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Localizing the Urban Transect Theory as a Regulating Tool for the Urban Design of Duhok City to Enhance Sustainability

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ABSTRACT

Recently, the urban districts of Duhok City have undergone a rapid expansion, extending into the suburbs and surrounding villages, resulting in significant transformations to their urban form. However, conventional land-use planning fails to address local contextual challenges, including low-quality built environments. Therefore, this study claims that the existing urbanrelated symptoms of unsustainability in Duhok City can be approached through the theory of Urban Transect. The Urban Transect approach is a novel land use classification structure that focuses on increasing urban-natural environment integrity and enhancing neighborhood characteristics. Derived from environmental studies, this theory has recently gained traction in urban planning and design as an alternative to conventional zoning for multiple purposes. It's an analytical and regulatory tool that reduces uncontrolled sprawl, improves neighborhood performance, and balances natural and built environments for smart and sustainable development. This research explores how the Urban Transect theory can be adapted and applied to Duhok City's physical characteristics. In addition to proposing a localized Urban Transect Matrix, it demonstrates the potential advantages of incorporating the adapted Urban Transect theory into the planning and design process through an analysis of the city's current urban design practices. It intends to provide urban planners, policymakers, and designers involved in shaping the future of Duhok City with valuable understandings and recommendations that could foster sustainable development, improve the quality of life, and optimize the physical environment.

KEYWORDS: Urban Transect, Transect Zone, Smart Codes, New Urbanism, Context-Based Codes.

1. INTRODUCTION

The rapid development of cities in the 20th century brought about significant changes in urban planning, with cities around the world employing similar design models. While this uniform approach enhanced functionality and aesthetics, it led to the homogenization of cities, causing them to lose their distinctive identities (Kriken, 2006). A call for localized urban design techniques and approaches has gained traction in response to this development (CABE, 2000). The objective of these context-specific designs is to preserve the identity of the local physical environment and promote sustainable development.

Duhok City, situated in Kurdistan Region of Iraq, is considered to be one of the cities that faced rapid development challenges. The urbanization process in Duhok City is primarily characterized by the phenomenon of organic growth and the subsequent emergence of urbanized villages. This study aims to localize the theory of Urban Transect in order to promote sustainable urban development. The theory of Urban Transect is shown by a simplified typology of "transect zones". New Urbanists split the human environment into six zones, from very rural to suburban to urban, using the transect. The way everything in building form, use, the character of streets, and open spaces reinforces a certain overall physical character of place distinguishes each of these settings (Parolek 2008). This research has been conducted in three steps: constructing a theoretical framework based on the Transect Zone concept, conducting a comprehensive analysis of Duhok City, and concentrating on the Masike district as a case study of urban transformation. Site observations, surveys, and expert interviews were used to capture data, which has been analyzed using tools such as Arch GIS and AutoCAD. The proposed localized Transect Matrix will help urban planners, policymakers, and designers shape the future of Duhok City. In addition, it encourages further studies to provide transect-based codes.

2. The Theory of Urban Transect: An Overview

This section will present an overview of the Urban Transect Theory, offering a contextual foundation for the subsequent analysis. It will commence with an exploration of the historical context, followed by elucidating the theoretical definitions and the genesis of the concept. Subsequently, it will provide an illustration of the key components of the theory and conclude with illustrative instances from various regions around the world.

2.1. The historical background of emergence

The transect concept is deeply rooted in environmental studies. Firstly, it has been used in geography, then as an analytical tool in landscape design, and finally as an urban planning and design strategy (Duany, 2002). In 1793, a Prussian geographer named Alexander von Humboldt used a transect to sketch Patagonia from ocean to ocean. In the modern era, this method is used by planners and architects. Landscape architect Ian McHarg's groundbreaking book "Design with Nature" employed the transect as an analytical tool (Deal, 2017). During the past fifteen to twenty years, New Urbanist architects and developers have popularized it. Brothers Andres and Douglas Duany, an architect/urban designer, and a landscape architect, identified a rural-to-urban transect for Miami Beach, Florida. They and other New Urbanists began to investigate the local transect around the US to find the DNA for the regeneration of human settlements, realizing the threat of sprawl and the codes that promote traditional suburban developments (Cekic, 2016). "New Urbanism" and "Smart Growth" attempted to limit suburban sprawl. Andres Duany's "urban transect" model defines zones from rural to urban with sizes that connect developments with residential and commercial land uses (see Fig. 1). By designing urban developments around a central hub containing retail and public space, residents can benefit from connectivity and simple access to essential services (Friedman, 2020).



