Erbil's Urban Transformation: Green Infrastructure and Innovation in a Medium-Sized City Facing Global Challenges

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1 ABSTRACT

Medium-sized cities increasingly play a central role in global urbanisation dynamics. While megacities dominate academic and policy discourse, rapidly expanding medium-sized cities face acute challenges. These include land conversion, infrastructure strain, climate stress, and governance transition. Erbil, the capital of the Kurdistan Region of Iraq, is an example of such transformation.

In the past two decades, Erbil's demographic growth and spatial expansion have accelerated. The city has expanded beyond historic ring roads, driven by political stabilisation, economic concentration, and internal migration. This growth has put pressure on peri-urban agricultural land, environmental systems, and infrastructure. In response, Erbil's updated master planning framework introduces growth boundaries, zoning reforms, density regulation, and environmental overlay mechanisms to regulate expansion and enhance environmental integration.

Within this restructuring process, green infrastructure – including Sami Abdulrahman Park and the Orbital Green Belt Project – has emerged as a central planning component operating at multiple spatial scales. Simultaneously, major water infrastructure investments expand supply reliability and support the long-term feasibility of large-scale vegetation systems in a semi-arid climate context.

This paper examines if green infrastructure in Erbil functions only as environmental enhancement or also as a spatial governance instrument integrated with growth management strategies. By using planning documentation, project descriptions, and spatial development interpretation, the study places Erbil in broader discussions of resilience, governance transition, and environmental planning. The case contributes to debates on how transitional governance can embed environmental strategies into regulatory planning frameworks.

Keywords: Green Infrastructure, Medium-Sized Cities, Urban Growth Management, Spatial Governance, Zoning Reform

2 INTRODUCTION

Medium-sized cities are playing an increasingly important role in global urbanisation, especially in transitional regions. There, rapid expansion often outpaces regulatory consolidation. This creates a governance gap, leading to peri-urban sprawl, agricultural land conversion, infrastructure strain, and environmental vulnerability. Erbil, the capital of the Kurdistan Region of Iraq, is an example of this change. Since the early 2000s, political stabilisation and economic concentration have driven fast demographic growth and expansion beyond historic urban boundaries. This has increased pressure on peri-urban land, water systems, and infrastructure.

In response, the Erbil 2050 Master Plan update supported by the Japan International Cooperation Agency (JICA, 2022) introduces structured growth management tools, including urban growth boundaries, zoning reform, density regulation, and environmental overlay zoning. These measures reflect a transition from largely market-led expansion toward a more coordinated metropolitan planning framework.

Within this evolving system, green infrastructure – particularly Sami Abdulrahman Park and the Orbital Green Belt Project – has emerged as a key planning component. Supported by major water infrastructure investments, these initiatives operate not only as environmental enhancements but as spatial instruments influencing urban expansion and land protection.

This paper examines the role of green infrastructure in Erbil's planning transition. It evaluates whether green infrastructure functions primarily as an environmental amenity or as an emerging governance instrument integrated with growth management in a rapidly expanding medium-sized city.

3 THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Green Infrastructure as a Structural Urban System

Green infrastructure has moved beyond a narrow association with parks and urban greenery. Contemporary planning literature defines it as a strategically planned network of natural and semi-natural systems – parks, green belts, ecological corridors, agricultural protection zones, and urban forests – designed to deliver ecosystem services and environmental regulation (Benedict & McMahon, 2006; European Commission, 2013). Its functions typically include urban heat moderation, air quality improvement, soil stabilisation, biodiversity support, and flood mitigation.

In semi-arid cities, these functions become more critical. High temperatures, limited precipitation, and seasonal dust events intensify heat stress and reduce outdoor comfort. Green infrastructure can improve microclimates through shading and evapotranspiration, reduce dust movement via vegetative buffers, and support soil stability in peri-urban areas where land conversion may accelerate erosion and surface runoff.

