People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
Echahid Cheikh Larbi Tebessi University-Tebessa
Faculty of Science and Technology
Department of Architecture

Ref. mm/dd/yyyy

Thesis

Submitted for the attainment of the degree of

Doctorate in

Program: Architecture

***Specialization*: Architecture**

Topic:

Green Urban Design to Enhance Children's Urban Liveability: A Correlation of Urban Spatial Configuration and Outdoor Thermal Comfort in El Khroub

by:

Abir Labdani

Academic year: 2025/2026

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Publicly presented and defended on 10/14/2026, before the jury composed of:

First and last name	Position	University	Quality
Atef Ahriz	Professor	University of Tebessa	President
Soufiane Fezzai	Professor	University of Tebessa	Supervisor
Lazhar Gherzouli	Professor	University of Tebessa	Co-supervisor
Aissa Grib	Associate professor	University of Tebessa	Examiner
Islam Boukhelkhal	Associate professor	University of Constantine 3	Examiner
Med Elhadi Maatallah	Associate professor	University of Biskra	Examiner

Academic year: 2025/2026

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DEDICATION

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LIST OF ABBREVIATIONS

AADL: *Agence nationale de l'Amélioration et du Développement du Logement*

ACV: Actual Comfort Vote

APCI: Average Perceived Comfort Index

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASV: Actual Sensation Vote

AV: Air Velocity

CEN: *Comité Européen de Normalisation*

CFD: Computational Fluid Dynamics

COMFA: Comfort Formula

COMFA-TB: Comfort Formula–Thermal Balance

CUL: Children's Urban Liveability

EST: Ecological Systems Theory

GIS: Geographic Information System

GOCI: Global Outdoor Comfort Index

GPS: Global Positioning System

GUD: Green Urban Design

HH: Hillier & Hanson

HTP: House-Tree-Person

IMCL: International Making Cities Liveable Conference

ISO: International Organisation for Standardisation

IZA: Thermal Comfort Index for Cities of Arid Zones

LPP: *Logements Publics Promotionnels*

MD: Mean Depth

MEMI: Munich Energy Balance Model for Individuals

MOCI: Mediterranean Outdoor Comfort Index

OTC: Outdoor Thermal Comfort

PAV: Perceived Accessibility Vote

PAVo: Place Attraction Vote

PDAU: *Plan Directeur d'Aménagement et d'Urbanisme*

PET: Physiological Equivalent Temperature

PMV: Predicted Mean Vote

PPD: Predicted Percentage of Dissatisfied

PPS: The Project for Public Spaces

PSV: Perceived Safety Vote

PVFV: Place Visit Frequency Vote

PVV: Perceived Visibility Vote

QGIS: Quantum Geographic Information System

RH: Relative Humidity

RUROS: Rediscovering the Urban Realm and Open Spaces

S1–S4: Selected Spots 1 to 4

SET: Standard Effective Temperature

SPACES: Safety, Play, Access, Child Health, Equity, and Sustainability

Ta: Air Temperature

TC: Topological Choice

TCV: Thermal Comfort Vote

TGA: Difference between globe and air temperature

Tmrt: Mean Radiant Temperature

TOCI: Turkish Outdoor Comfort Index

TSV: Thermal Sensation Vote

UNICEF: United Nations Children's Fund

UN-Habitat: United Nations Human Settlements Programme

USC: Urban Spatial Configuration

UTCI: Universal Thermal Climate Index

VGA: Visual Graph Analysis

VI: Visual Integration

Abstract