Figure 1. Standard Urban Transect Matrix (Zyberk, 2023)

The American city crisis led to new urbanism. Uncontrolled urban sprawl destroyed natural habitats and resources, community identity, and secure living areas (Özdemir, 2010). Since sprawl is characterized by isolated, single-use pods of congested roads, strip shopping complexes, office parks, large boxes, and gated cul-de-sac subdivisions. This land-use pattern, common in suburbs but also in cities, wastes water, energy, land, and traffic time (Tachieva, 2010). Urban Transect-based codes were found as a solution to provide compact, pedestrian-friendly, and community-oriented communities (Özdemir, 2010). A compact city is widely recognized as one of the most promising urban development patterns for achieving the main sustainability objectives. (Pradhan, 2017). Meanwhile, the Urban Transect System enables the zoning of the city according to sustainable planning standards and provisions for physical requirements (Jothilakshmi and Vedamuthu, 2010). Finding the right balance between natural and man-made environments improves places across the board and stops sprawl (Duany, 2006).

On the other hand, Bohl and Plater-Zyberk (2006) claimed that, an innovative framework is required that enables a larger variety and quality of preserved and constructed places. The rural-to-urban transect is one alternative tool for regulating such a transformation (Bohl and Plater-Zyberk, 2006). It is the first transect designed to be utilized by local authorities in response to demands for a more straightforward and explicit land use coding procedure (Deal, 2017). Also, it could be able to resolve the tensions, separations, and conflicts that exist in urban planning practice today. It is a system that seeks aesthetics and a sense of place in urban environments. Different zones have different architecture, landscaping, building types and styles, and street layout standards (Talen, 2002).

2.2. Theoretical definitions: Various approaches and perspectives

The Urban Transect is a geographic cross-section of an area that reveals a succession of environments. For human environments, this section can be used to categorize habitats that range from rural to suburban to urban in terms of urban character (Duany, 2006). Transect zones describe the physical attributes of a particular area at different levels, taking into account the concentration and intensity of activities and urbanization (Miami, 2010). The Urban Transect, as viewed from various perspectives in the literature, described as:

• A tool for *planning and design* that effectively arranges urban elements in a systematic manner to preserve the integrity of diverse habitats. Urban Transect enables the

implementation of context-sensitive codes related building form, placement, parking, use, signage, public spaces, and lighting to create spaces that are desired and ideally suited to their surroundings (Duany and Talen 2002, Parolek, 2008). It provides a conceptual framework for describing and understanding the differences between different urban places and for determining future place-making and community-building plans, regulations, and guidelines (Bohl & Plater-Zyberk, 2006). Additionally, it serves as a basis for drafting codes that address problems at the regional level, city level, town level, and neighborhood level (Ben-Joseph & Szold, 2005).

- A new *land use classification scheme* that focuses on increasing urban-natural environment integrity and enhancing neighborhood characteristics (Li and Zhang, 2022).
- An effective *policymaking tool* that can create powerful links between the requirements of identifying distinct community components, diagnosing problems and obstacles, recommending policies, and assigning implementation actions (Onaran, 2018). Urban Transect matrix is facilitating communication between the community and stakeholders due to its effective role in educating communities about what kind of urban density is desirable, and how transect-based codes could help reinforce that kind of development (Miami, 2010).
- A *sustainability enhancement* tool allows for the zoning of a city in accordance with sustainable planning standards. Urban Transect employed as a means of establishing communities that exhibit social diversity, environmental sensitivity, and economic sustainability (Bohl and Plater-Zyberk, 2006). This includes ensuring physical requirements, as well as promoting safety, security, and protection. It also aims to create a conducive social environment, promote a positive image and reputation, encourage innovation, and establish an aesthetically pleasing environment (Jothilakshmi and Vedamuthu, 2010). It can be used to allocate resources efficiently in accordance with urban standards and performance metrics (Deal, 2017).