A key planning shift is that green infrastructure increasingly operates as a structural element shaping urban form. When integrated with zoning, growth boundaries, and land-use regulation, green infrastructure can influence expansion patterns by protecting land, directing development, and strengthening institutional coordination.

3.2 Growth Management and Regulatory Evolution in Medium-Sized Cities

Medium-sized cities often experience fast growth during governance transition. Expansion is driven by administrative centralisation, investment concentration, internal migration, and real estate dynamics. In these contexts, development often comes before regulatory consolidation. The result is peri-urban sprawl, fragmented subdivision planning, uneven infrastructure, and environmental vulnerability.

Growth management tools – urban growth boundaries, zoning systems, and density controls – are used internationally to address these challenges (Angel, 2012; UN-Habitat, 2016). Urban growth boundaries limit expansion, protect agricultural land, and guide infrastructure investment. Zoning structures land-use categories and development parameters like use control, setbacks, and height limits. Density management tools such as FAR controls link building intensity to planning goals.

In transitional settings, these tools are often adopted incrementally. Their effectiveness depends not only on technical design but also on enforcement capacity. Institutional coordination and the ability to align infrastructure investment with growth zones are also important.

3.3 Green Infrastructure as a Governance Instrument

Green infrastructure can function as a governance instrument when it is operationalised within regulatory planning – particularly through green belts, overlay zones, and land protection mechanisms. A green belt can serve environmental objectives while also acting as a spatial containment measure that stabilises metropolitan structure, reduces uncontrolled land conversion, and strengthens coordination across agencies responsible for land administration and infrastructure delivery.

This paper adopts a governance-oriented lens: green infrastructure is assessed not only by its physical presence but by its relationship to planning rules, growth boundaries, land protection, and institutional implementation. This framework allows evaluation of green infrastructure as part of an evolving planning system rather than isolated projects.

4 URBAN TRANSFORMATION AND GROWTH DYNAMICS OF ERBIL

4.1 Demographic Expansion and Growth Trajectory

Erbil's transformation since the early 2000s reflects its role as the political, administrative, and economic centre of the Kurdistan Region. Stabilisation and investment concentration increased employment opportunities and institutional activity, reinforcing internal migration and demographic growth. Population estimates commonly referenced in planning discussions indicate approximately 879,000 urban residents in 2018, while the broader Erbil Governorate exceeded 1.76 million by 2023. Planning projections integrated into the master planning process anticipate continued growth through 2030 and 2050 (JICA, 2022).

For planning, the significance is not only population size but institutional response. The use of forecasts to inform zoning, density regulation, and boundary definition indicates an emerging shift toward anticipatory governance. Rather than relying on reactive subdivision approvals, the planning framework seeks to structure growth through designated development areas, controlled densities, and protected zones.

4.2 Spatial Expansion and Peri-Urban Transformation

Erbil's demographic growth has been accompanied by significant outward expansion. Historically the city developed concentrically around the Citadel and expanded through successive ring roads, but recent growth has extended beyond the 120-meter Ring Road into peri-urban areas previously dominated by agriculture and low-density settlement. Planning assessments highlight expansion pressure particularly toward western and southwestern sectors (JICA, 2022), where development follows transport corridors and land market dynamics.

This peri-urban transformation has produced characteristic challenges:

- Conversion of agricultural land to housing and commercial uses.
- Fragmented land-use patterns with limited spatial coordination.
- Infrastructure strain in water supply, transport, and services.
- Increased exposure to environmental risk in areas affected by seasonal flows and drainage constraints.

These patterns are common in medium-sized cities where growth outpaces regulation. The result is a widening governance gap: land conversion becomes difficult to reverse, infrastructure becomes costlier to extend, and environmental systems become more vulnerable.

4.3 Transition Toward Structured Growth Management

The Erbil 2050 Master Plan update introduces structured growth management mechanisms. A central element is the Urban Growth Boundary (UGB) projected through 2050, intended to guide expansion and protect surrounding agricultural and environmental areas. In parallel, an Urbanisation Promotion Boundary (UPB) projected through 2040 designates areas targeted for priority development and infrastructure investment (JICA, 2022).

