devices, overhangs, materials, and adaptive systems all drive building form by way of projections, depths, modularity, and surface expression (Udara, 2025). A great number of research projects address the matter of how envelope systems lead to specified appearance and performance (Schittich 2012), (Udara, 2025).

Table 2: Variables and Comprehension of technological and formal categories

Category	Variable	Definition / Operationalization
Technological	BIM / parametric design tools (early stage)	Whether these tools used, and at what level (just visualization, or full parametric form iteration)
Technological	Envelope / façade shading + external devices	Presence of louvers, overhangs, fixed/adjustable shading, depth/projection of façade elements
Technological	High performance materials / insulation / glazing	Wall/roof insulation level, glazing U-value, window transparency, envelope thickness
Contextual	Climate features	Solar exposure, summer peak heat, winter cold, diurnal variation in Sulaymaniyah
Contextual	Regulation / standards compliance	How strongly local/international energy/architectural standards are enforced (e.g., Northern Iraq study showed weak compliance except window design)
Contextual	Budget, material supply, client preference	Cost constraints; whether designer/developer seeks luxury vs basic; availability of high-performance materials etc.
Formal	Massing / plan geometry	Orthogonal vs non-orthogonal; volume shape; setbacks; orientation; overhangs
Formal	Façade articulation / depth	Projections, façade shading devices, envelope modules, façade geometry
Formal	Fenestration / window design	Size, number, glazing type, window-wall ratio, transparency

6. HYPOTHESES

1. Projects using BIM/parametric tools will show more optimized façades (greater depth, better shading), more favorable orientation and more varied massing.
2. Envelope shading devices (louvers, overhangs) will significantly reduce cooling loads and therefore influence façade form.
3. High performance materials/glazing will allow greater transparency (larger glazing areas) without excessive energy penalty; thus form (window size, proportion) will respond accordingly.
4. Luxury/high-budget residential projects will show more expressive formal features (large glazing, panoramic views) than more regular housing projects.
5. Regulation / enforcement (e.g. architectural standards, energy performance) will moderate the relationship; weak enforcement will lead to forms less optimal and closer to conventional

7. PRACTICAL STUDY

The practical research will investigate the impact of advanced technology on the architectural form in high-rise housing projects in Sulaymaniyah City. For this purpose, eight selected high-rise housing projects (+20 levels) will be analyzed to understand how technological developments have driven new architectural expressions of their design strategies and overall spatial configuration. This evaluation will involve two key participant groups: eight architectural designers of the projects, who are directly involved in the design and planning of these projects, and eight expert architects with extensive professional experience in high-rise residential development. Through structured evaluation and expert assessment, this study looks forward to informed opinions on the integration of advanced technologies like those revolving around digital design tools and structural innovations in driving changes in architectural form.

Collected data will be analyzed in a structured manner and critically discussed to establish patterns, correlations, and variations among the selected projects. This would give insights into how the relationship between technology and architecture is developing within the urban and cultural fabric of Sulaymaniyah. **Table 3.**

Table 3: Evaluation form

Category	Variable	0%	25%	50%	75%	100%
		1	2	3	4	5
Technological BIM	Parametric design tools					
Technological Envelope	façade shading					
	Eternal Devices					
	insulation					

Technological materials	glazing					
Contextual	Climate features					
	Regulation					
	standards compliance					
	material supply,					
	client preference					
Formal	Massing					
	plan geometry					
	Façade articulation / depth					
	Fenestration / window design					

1–5 Likert (1=Strongly Disagree, 5=Strongly Agree)

8. DISCUSSION (DATA DESCRIPTIONS)

8.1. Reliability test

Reliability testing is an essential step in questionnaire-based research to ensure that the instrument consistently measures what it is intended to measure. Cronbach's alpha was used to measure the reliability of the questionnaire, and the values of (Cronbach's alpha) are considered statistically acceptable when these values are equal to or greater than (0.60).

Table 4: Cronbach's alpha coefficient to measure the reliability of the questionnaire

Variables	Cronbach's alpha	coefficient validity
Total	0.865	0.930

Table (4): shows the value of the reliability coefficient (Cronbach's alpha) and the validity coefficient. It is clear from the table that the value of the Cronbach's alpha coefficient was high for as whole, and it is equal to (**0.865**), and this means that the reliability coefficient of the questionnaire is high and is considered acceptable at a very good level from the statistical perspectives, as well as the value of validity was high for the overall questionnaire, which is (**0.930**), which means that the validity coefficient of the questionnaire is high and is considered acceptable at a high level.