2.3. Key components of the Urban Transect

The Urban Transect Matrix outlines the hierarchical progression of development intensity, ranging from low-density suburban areas to high-density urban cores. The typical transect matrix is partitioned into distinct zones, ranging from rural to urban. The various types of zones include the natural zone (T1), rural zone (T2), sub-urban zone (T3), general urban zone (T4), urban center zone (T5), and urban core zone (T6), in addition to special districts (SD) (Parolek 2008, Zhang 2019). As shown in Table 1, each zone is distinguished by its particular land uses, building types, public and private frontages, thoroughfares, and open spaces (Duany, 2006). In this research, the focus is on land use, buildings, thoroughfares, and open space characteristics of each zone.

T-Zones	le	Description	Main Characteristics
	Zon		
		Topography, hydrology, and vegeta-	Land Use: Natural preserve, recreation and camping
man - Ca	T1	tion make these places unsuitable for	Buildings: Utility infrastructure and camp buildings.
27 4 4 4 4 E		settlement.	Thoroughfares: Highways and roads.
the man of			Open Spaces: Parkland
My the American	T2	It is open, cultivated, or sparsely set-	Land Use: Natural reserve, agriculture, recreation and
and the bridgest and the		tled. These include forests, agricul-	camping.
Adr Sta		tural areas, grasslands, and irrigable	Buildings: infrastructure, agricultural buildings and farm-
Le PE		deserts.	houses, and campgrounds.
			Thoroughfares: Highways and roads
- ALLER			Open Spaces: Farming, forests, orchards and parkland.
THALLAND.		Urban T-zones are usually nearby.	Land Use: Low density residential and home occupations.
- 200		Planting is naturalistic in this zone.	Buildings: Houses and outbuildings.
CLO IL LOST	T 3	Blocks may be large, and roads irreg-	Thoroughfares: Roads and a few streets; some unpaved.
and the and the		ular to accommodate site conditions.	Open Spaces: Orchards, parks and greens.
VAR USA APRIL			
and share bent		Densely residential urban fabric.	Land Use: Medium density residential; limited commer-
Bry Lotter by Orea		Mixed-use commonly occurs in cor-	cial and lodging.
ALL OF CHAR	T4	ners. This area contains singles, side	Buildings: Houses, side-yard houses, townhouses,
DEAD HOP		yards, and row houses. Street tree set-	live/work units, corner stores, inns.
The state of the second		backs vary. Streets divided medium-	Thoroughfares: Streets and rear lanes.
C777 1000		sized blocks.	Open Spaces: Squares and playgrounds.
STITESE		Major street area. Retail, office, and	Land Use: Medium intensity residential and commercial:
C 1 1 1 1 1 1 1 1		residential structures, are in this zone.	retail, offices, lodging, civic buildings.
		This neighbourhood includes a com-	Buildings: Townhouses, apartment houses, live-work
Topologi La Version Co.	T5	pact street network, large sidewalks,	units, shopfront buildings and office buildings, hotels, and
North A Carton		street trees, and buildings near the	schools.
and the second of		frontages.	Thoroughfares: Boulevards, avenues, couplets, main
(4) + 1 + 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5			streets, streets and rear alleys.
and the second			Open Spaces: Squares, plazas and playgrounds.
Mark UR 40 3		Equal to downtown. It has the densest	Land Use: High intensity residential and commercial: re-
A AND AND AND AND AND AND AND AND AND AN		urbanism, tallest structures, and most	tail and offices, lodging, civic buildings.
Contrast in	T6	uses, including unusual ones like	Buildings: High- and medium-rise apartment and office
STATE		banking districts and key civic build-	buildings, hotels; townhouses, shopfronts, churches, civic
A CAR		ings. The least naturalistic zone is this	buildings.
AL ON THE		one.	Thoroughfares: Boulevards, avenues, couplets, main
			streets, streets and rear alleys.
			Open Spaces: Squares, plazas and playgrounds.