These boundaries are designed to:

Define spatial limits for long-term growth.

- Protect agricultural land from uncontrolled conversion.
- Guide infrastructure investment to planned development zones.
- Support more efficient density distribution and land use.

The adoption of boundaries signals a governance transition. It represents an attempt to move from market-led outward growth to planned expansion with clearer spatial priorities.

4.4 Zoning Reform, Density Regulation, and Environmental Overlays

Complementing boundary tools, the planning framework incorporates a zoning-based system. Zoning establishes land-use classifications and development parameters such as building height, setbacks, and FAR. FAR recalibration is particularly significant because it links allowable density to projected population distribution and desired urban form, aiming to reduce inefficient low-density sprawl while supporting planned intensification in appropriate zones.

Environmental overlay zoning strengthens resource protection. Overlay categories referenced in planning discussions include agricultural protection, green belt planning areas, flood risk zones, and groundwater protection zones. Overlays function as an additional regulatory layer independent of base zoning, making it possible to restrict development or impose conditions in sensitive areas.

Together, zoning reform, density management, and overlay protection form a regulatory package that supports environmental integration. Their practical effect depends on enforcement, land administration alignment, and the ability to address encroachments and existing land-use conflicts.

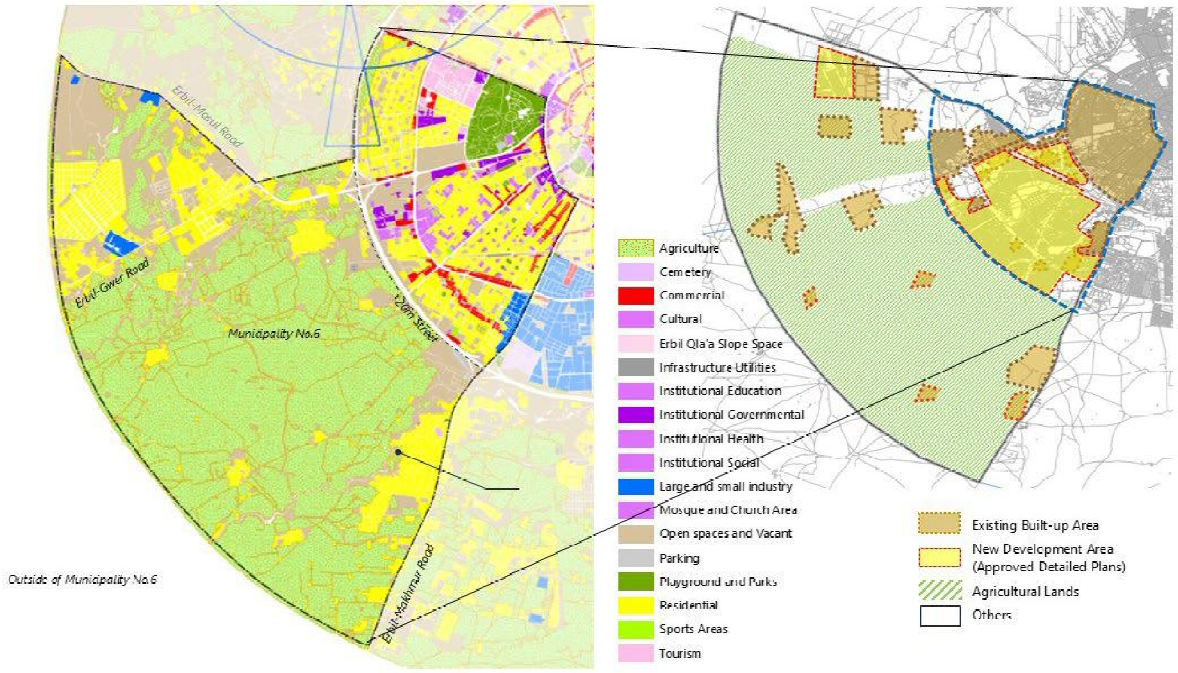

Figure 1: Location Map for the Area for A Pilot Zoning Scheme Formulation

5 GREEN INFRASTRUCTURE INITIATIVES IN ERBIL

5.1 Sami Abdulrahman Park: Civic Anchor and Environmental Precedent

Figure 2: Sami Abdulrahman Park

Sami Abdulrahman Park is the most prominent urban green infrastructure project in Erbil's core. It is widely associated with the transformation of a former military base into a major public park following the political transition in the Kurdistan Region. This conversion represents a symbolic redefinition of land use: from restricted military space to an accessible civic landscape.

The park is commonly described as approximately 200 hectares in a landscaped core area, with some sources referencing a broader boundary including surrounding facilities and phased areas. Its key roles include:

- Recreational and social space supporting public life.
- Localised microclimate moderation and environmental cooling.
- Enhancement of urban identity and city image.

- Demonstration of institutional capacity to deliver large-scale green space.

From a governance perspective, the park's influence is primarily intra-urban. It enhances livability and establishes precedent for environmental projects, but it does not directly regulate metropolitan expansion. Its strategic importance lies in normalising large-scale green interventions and reinforcing legitimacy for broader environmental planning.