Green Urban Design (GUD) is a sustainable planning approach that integrates ecological principles to minimise environmental impacts while promoting long-term urban sustainability and meeting essential urban needs. Two of the primary mechanisms through which GUD achieves this are Urban Spatial Configuration (USC) and Outdoor Thermal Comfort (OTC), which jointly condition how, when, and whether children inhabit urban spaces. Within this framework, USC and OTC are the core focus of this dissertation, as both play pivotal roles in shaping Children's Urban Liveability (CUL), with direct implications for their well-being. In the present study, USC is examined through the analysis of spatial configuration, understood as the structural organisation of outdoor places. Internationally, OTC and spatial configuration are often examined as separate research domains, and studies that integrate both perspectives remain limited. Spatial configuration research typically focuses on movement patterns, accessibility, and spatial connectivity, whereas OTC studies primarily address microclimatic conditions and thermal mitigation strategies. Consequently, limited attention has been given to how the spatial configuration of outdoor places interacts with microclimatic conditions to influence CUL. This gap is particularly pronounced in semi-arid urban contexts such as El Khroub, Algeria, where empirical evidence on how these factors collectively influence CUL remains scarce. As a result, urban planners and designers lack clear evidence regarding which environmental factors most strongly shape children's use and spatial behaviour in outdoor places, limiting the development of child-friendly cities. Conceptually, spatial configuration represents a relatively stable structural property of outdoor places, whereas OTC varies dynamically across space and time in response to climatic conditions. This interaction suggests that children's patterns of space use may fluctuate throughout the day as thermal conditions change. Highly accessible areas may become underused during periods of thermal discomfort, while thermally favourable but less connected areas may attract higher levels of children's activity. In response to this research gap, this study investigates how OTC and spatial configuration jointly shape CUL in three outdoor places in El Khroub, the Square, Snoberland, and Martyr Plaza, during typical summer and winter weeks. A hybrid methodological design was adopted to combine measurable environmental data with children's lived experience. The quantitative strand included in-situ measurements of thermal parameters, UTCI-based comfort modelling through a Rhinoceros workflow, and Space Syntax analysis using DepthmapX to assess Topological Choice (TC) and Visual Integration (VI). Behavioural mapping was conducted in parallel to document children's spatial use and activity patterns across the three sites. The qualitative strand included questionnaires with children and caregivers to capture thermal perceptions and spatial experiences, together with participatory drawing exercises through which children expressed their preferred improvements for each outdoor place. In the final analytical stage, the OTC parameters are correlated with spatial configuration indices to assess their respective contributions to CUL. The findings show that, although both thermal conditions and spatial structure influence children's outdoor use, OTC has a stronger short-term effect. This highlights the need for child-responsive and climate-sensitive public space design that integrates OTC with spatial configuration to support CUL.

Keywords: Children, Outdoor thermal comfort, Spatial configuration, Urban liveability, Green urban design, Space Syntax, UTCI, El Khroub.