Table 5: the split-half method to measure the reliability of the questionnaire

variable	Spearman Correlation coefficient	Spearman Brown
Overall variables	0.729	0.843

It is clear from the results of (Table 5) that the value of the adjusted correlation coefficient (Spearman-Brown) is high and statistically significant for overall questionnaire, which is (**0.843**), and this means that the adjusted correlation coefficient (Spearman-Brown) is very high. Based on the results of the tests mentioned above, it was concluded that the research questionnaire demonstrated both validity and reliability, thereby confirming full confidence in its overall soundness and credibility.

8.2. Descriptive Statistics

Table 6: distribute sample study according to Education and Years of experience as architect

Type	Variable		No	%
Evaluators	Education (highest degree completed in Architecture)	BSc	2	25.0
		MSc	4	50.0
		PhD	2	25.0
	Years of experience as architect	10-19	1	12.5
		20-29	4	50.0
		30-39	3	37.5
Total			**8**	**100.0**
designers	Education (highest degree completed in Architecture)	BSc	5	62.5
		MSc	2	25.0
		PhD	1	12.5
	Years of experience as architect	10-19	3	37.5
		20-29	5	62.5
Total			**8**	**100.0**

Table (6) presents the distribution of the study sample according to educational level and years of professional experience in architecture. Among the **evaluators**, half of the participants (50%) hold an **MSc** degree, while **25%** possess a **BSc** and another **25%** hold a **PhD**. Regarding experience, the majority (50%)

have **20–29 years** of architectural practice, followed by **37.5%** with **30–39 years**, and **12.5%** with **10–19 years** of experience. For the **designers**, **62.5%** hold a **BSc**, **25%** an **MSc**, and **12.5%** a **PhD**. In terms of experience, most designers (62.5%) have **20–29 years** of experience, while **37.5%** fall within the **10–19 years** range. Overall, the data indicate that both groups are academically and professionally well-qualified, with evaluators having relatively higher academic qualifications and longer experience compared to designers.

8.3. Results of Advanced Technology effect on Architectural Form

Based on the results of the regression analysis that confirmed there is a significant effect of technological BIM effect on Architectural Form as shown in the table below:

Table 7: Results of Advanced Technology Effect on Architectural Form

Independent Variables	Architectural Form (dependent variable)					
	R-square	F-test		t-test		Beta
		F-test	P-value	t-test	P-value	
technological BIM	66%	28.99	0.000	5.38	0.000	0.812
technological Envelop	78%	52.09	0.000	7.22	0.000	0.881
technological Materials	90%	140.2	0.000	11.84	0.000	0.950
Contextual	87%	101.8	0.000	10.09	0.000	0.934

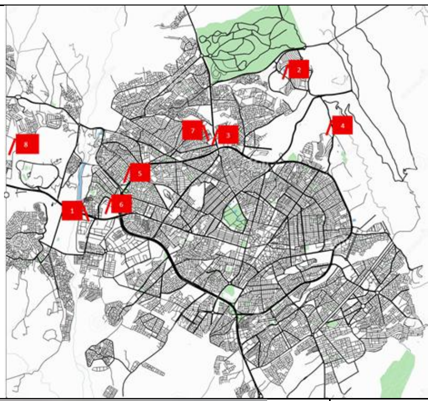
From Table (7), it can be determined that changes in Architectural Form are influenced by Advanced Technology, including technological BIM, technological envelope, technological materials, and contextual factors. For the technological BIM, the results show a statistically significant effect on architectural form, with an R^2 value of 0.66, meaning that technological BIM explains 66% of the variation in architectural form. The F-test value (28.99) with a p-value of 0.000 (less than 0.05) confirms the model's overall significance. The t-test value (5.38) with a p-value of 0.000 reveals that technological BIM has a significant individual effect, and the Beta coefficient (0.812) indicates a positive relationship. This means that for every one-unit increase in technological BIM application, the architectural form improves by 0.812 units.