Table 1. Key components	of Urban Transect	(Duany, 2006)
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2.4. Localizing the Urban Transect Theory: Examples from globe

Numerous empirical studies recommend that a better understanding of how unknown tools like building codes, engineering standards, zoning regulations, and other professional tools shape place-making and community building before a designer picks up a pencil is needed (Bohl and Plater-Zyberk, 2006). Since all development forces work to uniform cities today and in the future. Developers copy successful projects. Building materials and technologies are the same worldwide. Leveling slopes, filling valleys, and channelizing waterways simplify building conditions. Because of this, a positive framework for settlement and development should employ every possible tool to promote the unique character of each location (Kriken, 2006). In order to achieve the objectives of urban design, it is imperative that the planning toolkit be tailored to reflect the specific characteristics and requirements of the local context (CABE, 2000).

The Urban Transect has been developed and applied in various cities in the US after being applied within the Miami 21 codes, for instance, Mississippi, Nashville, and Texas. After their popularity in the US, the Urban Transect-based codes have been adopted and tailored to different contexts worldwide (Sanders et al., 2016). The local context of Hong Kong required the addition of six subdivisions to the urban core zone and an additional matrix for the upper and underground levels to the standard Urban Transect matrix, which facilitates more complex urban development (Zhang, 2019). On the other hand, urban neighborhoods, developed under transect urban codes in Saudi Arabia, are pioneering MENA example of a sustainable, compact, walkable, and human-scale community that reacts to the local natural environment, climate, and heritage (Khalid Sabri and Galal Ahmed, 2019). In Wadi Hanifa localized Urban Transect matrix, the urban core zone has been missed due to the context of the selected area for development, while T2, T3, T4, and T5 were subdivided into two subdivisions to distinguish the zone based on different types of buildings (RiyadhCity, 2020).



Figure 2. Different appearances of each zone in various cities around the world due to different contexts, (Schnabel 2016, Bohl and Plater-Zyberk 2006, RiyadhCity 2020)



Figure 3. Localized Urban Transect Matrix of Hong Kong, China, (Zhang, 2019)



Figure 4. Localized Urban Transect Matrix of Wadi Hanifa, Saudi Arabia, (RiyadhCity, 2020)

3. The urban state in Duhok City

Duhok City is situated in the central region of Duhok Province within the Kurdistan Region of Iraq. Its establishment dates back to 1887, a period characterized by the presence of the Ottoman caliphate (Hassan and Kotval-K, 2019). The urban area encompasses an area of 36 square miles, situated within the valley that lies between the northern mountain range known as Bekhair and the southern mountain range known as Zawa. The Duhok River, which flows through the city center, forms a distinct natural green corridor in its surrounding area (see Figure 5). The urbanization process in Duhok City has witnessed a significant and rapid expansion of its urban area over time. As the city expanded into the suburbs and adjacent villages, its urban morphology experienced significant changes and underwent a process of transformation. Since the 1990s, rapid urban expansion in Duhok City has dramatically increased human activity's potential impact on the area (Mustafa, Ali, and Saleh, 2012).

Regarding urban planning and design practice, it is primarily based on conventional landuse planning. The master-plan is the critical tool of urban planning and design in Iraq, guiding the physical development of the city. During the 1990s, the municipalities in the Kurdistan Region of Iraq faced a deficiency in contemporary urban designs. Furthermore, a significant number of master plans that were intended to guide the development of their cities lacked a comprehensive context analysis. Professionals and institutions are lacking. Inefficient local and regional expertise hindered the quality and type of planning, limiting sustainable urban growth in Duhok (Hajani, 2019).

Thus, the local government advised writing another strategy with foreign and local knowledge. In 2007, Vössing, a German consulting firm, created a master plan for Duhok and adjacent municipalities for the local administration. To incorporate local perspectives into the master plan, Vössing invited local specialists from urban planning and many other relevant government organizations in Duhok to join a negotiation committee. The firm clearly copied Germany's spatial planning (Hajani, 2019).