5.2 Orbital Green Belt Project: Peri-Urban Buffer and Spatial Containment

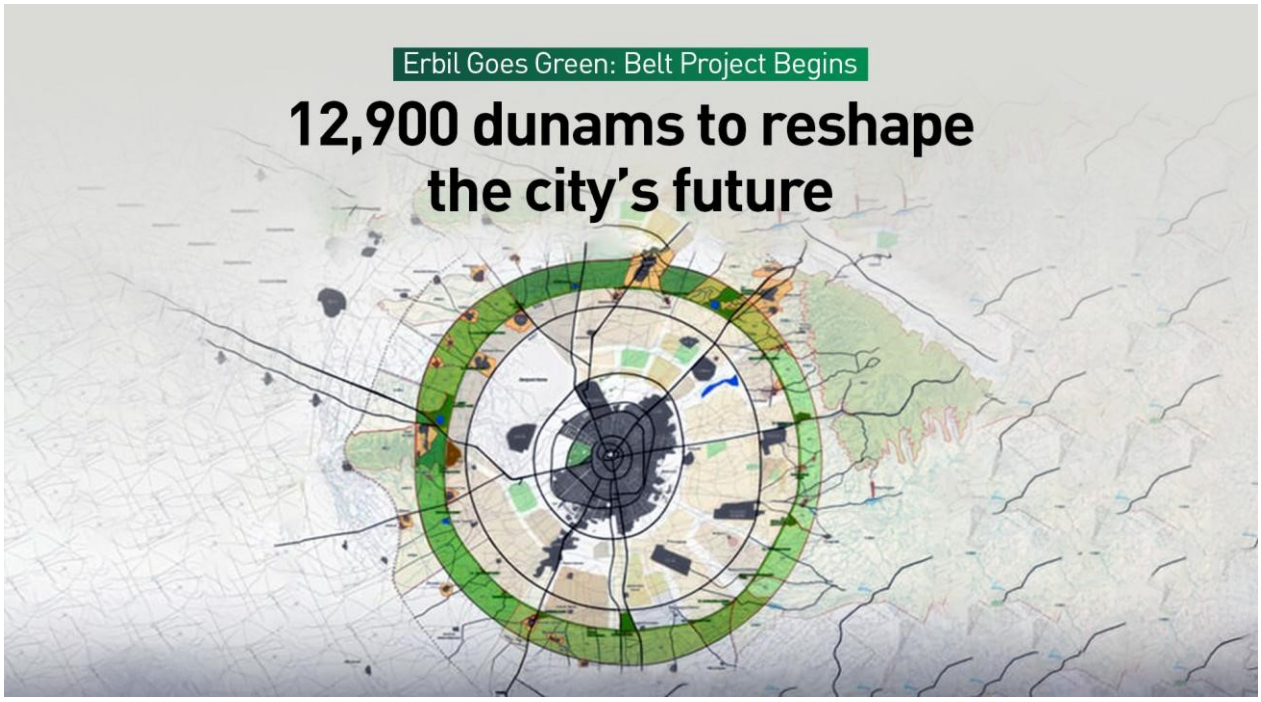

Figure 3 Green Belt Project

The Orbital Green Belt Project is a metropolitan-scale initiative to establish a continuous vegetated perimeter around Erbil. Public descriptions of the concept indicate an orbital structure encircling the city, with an approximate length of 92 kilometres and a width that varies by segment, often cited as 1.6-2.5 kilometres depending on location.

The green belt is expected to deliver several linked functions:

- Environmental buffering: Reducing dust infiltration, improving air quality, and supporting microclimate regulation in peri-urban zones.
- Land protection: Limiting the conversion of agricultural land and maintaining peri-urban ecological services.
- Spatial containment: Reinforcing growth boundaries by creating a visible and designated environmental perimeter.

Institutional coordination: Requiring cooperation across municipal authorities, regional institutions, and land administration bodies.

In governance terms, the most important dimension is containment. When aligned with the UGB and overlay zoning, the green belt becomes a physical and regulatory tool to stabilise the metropolitan edge and prevent uncontrolled outward expansion.

Implementation, however, is complex. Challenges typically include enforcement, development pressure at the urban fringe, and existing encroachments or overlapping land claims. These constraints are common in transitional governance contexts and highlight the gap between planning intention and land-market dynamics.

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5.3 Water Infrastructure as an Enabling System for Green Infrastructure