ملخص

يُعدّ التصميم الحضري الأخضر مقاربة تخطيطية مستدامة تدمج المبادئ البيئية من أجل تقليل التأثيرات البيئية، مع تعزيز الاستدامة الحضرية طويلة المدى وتلبية الاحتياجات الحضرية الأساسية. ومن بين الآليات الرئيسية التي يحقق من خلالها التصميم الحضري الأخضر هذه الأهداف كلٌّ من التكوين الفضائي الحضري والراحة الحرارية الخارجية، إذ يسهمان معاً في تحديد كيف، ومتى، وما إذا كان الأطفال يشغلون الفضاءات الحضرية. ضمن هذا الإطار، يشكّل التكوين الفضائي الحضري والراحة الحرارية الخارجية المحور الأساسي لهذه الأطروحة، نظراً لدورهما المحوري في تشكيل قابلية العيش الحضرية للأطفال.
في هذه الدراسة، يتم تناول التكوين الفضائي الحضري من خلال تحليل التكوين الفضائي، بوصفه التنظيم البنيوي للأماكن الخارجية. وعلى المستوى الدولي، غالباً ما تتم دراستهم كمجالين بحثيين منفصلين. عادةً ما تركّز أبحاث التكوين الفضائي على أنماط الحركة، وإمكانية الوصول، والترابط الفضائي، بينما تركز دراسات الراحة الحرارية الخارجية أساساً على الظروف المناخية الدقيقة واستراتيجيات التخفيف الحراري. ونتيجة لذلك، لم يُمنح اهتمام كافٍ لكيفية تفاعل التكوين الفضائي للأماكن الخارجية مع الظروف المناخية الدقيقة في التأثير على قابلية العيش الحضرية للأطفال. تتضح هذه الفجوة بشكل خاص في السياقات الحضرية شبه الجافة، مثل مدينة الخروب، حيث لا تزال الأدلة التجريبية حول كيفية تأثير هذه العوامل مجتمعة على قابلية العيش الحضرية للأطفال محدودة. ونتيجة لذلك، يفتقر المصممون الحضريون إلى أدلة واضحة حول العوامل البيئية الأكثر تأثيراً في استخدام الأطفال للأماكن الخارجية. مفاهيمياً، يمثل التكوين الفضائي خاصية بنيوية مستقرة نسبياً للأماكن الخارجية، في حين تتغير الراحة الحرارية الخارجية ديناميكياً عبر المكان والزمن تبعاً للظروف المناخية. استجابةً لهذه الفجوة البحثية، تبحث هذه الدراسة في كيفية تشكيل الراحة الحرارية الخارجية والتكوين الفضائي معاً لقابلية العيش الحضرية للأطفال في ثلاثة أماكن خارجية بمدينة الخروب، وهي: السكوار، حديقة سنوبرلاند، وساحة الشهداء، وذلك خلال أسابيع نموذجية في فصلي الصيف والشتاء. وقد تم اعتماد تصميم منهجي هجين يجمع بين البيانات البيئية القابلة للقياس وتجربة الأطفال المعيشة. شمل الجانب الكمي قياسات ميدانية مباشرة للمعايير الحرارية، ونمذجة مناطق الراحة المستندة إلى مؤشر المناخ الحراري العالمي UTCI من خلال سير عمل باستخدام Rhinoceros، وتحليل النحو الفضائي باستخدام DepthmapX لتقييم مؤشرين نحويين هما الاختيار الطوبولوجي والتكامل البصري. كما تم إجراء الخرائط السلوكية بالتوازي لتوثيق استخدام الأطفال للفضاء عبر المواقع الثلاثة. أما الجانب النوعي، فقد شمل استبيانات مع الأطفال ومرافقيهم من أجل رصد التصورات الحرارية والتجارب الفضائية، إلى جانب تمارين الرسم التي عبّر من خلالها الأطفال عن التحسينات التي يفضلونها. وفي المرحلة التحليلية النهائية، تم ربط معايير الراحة الحرارية الخارجية بمؤشرات التكوين الفضائي من أجل تقييم مساهمتها النسبية في قابلية العيش الحضرية للأطفال. وتُظهر النتائج أنه على الرغم من أن كلاً من الظروف الحرارية والبنية الفضائية يؤثران في استخدام الأطفال للأماكن الخارجية، فإن الراحة الحرارية الخارجية تمتلك تأثيراً أقوى على المدى القصير. ويبرز ذلك الحاجة إلى تصميم فضاءات عامة مستجيبة للأطفال وحساسة للمناخ، تدمج الراحة الحرارية الخارجية مع التكوين الفضائي من أجل دعم قابلية العيش الحضرية للأطفال.

الكلمات المفتاحية: الأطفال، الراحة الحرارية الخارجية، التكوين الفضائي، قابلية العيش الحضرية، التصميم الحضري الأخضر، النحو الفضائي، مؤشر UTCI، الخروب.