The master plan is not precisely tailored to Duhok's local context due to a deficiency of local urban planning expertise and explicit context-specific studies. (Municipality of Duhok, 2023). Moreover, the urban development in Duhok was significantly impacted by the master plan due to an underestimation of the rapid rate of urban growth and informal development. Thus, the city's macro- and micro-level physical urban development patterns have not been adequately defined (Hajani 2019). They struggle to solve local issues like lack of accessibility and poor built environment performance (General Directorate of Urban Planning of Duhok, 2023). They are still missing the essential design guidelines for the quality of physical features of urban form, a sense of place unique to their context, and public realm quality (Shingali and Malaika, 2016).

The lack of detailed site-specific regulations and the use of homogeneous urban codes across different urban contexts in Duhok have led to a number of urban environmental problems, as illustrated in Table 2 below. On one hand, the building permits department in the Municipality of Duhok primarily relies on street width as the only factor for enforcing codes and guidelines concerning urban design. However, there is a notable absence of a comprehensive analysis that takes into account the specific contextual factors of the site. On the other hand, according to regulation No.1143 (2019), updates have been applied to a specific part of the existing master plan for the city of Duhok; nevertheless, there is no clear justification for these updates. As a significant portion of these modifications related to the building's height, setback, and uses, they lacked a conceptual framework for detailed design control. For instance, building height standards for the areas located on a part of Barzan Street were only four floors, then increased to eight floors, and finally to 12 floors (Municipality of Duhok, 2023).



Figure 5. Duhok city location in Iraq, (left) Iraq map and (right) Duhok City, (https://d-maps.com 2023)

Table 2. Lack of site-specific regulations: The current situation in Duhok City, (based on a field survey,2023)

Urban-related symptoms of unsustainability	Visual Documentation		
The negative effect of different plot coverage on the sense of place of the panoramic image and landscape of the city is due to the lack of site-specific regulations and codes.			
The negative effect of different building widths, heights, and the number of floors in the same urban corridor of the city on the urban form and the sense of place related to the specific context.			
Different building heights, and the number of floors in the his- torical urban area (20-meters street) without consideration of the identity of the area.			
Different building setbacks in the same urban corridor are negatively affecting walkability and public realm quality.			
Using a grid street pattern for different topographies, includ- ing mountainous and semi-level areas, has a negative impact on accessibility in areas with difficult topography due to the lack of site-specific studies.			

4. The relevance of Urban Transect Theory for Duhok City: The research question, objectives, and methodology

The Urban Transect has been widely employed in urban planning as a tool for analysis and regulation due to its extensive global evidence base. It offers potential solutions for enhancing neighborhood performance, promoting smart growth, and fostering sustainability. During the data collection phase, this study found significant instructions from the Ministry of Municipalities and Tourism in the Kurdistan Region of Iraq. The Ministry has informed the relevant authorities in Duhok to integrate three villages into the city master plan. The vision for these villages is to flourish as integral neighborhoods within the city's eastern border. A joint committee was assembled in July 2023 with a focused responsibility of providing detailed design for these areas. This study claims that the Urban Transect serves as a valuable urban planning tool for the City of Duhok, as it addresses the current urban-related indicators of unsustainability outlined in the preceding section. Additionally, it could potentially be utilized as a regulatory tool, offering valuable guidance for subsequent urban planning and design.

The present study is motivated to examine the potential adoption of the Urban Transect as a solution tool. It is central to keep in mind that the application of this tool cannot be implemented

without considering the diverse urban contexts found in different regions across the globe. Hence, it is imperative to employ a "localized" Transect matrix in order to enable urban planners and designers to formulate plans that are grounded in the distinctive characteristics and qualities of each specific area. However, additional research is required in order to establish the transect-based codes for different urban zones in Duhok in order to identify each zone.

4.1. The research question

Can the theory of Urban Transect be adapted to Duhok's physical context?

If Yes, how can it be tailored to the local context?