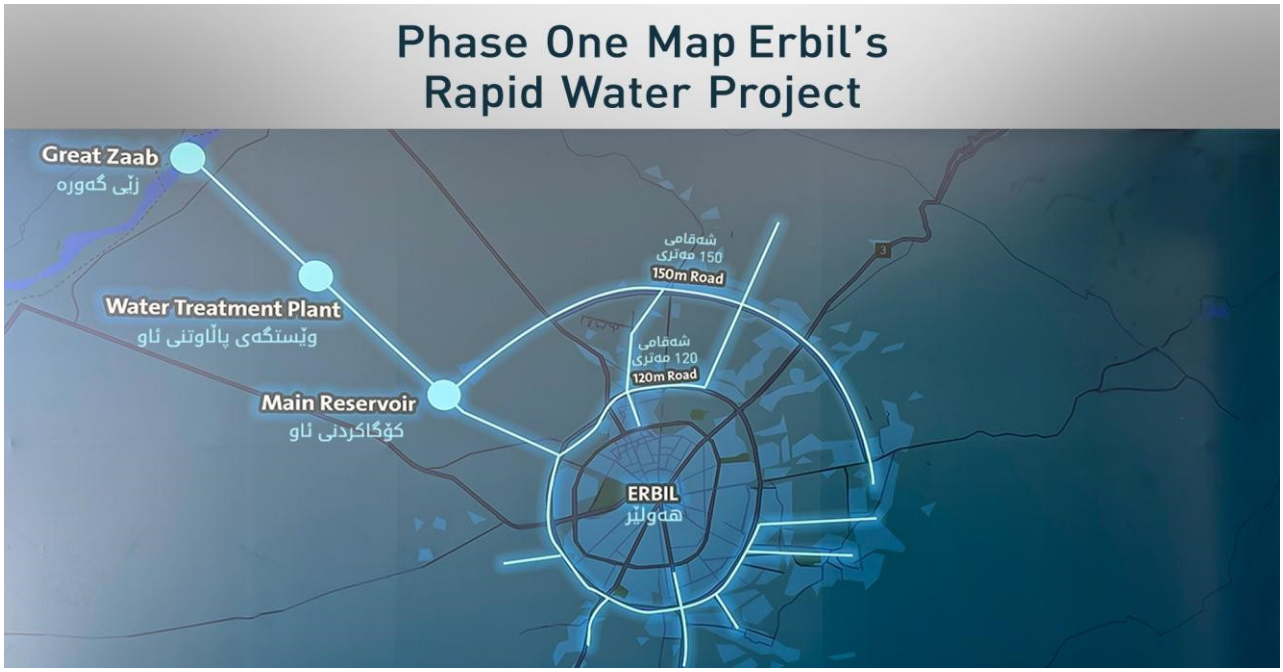

Figure 4 : Rapid Water Project

In semi-arid environments, the sustainability of large-scale vegetation systems depends on water availability. Without a reliable supply, green belts and extensive urban forestry become difficult to maintain and risk long-term degradation. Recognising this constraint, Erbil has pursued major water supply investments linked to the Great Zab River, described in planning discussions as a large-scale emergency supply expansion with substantial daily capacity (commonly referenced around 480,000 cubic meters per day).

From a planning perspective, the water project is not separate from environmental strategy. It forms an enabling system that:

- Supports irrigation and maintenance for green infrastructure.
- Increases resilience against shortages during periods of growth.
- Strengthens the feasibility of metropolitan-scale vegetation systems.

This linkage is critical: green infrastructure in Erbil gains strategic credibility when backed by resource infrastructure capable of sustaining it.

5.4 Multi-Scalar Integration within Spatial Governance

Taken together, the park, green belt concept, and water infrastructure illustrate a multi-scalar system:

- Urban scale: Parks improve livability and demonstrate environmental capacity.
- Metropolitan scale: the green belt supports containment and land protection.
- Infrastructural scale: water supply underwrites long-term sustainability.

This layered structure suggests a shift from "projects" to "systems" where environmental elements are increasingly positioned within the planning framework.

6 DISCUSSION: GREEN INFRASTRUCTURE AS EMERGING SPATIAL GOVERNANCE

Erbil experiences heat stress, limited rainfall, and seasonal dust. Urban expansion reduces vegetative cover and increases impervious surfaces, raising thermal load and environmental vulnerability. Green infrastructure can mitigate these impacts by providing shading, evapotranspiration cooling, and dust buffering. Sami Abdulrahman Park likely delivers localised cooling and supports public comfort, while the orbital green belt – if implemented and maintained – could provide broader peri-urban buffering effects.

Environmental effectiveness depends on sustained maintenance, irrigation, and institutional commitment. In this sense, water supply investments become integral to environmental planning, supporting long-term viability rather than short-term beautification.