Résumé

La conception urbaine verte constitue une approche de planification durable qui intègre des principes écologiques afin de réduire les impacts environnementaux, de renforcer la durabilité urbaine et de répondre aux besoins essentiels de la ville. Dans cette perspective, la configuration spatiale urbaine et le confort thermique extérieur représentent deux mécanismes majeurs qui influencent la manière dont les enfants utilisent, perçoivent et occupent les espaces urbains extérieurs. Cette thèse examine ainsi leur rôle conjoint dans la formation de la vivabilité urbaine des enfants, en lien direct avec leur bien-être. À l'échelle internationale, le confort thermique extérieur et la configuration spatiale sont souvent étudiés séparément. Les recherches sur la configuration spatiale portent principalement sur les schémas de mouvement, l'accessibilité et la connectivité, tandis que les études sur le confort thermique extérieur s'intéressent surtout aux conditions microclimatiques et aux stratégies d'atténuation thermique. Cette séparation limite la compréhension de la manière dont la structure spatiale des espaces extérieurs interagit avec les conditions thermiques pour influencer l'usage des lieux par les enfants. Cette lacune est particulièrement importante dans les contextes urbains semi-arides, tels qu'El Khroub, en Algérie, où les données empiriques sur cette interaction restent limitées. Conceptuellement, la configuration spatiale constitue une propriété relativement stable des espaces extérieurs, tandis que le confort thermique varie dans l'espace et dans le temps selon les conditions climatiques. Ainsi, des espaces accessibles et bien connectés peuvent être sous-utilisés durant les périodes d'inconfort thermique, alors que des zones thermiquement favorables peuvent attirer davantage d'activités enfantines, même lorsqu'elles sont moins connectées. Cette recherche interroge donc la manière dont ces deux dimensions contribuent ensemble à la vivabilité urbaine des enfants. L'étude porte sur trois espaces extérieurs situés à El Khroub : le Square, Snoberland et la Place des Martyrs, observés durant des semaines représentatives de l'été et de l'hiver. Un dispositif méthodologique hybride a été adopté afin de combiner des données environnementales mesurables avec l'expérience vécue des enfants. Le volet quantitatif comprend des mesures in situ des paramètres thermiques, une modélisation des zones de confort fondée sur l'indice universel du climat thermique à l'aide de Rhinoceros, ainsi qu'une analyse par syntaxe spatiale avec DepthmapX, à travers le choix topologique et l'intégration visuelle. Une cartographie comportementale a également été réalisée afin de documenter l'usage spatial et les activités des enfants dans les trois sites. Le volet qualitatif repose sur des questionnaires adressés aux enfants et à leurs accompagnateurs, ainsi que sur des exercices de dessin participatif permettant aux enfants d'exprimer leurs préférences et les améliorations souhaitées. Dans la dernière étape analytique, les paramètres du confort thermique extérieur sont corrélés aux indices de configuration spatiale afin d'évaluer leurs contributions respectives à la vivabilité urbaine des enfants. Les résultats montrent que les conditions thermiques et la structure spatiale influencent toutes deux l'usage des espaces extérieurs par les enfants. Toutefois, le confort thermique extérieur exerce un effet à court terme plus important sur leur présence et leurs activités. Ces résultats soulignent la nécessité de concevoir des espaces publics à la fois adaptés aux enfants et sensibles au climat, en intégrant le confort thermique extérieur à la configuration spatiale pour mieux soutenir la vivabilité urbaine des enfants.

Mots-clés: Enfants, Confort thermique extérieur, Configuration spatiale, Vivabilité urbaine, Conception urbaine verte, Syntaxe Spatiale, UTCI, El Khroub.