4.2. The research objectives

This study is about investigating the applicability of the Urban Transect concept to promote sustainability in Duhok City. It intends to adapt the Urban Transect theory to Duhok's specific context in order to provide urban planners, policymakers, and designers with recommendations for sustainable development. Ultimately, the key step is providing a localized Urban Transect matrix for Duhok City.

4.3. The research methodology and methods

The research utilized a combination of qualitative and quantitative methods. Three steps were followed to resolve the study's problem and meet its objectives. Initially, in building the theoretical framework, the basics and key concepts of the Transect Zone concept were reviewed. Second, a comprehensive analysis of the urban form of Duhok City was conducted. Then, the Masike neighborhood was selected as an urbanized village example that shows rural-to-urban transformation in the city, with the aim of defining the process of transformation and identifying the main characteristics of each stage of its development. Primary data were collected through site observations, surveys, and interviews with urban planners, architects, and other relevant stakeholders in Duhok City. The adapted Urban Transect framework was developed based on data analysis and extensive discussions with local experts and professionals. Arch GIS and AutoCAD were used for analyzing and visualizing the data.

5. Duhok City as the research context

5.1. Duhok City Urban Development

From a historical perspective, it can be observed that the city of Duhok has its origins rooted in a small village, which can be characterized as an attractive representation of rural existence. Over the period of its development, the entity progressively extended its geographic boundaries, assimilating adjacent villages into its urban structure. These villages, including Masike, Zirka, Malta Nasara, Malta Islam, Gavariki, Shindokha, Shakheki, Baroshke, Nizarki, Eatiti, and Qasara have been transformed into quarters of the city. This expansion, marked by the unplanned incorporation of various villages into a unified urban entity, is a notable characteristic that defines Duhok's urban morphology. An interview conducted with the heads of the urban design and building permits departments in the Municipality of Duhok in 2023 revealed that all of these surrounding villages were originally established in close proximity to mountains, Duhok River, or natural valleys. Agriculture served as the primary source of income for the residents. However, as the city of Duhok rapidly expanded, some residential buildings were constructed illegally, leading to concerns about uncontrolled development. In response to these challenges, a committee of stakeholders and designers was formed to resolve the issue and make decisions regarding urban development. The process of urbanizing villages is illustrated in Figure 6 below.



Figure 6. The institutional process of urbanizing villages, (based on Municipality of Duhok 2023)

In general, the design process of urbanizing villages undergoes multiple stages of modification and adaptation over time to accommodate the changing requirements and growing demands of a city. However, it is notable that all the villages incorporated into the city exhibit identical trends in terms of their physical development. Therefore, this study carefully chooses one of the previously mentioned urbanized villages and conducts an analysis to describe the process of transformation and identify the main characteristics that characterize each stage of its development.

5.2. Masike district as the research sample

Masike village is a recently developed area within the city of Duhok that has undergone a transition from a rural to an urban setting. It is selected as a case study to illustrate the changes that occurred within the region between 2003 and 2023, alongside the proposed design outlined in the city's master plan for future development (see table 3). Hence, it will serve as an example that illustrates the development path of other villages within the city across various temporal phases.

Masike village is geographically located close to Bekher Mountain to the north and a natural valley to the southwest. Historically, the majority of the village's land was characterized by its natural state and agricultural use, which has since been predominantly transformed into

residential areas. An organic growth was observed subsequent to the year 2003. After going through three design stages the final update tooke place in 2012 as a suggested future development for the area (Municipality of Duhok,2023). As illustrated in Figure 8, the expansion of the development beyond the boundary of the original village area is characterized by the emergence of a more uniform plot layout, a more regular street pattern, and a higher percentage of mixed-use development.



Figure 7. Duhok City neighborhoods (Hajani, 2019) and Masike areal map, (CityEngine map, 2023)



Figure 8. The direction of urban development in Masike, (based on data and field survey, 2023)

6. Analyzing the research sample

As illustrated in Table 3, the density of development increased from 4 dwelling units per hectare in 2003 to 112 dwelling units per hectare in 2023. As a result of extensive changes to the natural environment caused by urbanization. The percentage of agricultural land decreased dramatically from 38% in 2003 to 4% in 2023, but it's suggested to increase slightly in the future development plan.