Regarding the technological envelope, the results indicate a significant positive impact on architectural form, with an R^2 value of 0.78, suggesting that 78% of the variation in architectural form can be explained by technological envelope features. The F-test (52.09) and p-value (0.000) confirm the overall model's significance. The t-test value (7.22) with a p-value of 0.000 shows a highly significant individual effect, while the Beta value (0.881) indicates a strong positive relationship. This implies that for each one-unit increase in the application of advanced envelope technology, the architectural form improves by 0.881 units. For the technological materials, the analysis shows the strongest effect among all variables, with an R^2 of 0.90, indicating that technological materials account for 90% of the variation in architectural form. The F-test (140.2) with a p-value of 0.000 demonstrates that the regression model is statistically significant. The t-test (11.84) with a p-value of 0.000 confirms a highly significant individual impact. The Beta coefficient (0.950) reflects a very strong positive relationship, meaning that for each one-unit increase in the use of advanced technological materials, the architectural form improves by 0.950 units. For the contextual factor, the results also show a highly significant effect, with an R^2 value of 0.87, indicating that contextual considerations explain 87% of the variation in architectural form. The F-test (101.8) and p-value (0.000) confirm that the model is statistically significant. The t-test (10.09) with a p-value of 0.000 shows a strong individual effect, and the Beta coefficient (0.934) indicates a strong positive relationship. This means that every one-unit increase in contextual adaptation improves the architectural form by 0.934 units.

Finally, all variables have a significant positive effect on architectural form, with technological materials being the strongest predictor, followed by contextual, technological envelope, and technological BIM, respectively.

Table 8: Description of Projects of the case study- Sulaymaniyah - KRG-IRAQ

Project Code	Name of project	Description	Photo -Form of the project

	Sulaimani master plan	Location of the projects in Sulaymaniyah city		
B1	**Park 77**	Condition: Built Investor: Nawroz Company (Sargalu Company) Design: Arc Studio Number of floors: 39 Number of apartments: 222		
B2	**Barzayakani Slemani**	Condition: Built Investor: Qaiwan Group Design: Al-Bayati Architects Number of floors: 22 Number of apartments: 88		
B3	**Suli View Towers**	Condition: Built Investor: MJ group Design: MA Consultancy Number of floors: 30 Number of apartments: 168		

B4	**Daik Project, Baban Trintiy**	Condition: Under Construction Investor: South Kurdistan Group Design: Pi Group and Freelance Architect Number of floors: 46 Number of apartments: 293		
B5	**Jaff Towers**	Condition: Built Investor: Private ownership Design: Ruya for Engineering Consultancy Number of floors: 35 Number of apartments: 210		
B6	**Baran Complex**	Condition: Built Investor: Faruk Investment Group Design: Virtu Architects Number of floors: 26 Number of apartments: 294		
B7	**Dania City**	Condition: Built Investor: Najmadin group Design: Mariwan Bureau and Vogue Architects Number of floors: 29 Number of apartments: 94		

B8	**Miran City**	Condition: Built Investor: Goizha group Design: RMA Studio Number of floors: 21 Number of apartments: 84		

9. CONCLUSIONS

9.1. Theoretical Part

1. Literature (global+ local) shows advanced technologies (BIM, shading, envelope materials, parametric design) have potential to reshape form: massing, façades, windows, orientation.
2. Local studies (Sulaimani louvers; Northern Iraq architectural standards; local BIM adoption) show that some formal change is already happening, especially via envelope and façade design.
3. However, many local high-rise projects may not make full use of technologies, especially in massing/form complexity, due to cost, regulation, materials, skills, client preference.
4. The empirical study of the 8 Sulaymaniyah housing projects will clarify to what extent these findings apply locally: which formal changes are realized, under what technology adoption, and what constraints limit them.
5. For policy / design practice: encouraging strong regulatory standards, supporting technology training (BIM / parametric), incentivizing high performance materials and shading design, and promoting luxury projects' formal lessons into more standard housing.

9.2. Practical Part

1. The reliability and validity tests revealed the strength of the research instrument in that Cronbach's Alpha was 0.865, with a validity coefficient of 0.930, showing internal consistency. Its Spearman–Brown coefficient, 0.843, means that this is a rather robust questionnaire, and ensuring confidence in the collected data.
2. Sample characteristics showed that respondents were academically and professionally qualified, as evaluators and designers had extensive architectural experience in ranges of 10–39 years and varied academic backgrounds. This enhanced the credibility of their judgments on the use of advanced technologies in high-rise housing projects.
3. All the advanced technological variables thus exert a statistically significant positive effect on architectural form, confirmed through regression analysis. Each of BIM technologies, advanced envelope systems, technological materials, and contextual factors contributed meaningfully to shaping the architectural outcome in Sulaymaniyah's high-rise housing projects.
4. The results showed that technological materials were the most influencing factor, which explained 90% of the variation in architectural form, followed by contextual considerations, which made up 87%, advanced envelope technologies with 78%, and BIM applications with 66%. This hierarchy shows that material innovation and contextual adaptation are the most dominant forces of change in architectural form in these projects.