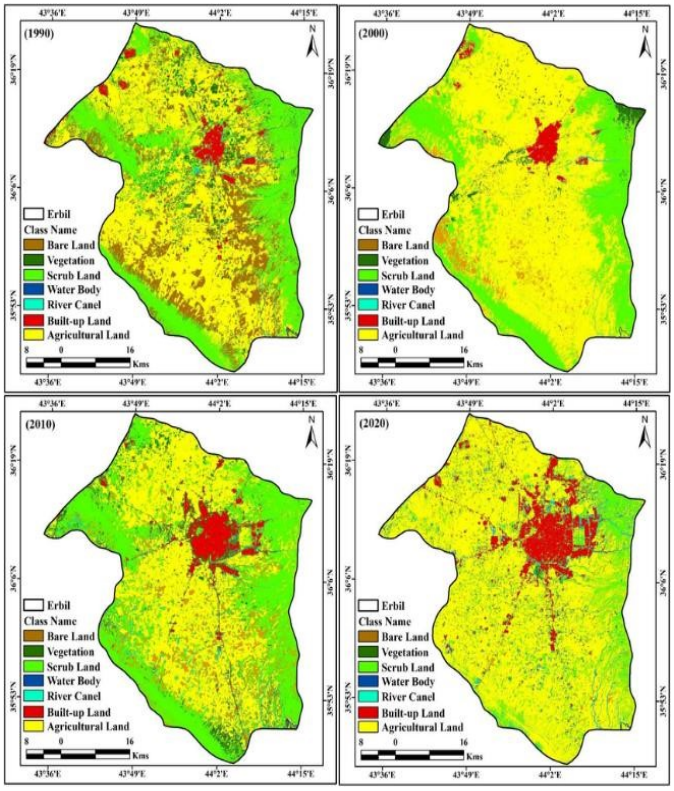

Figure 5: Land use and vegetation change in Erbil from 1990 to 2020, illustrating urban expansion and reduction of green areas.

6.1 Growth Containment and Spatial Regulation

The core governance question is containment. The orbital green belt concept is significant because it operates at the metropolitan edge, where land conversion pressures are highest. When aligned with the UGB and environmental overlays, the green belt can function as a spatial governance instrument that:

- Limits uncontrolled outward expansion.
- Protects agricultural land and sensitive zones.
- Encourages more coordinated development within designated growth areas.

In medium-sized cities, such measures can meaningfully shape urban form if enforcement mechanisms are credible and aligned with infrastructure investment.

6.2 Institutional Coordination and Governance Consolidation

Large-scale green infrastructure requires multi-actor coordination across planning, land administration, and infrastructure agencies. This coordination can strengthen governance capacity by institutionalising shared objectives, clarifying land protection responsibilities, and linking environmental regulation to zoning and boundary tools.

At the same time, implementation challenges – encroachments, land claims, and development pressure – illustrate the realities of governance transition. The presence of such challenges does not negate governance evolution; rather, it highlights the incremental nature of regulatory consolidation in rapidly expanding cities.

6.3 Symbolic Transformation and Urban Identity

Green infrastructure also operates symbolically. The conversion of a former military site into a major public park reflects political and social transformation and strengthens civic identity. Such visible projects can increase public support for planning reforms by demonstrating tangible improvements to quality of life.

Symbolic legitimacy matters in transitional contexts: when planning authority is still consolidating, highly visible projects can help build confidence in broader regulatory measures, including growth boundaries and land protection rules.

6.4 Implications for Medium-Sized Cities