	The Outline	Development layout	Open Spaces	Buildings Form
2003				
2013				
2023				
Future development			Construction of the second sec	Unavailable

Table 3. Masike District urban development, (based on data and field survey, 2023)

Furthermore, the design of the area was significantly modified. In the most developed section, the street pattern changed from irregular with the availability of cul-de-sacs in the original village area to completely connected and regular with right angles. On the other hand, the whole area perceived a change from unpaved to mostly paved and automobile- oriented streets. The division of the plot shifted from irregular shapes and areas between 800 and 70 m² in its earliest part to regular shapes and areas of 200 m² or slightly more in a small number of plots. Table 3. Masike District urban development, (based on data and a field survey in 2023)

Regarding building placement, in the original village, which consisted primarily of singlefamily houses, the plot coverage was approximately 50% with an internal garden, forecourt, and backcourt. In contrast, the newest part of the neighborhood consists primarily of attached raw houses, with 70% plot coverage and only forecourts provided. Moreover, the front setback is the only requirement. Considering building configuration, the original village featured primarily onestory and rarely two-story houses. While, in the most developed part of the neighborhood, the building height consists of one- to three-story houses. In certain areas, however, the height of non-residential buildings may reach eight stories.

7. Results and findings

In this research, a dual-level analysis was employed. The first level concerned Masike, whereas the second level encompassed the entire city, assuming the applicability of the Masike situation to all other city districts. After reviewing the theoretical background of the Urban Transect Theory and a comprehensive analysis of the pattern of Duhok City, the research question was answered and the objectives met. Several districts within the city exhibit common characteristics in terms of their main indicators, which align with the new urbanism principles. However, it is essential to note that these districts also possess distinct variations that have been identified as unique to the local context, as acknowledged by the research. In this research, as shown in Tables 4 and 5, the focus is on the land use, buildings, thoroughfares, and open space characteristics as a key concept for recognizing T-Zones because of the lack of a clear definition for the frontage in Duhok urban design standards and regulations. The tailored Urban Transect Framework is the basic requirement to provide site-specific codes and regulations to preserve the identity of different urban zones in the city and foster sustainable development.

In addition to the natural zone T1, which is identified as the Duhok River and the green area surrounding it, as well as the Bekher and Zawa Mountains, the following Urban Transect Zones are tailored to Duhok City's physical context:

- General Urban Zone (T4): This zone has been divided into three subdivisions zone because they share the main characteristics of the same zone in the original theory, which are mainly residential zone, but they have some variations in specific regulations and forms in the local context. *T4-1*: the original village area (the oldest part of the neighborhood), *T4-2*: the newest part of development (sprawled area), and *T4-3*: the housing complexes in the city.
- Urban Center Zone (T5): Commercial streets as called in the main regulations established by the authorities (the main streets with mixed and commercial use development).
- Urban Core Zone (T6): the historic Commercial Business District (CBD) of the city.

Rural Area Zone (T2) and Sub-Urban Zones (T3) are absent from the localized Urban Transect Matrix of Duhok, according to Figure 9. This absence is a result of unsustainable urban development practices. The sprawling development of the city in addition to the urbanization of the central areas of the villages has resulted in a notable increase in building density and a significant reduction in natural land, which has led to the gradual disappearance of their rural character.

Urban Elements		T4-1 The original village area	T4-2 The new development area	T4-3 Housing complexes	T5 Main com- mercial streets in the city	T6 The Historical City Center (CBD)
layout						
Street Pat- tern						
Land Use	Legend Article Marken Career Brahemal Career Brahemal Markin Careen Markin C					
Building	Type					

Table 4. Urban Transect Framework for Duhok City, (Author 2023)



Figure 9. Localized Urban Transect Matrix for Duhok City, (Author 2023)