10. RECOMMENDATIONS

1- Provide a deeper integration of advanced materials in high-rise housing: Given that technological materials showed the most significant effect on architectural form, with $R^2 = 0.90$, developers should focus on high-performance insulation, advanced glazing, and innovative envelope materials in order to provide both expressive façade design and improved energy efficiency.

2- Improve Early-Stage Utilization of BIM and Parametric Tools
Since BIM accounts for 66% of form variation, architectural offices should integrate BIM and parametric modeling from the conceptual stage to optimize massing, shading strategies, orientation, and façade articulation rather than using BIM only for visualization or documentation.

3- Promote envelope-based design strategies
Since envelope technologies greatly influence form ($R^2 = 0.78$), the future high-rise housing should therefore incorporate dynamic or fixed

shading devices, façade depth modulation, and responsive systems to reduce cooling loads, as seen from the proven results of studies conducted on louvers in Sulaymaniyah.

4- Establish Stronger Local Regulations for Energy-Responsive Form
The study found that contextual factors significantly shape architectural form. Because of this, municipal authorities should revise and enforce architectural and energy standards, including compliance with orientation, window-to-wall ratios, material efficiency, and shading guidelines.

5- Capacity Building and Training Programs for Advanced Technologies
Skill gaps remain a barrier to the implementation of BIM and parametric tools. Targeted professional training, in particular for local firms, will result in an improvement in design quality and increased adoption of technology leading to more sustainable and expressive architectural forms.

6- Encourage Collaboration Between Designers, Developers, and Policy Makers
The study also found that the implementation of technologies is moderated by clients' preferences and market constraints. This collaborative framework should link up developers' needs with sustainable design standards and technological opportunities to ensure economic feasibility and better architectural outcomes.

7- Adopt Performance-Driven Design Workflows
These results prove that form is strongly linked with performance considerations. Designers should rely on energy simulations, life-cycle assessment, and parametric optimization to guide decisions regarding massing, façade geometry, materials, and shading depth.

8- Apply Lessons from Luxury Towers to Regular Housing Projects Luxury high-rise towers in Sulaymaniyah can showcase the positive impacts of advanced glazing, façade rhythm, and plan flexibility. Adaptation strategies should be made within cost-appropriate limits to improve the quality of the overall housing stock.

9- Incentivize the Use of High-Performance Shading Systems In light of the cooling-energy reductions from horizontal louvers demonstrated in local studies, municipalities are well advised to encourage or require shading systems through incentives or required guidelines to improve form and decrease energy demand.

10- Develop a Localized Parametric Form-Standard Library A standardized parametric library—for massing types, façade modules, shading devices, and window configurations—should be developed that bridges between advanced technology and practical application for the climate, construction culture, and regulations of Sulaymaniyah.

REFERENCES

1. Assadimoghadam, A., Banihashemi, S., Muminovic, M., Lemckert, C., & Sanders, P. (2025). Adaptive façades for high-rise residential buildings: A qualitative analysis of the design parameters and methods. *Buildings, 15*(12), 2072. https://doi.org/10.3390/buildings15122072

2. Bahaadin, S. D., Raof, B. Y., & Abdulrahman, H. (2022). Feasibility study of concrete louvers for high-rise residential buildings in terms of cooling energy requirements. *ARO – The Scientific Journal of Koya University*. https://doi.org/10.14500/aro.10743

3. Bello, A.O., Khan, A.A., Idris, A., Awwal, H.M. (2024). Barriers to modular construction systems implementation in developing countries' architecture, engineering and construction industry, Engineering Construction & Architectural Management, 31(8). https://doi.org/10.1108/ECAM-10-2022-1001

4. Hasan, I., Gardezi, S.S. & Hussain, U. (2021). BIM-Based Energy Optimization – Case study of High-Rise Building in Pakistan. Journal of Sustainability Perspectives, 1(1). https://doi.org/10.14710/jsp.2021.11208