Erbil illustrates how a medium-sized city can begin to institutionalise environmental planning within governance systems. Compared to megacities with entrenched patterns, medium-sized cities may have greater flexibility to introduce boundaries, overlays, and density reform during active growth phases. The key condition is coordination between planning rules and enabling infrastructure, particularly water supply for vegetation systems.

7 CONCLUSION FINAL REFLECTION

7.1 Conclusion

This paper examined green infrastructure in Erbil within the broader context of demographic expansion, periurban transformation, and planning reform. The analysis suggests that green infrastructure is increasingly positioned not only as environmental enhancement but as part of an emerging spatial governance framework.

Sami Abdulrahman Park contributes primarily to livability, environmental quality, and symbolic civic transformation. The orbital green belt concept – by contrast – operates at the metropolitan scale and intersects directly with growth containment and land protection objectives. Water infrastructure investments provide a critical enabling system for sustaining vegetation in a semi-arid context, strengthening the feasibility of large-scale green infrastructure.

Taken together, these elements indicate a shift from isolated projects toward a layered system integrated with zoning reform, growth boundaries, and environmental overlays. While long-term outcomes will depend on implementation and enforcement, the planning direction reflects an evolving governance capacity aimed at shaping urban form and strengthening environmental regulation.

7.2 Final Reflection

Erbil's experience illustrates how a rapidly expanding medium-sized city in a semi-arid transitional context can begin to institutionalise green infrastructure within its regulatory architecture. While implementation challenges remain inherent to large-scale spatial reform, the structural embedding of environmental overlays, growth boundaries, and hydraulic infrastructure suggests movement toward a more integrated planning paradigm.

In this sense, Erbil contributes to broader discussions at REAL CORP concerning the role of medium-sized cities as arenas of innovation in global urbanisation.

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