Zones	Area	Land Use	Building Types	Thoroughfares	Open Spaces
T4-1	The original village area	*Mostly irregular plots. *Plot area (800-85 m ²) * Medium density residen- tial *Mainly residential. Mixed use and randomly distributed services.	*Row house buildings (2 sides attached) *The plot divided to three parts (Foreyard with gar- den, backyard, and the main building). *Building height ranged be- tween 1 and 2 stories (mostly 1 story).	*Irregular street pat- tern with some col-de- sac *Street width varied from 6-15 m without separation between car and pedestrian path. * Presence of unpaved roads	*Private garden *Public parks mostly non- designed or vacant lands.
T4-2	New developed area	*Regular uniformed plots. *Plot Area ranged between 400-150 m ² (uniform dis- tricts, for instance, 200 m ² district). * Medium density residen- tial *Mainly residential use and scattered services and mixed-use areas (randomly distributed).	*Row house (3 sides at- tached). *The plot divided to two parts (Foreyard, and the main building). *Building height ranged be- tween 1 and 3 stories (mostly 3 stories). * Some mixed residential- commercial use buildings with high more than 3 sto- ries	*Regular street pattern (grid system). *Street width varied from 10-20 m. * Auto oriented streets. *Paved streets	*Scattered public parks *Generally designed and imple- mented. * Limited play- grounds
T4-3	Housing complex	*Regular uniformed plots. * High density residential *Mainly residential use and designed service and mixed use.	*Apartments and villas *Medium and High-rise buildings (3- 12 stories)	 * Streets patterns depend on the project designer (no limitations). *Paved streets. * Walkways is presence in some well-designed areas. 	*Designed public parks * Plazas *Play- grounds
TS	Main commercial streets	*Generally regular plots *Plot Area (1200-150 m ²) *Mainly commercial, mixed use, (Commercial-Residen- tial), Hotels, schools, and health care.	*Medium and high rise (3 sides attached buildings). * The range of building heights varied from 3 to 8 stories, while certain main streets in the city included tower buildings with a max- imum height of 42 stories.	* Regular street pattern *Located on the main streets in the city and biggest, and busiest street within the neigh- borhood area that has width 12 m or more. *Auto Oriented streets *Paved streets	*Mostly not available *Street trees in some wide streets.
T6	Historical City Center	*Irregular plots *High density commercial, mixed use, hotels, general buildings, religious, and lim- ited residential. *Plot Area (1000-70 m ²)	*Low rise (1-2 stories) in the middle of the area and medium and high-rise buildings (3-8 stories) on the main streets. *3 sides attached buildings. *The plot is totally built-up	*Irregular street pat- tern with some col-de- sac. *Pedestrian oriented in the middle of the area. *Paved streets	*Plaza and Public Park in the cor- ner.

Table 5. The description of Urban Transect Framework for Duhok City (Author 2023)

CONCLUSIONS AND RECOMMENDATIONS

The adoption of the Urban Transect has been proposed as a potential solution to address the challenges associated with urban sprawl. It has been employed as a regulating tool to achieve sustainable development in urban design and planning worldwide. It serves as an organizing principle for the development of form-based and context-sensitive codes. These codes facilitate the creation of sustainable urban environments that aim to foster a diverse sense of place within these urban areas.

The current situation of urban design and planning in Duhok revealed a deficiency in the availability of a tailored toolkit that can serve as an effective framework for guiding the growth and development of urban areas. This phenomenon resulted in the utilization of homogeneous urban codes across various contexts in a uniform manner. The proposed Urban Transect aims to promote sustainable urban development by localizing heterogeneous design codes that effectively indicate different contexts and reinforce the sense of different urban places.

An analysis was performed to examine the urban form of both the entire city and the newly developed urban neighborhoods, known as "urbanized villages," in Duhok City. This analysis involved a comparison with the established main components of the Transect Theory. The findings of this comparison revealed both the present and absent zones within the transect matrix, in addition to suggesting a localized transect matrix for the local context. This localized Transect matrix could be used as a classification tool for various urban areas, followed by the provision of context-sensitive codes to protect the local context's identity and promote sustainable development.

This study, enriched by its depth of analysis and foresight, could potentially be utilized as a regulatory tool, offering valuable guidance for subsequent urban planning and design in Duhok City. Additionally, further studies are recommended to provide Urban Transect- Based Codes for the local context.

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