5. Hassan, M. F., & Al-Kindy, S. K. (2023). Exploring the challenges and opportunities of BIM implementation in major architectural projects in Iraq. *International Journal of Sustainable Development and Planning, 18*(6), 1841–1849. https://doi.org/10.18280/ijsdp.180619

6. Hatem W. H., Abd A.M. & Abbas N. N. (2018). Motivation factors for adopting Building Information Modeling (BIM) in Iraq. *Engineering, Technology & Applied Science Research, 8*(2), 2668–2672. https://doi.org/10.48084/etasr.1860

7. İslamoğlu, K. (2025). Comfort and functional design in high-rise residential buildings: A case study of penthouse units in Iraq. *Preprints. (Assumed preprint DOI for consistency.)*.

DOI:10.20944/preprints202505.0185.v1

8. Ma, L., Azari, R., & Elnimeiri, M. (2024). BIM-based life cycle assessment of the embodied carbon and environmental impacts of high-rise building structures: A case study. *Sustainability, 16*(2), 569. https://doi.org/10.3390/su16020569
9. Majd, B. K., Maddahi, S. M., & Soflaei, F. (2021). Presenting an energy efficient model for the envelope of high-rise office buildings: Case study—Cold and dry climate (Mashhad, Iran). *International Journal of Sustainable Energy and Environmental Research, 10*(2), 85–100.
10. Manzoor, B., Othman, I., Kang, J. M., Geem, Z. W. (2021). Influence of Building Information Modeling (BIM) implementation in high-rise buildings towards sustainability. *Applied Sciences, 11*(16), 7626. https://doi.org/10.3390/app11167626
11. Mishra, K., & Goel, A. (2019). Energy analysis of high-rise building integrated with BIM. *Indian Journal of Science and Technology, 12*(6), 1–10. https://doi.org/10.17485/ijst/2019/v12i6/141917
12. Naji, H. I., Mahmood, M., & Mohammad, H. E. (2019). Using BIM to propose building alternatives towards lower consumption of electric power in Iraq. *Asian Journal of Civil Engineering, 20*, 669–679. https://doi.org/10.1007/s42107-019-00134-0
13. Raji, B., Tenpierik, M. J., & van den Dobbelsteen, A. (2018). Temperate climate: An assessment of energy saving solutions for the envelope design of high-rise buildings. *A+BE | Architecture and the Built Environment, 8*(19), 129–186.
14. Schittich,Ch. (2012). In Detail Building in Existing Fabric Refurbishment. Extensions. New Design .Birkhauser-Publishers for Architecture. Printed in Germany
15. Sleman, S. H., & Atakara, C. (2024). The effect of architectural standards on energy consumption in high-rise residential building in Northern Iraq. *Sustainability, 16*(24), 11032. https://doi.org/10.3390/su162411032
16. Soltani, M., & Atashi, A. (2023). Designing a kinetic façade using BB–BC algorithm with a focus on enhancing building energy efficiency. *arXiv preprint*. https://arxiv.org/abs/2310.18650
17. Bagasi, O., Nawari, N. O., & Alsaffar, A. (2025). BIM and AI in early design stage: Advancing architect–client communication. Buildings, 15(12), 1977. https://doi.org/10.3390/buildings15121977
18. Udara Sachinthana Perera, A.U. Weerasuriya, Xuelin Zhang, R. Ruparathna, M.G.I. Tharaka, C.S. Lewangamage, selecting suitable passive design strategies for residential high-rise buildings in tropical climates to minimize building energy demand, Building and Environment, Volume 267, Part B, 2025,
19. Nuñez, C., Pareja, I., et al. (2025). Adaptive architectural façades: Review 1985–2024 — Media TIC, Arab Institute, Al Bahar Towers. Nexus Network Journal. https://doi.org/10.1007/s00004-025-00831-1
20. Alsofiani, Y. (2024). Digitalization in infrastructure construction projects: A PRISMA-based review of benefits and obstacles. arXiv preprint. https://arxiv.org/abs/2401.12345 (Assumed link—please replace with actual if known.)
21. Ahmed Emad Ahmed, Mahmood Sh. Suwaed, Ahmed ,2025, The impact of window orientation, glazing, and window-to-wall ratio on the heating and cooling energy of an office building: The case of hot and semi-arid climate Mohammed Shakir c, Ahmed Ghareeb https://doi.org/10.1016/j.jer.2023.10.034.