GENERAL INTRODUCTION

Introduction

Green Urban Design (GUD) is defined as a conceptual model for zero-emission and zero-waste urban design (Hannon & Zaman, 2018; Lehmann, 2010). It promotes compact, energy-efficient urban development and seeks to transform and regenerate existing city districts, particularly post-industrial city centres, into socially and environmentally sustainable areas (Galdini, 2019). The approach emphasises the integration of nature into urban spaces, creating a balance between urban development and natural ecosystems (Breuste, 2023). According to Beatley, the primary goals of GUD are to construct cities that operate within their ecological boundaries, reduce their carbon footprint, and foster symbiotic relationships between urban areas and the surrounding natural environment (Beatley, 2012). Furthermore, this idea aligns with the notion of "eco-cities," which place a premium on energy-efficient infrastructure, green transit systems, and compact urban expansion (Hemmersam, 2010). New urban approaches, including green cities, transport-oriented development, New Urbanism, and urban liveability, offer important potential for creating more child-sensitive environments. Urban liveability is at the heart of GUD, shaping cities into places where people, not just buildings, thrive. In this thesis, GUD is understood as the broader conceptual and design framework through which Children's Urban Liveability (CUL) can be enhanced. Although GUD includes multiple environmental, climatic, spatial, social, cultural, ecological, functional, and governance-related dimensions (Carmona, 2009; Lehmann, 2010), this research focuses specifically on two dimensions that are directly connected to CUL and can be empirically assessed: Outdoor Thermal Comfort (OTC) and urban spatial configuration (USC). OTC represents the climatic and environmental dimension of GUD and helps explain when children can comfortably use outdoor places (Y. Li et al., 2024). USC is examined through spatial configuration, understood as the structural organisation of urban space in terms of accessibility, visibility, connectivity, and movement potential (Alsabbagh, 2024). It represents the spatial and morphological dimension of GUD and helps explain where children are likely to move, stay, or concentrate (Chakraborty, 2026). Together, these two dimensions help clarify how GUD can support CUL by creating outdoor places that are both thermally comfortable and spatially accessible. This dual focus requires attention to both the morphological and climatic dimensions of outdoor space. From a morphological perspective, this study focuses on the immediate environment surrounding individuals in outdoor places. Atmospheric qualities in specific locations are thereby defined through a discretisation of space with limits that are more or less artificial, often determined according to

morphological rules. Within Space Syntax theory, convex spaces and axial lines are defined at this scale based on intervisibility rules (Bill & Julienne, 1984). These spatial units are characterised by visual continuity and can consequently be understood instantaneously by individuals. This classification of space into discrete units serves as the foundation for implementing atmospheric measures, as the micro-scale level renders urban spaces intelligible through their discretisation and qualification. At this level, atmospheric qualities combine objective and subjective dimensions, understood as a perceptual totality encompassing objective elements and represented as environment, climate, and physical and human milieu (Augoyard, 1979), enabling an examination of the relationships between spatial design (constructed forms, measured material objects) and the sensory experiences of individuals (perceptions, representations, uses). In this context, OTC is a fundamental dimension of GUD, directly contributing to enhancing urban liveability (L. Chen & Ng, 2012). Its assessment requires a detailed understanding of microclimatic characteristics, including air temperature (Ta), relative humidity (RH), air velocity (AV), and mean radiant temperature (Tmrt) (Santucci, 2021). Climate has long been considered one of the major elements in the dynamics and atmosphere of urban space, as it conditions sensory factors such as sunlight, illumination, and wind direction, all of which are further shaped by the morphology of the surrounding space (Y. Li et al., 2025a). Creating outdoor environments that ensure thermal and perceptual comfort for city dwellers, therefore, stands as a fundamental challenge of sustainable urban development, one that depends largely on the capacity of urban planners to deliver outdoor spaces of high environmental quality. The quality of such spaces holds major significance, recognised as a direct contributor to the quality of life in urban settings, while conversely, its absence can reinforce isolation and social exclusion. The spatial configuration of the urban environment can influence the frequency of space use and the way in which people interact with the built environment (Askarizad, Lamíquiz Daudén, & Garau, 2024). By analysing urban morphology, it becomes possible to understand how patterns of use are shaped not only by spatial structure but also by climatic conditions (Benziada et al., 2025). These dynamics are particularly significant for children, who are among the most sensitive users of urban spaces. For them, a well-designed outdoor environment extends beyond the provision of green spaces, encompassing safe, comfortable, and engaging places that support play, exploration, and development. These configurational properties are especially important for CUL, since the spatial distribution of play areas, the visibility of others, and the ease of movement may directly influence children's use, preferences, and sense of comfort. Meanwhile, OTC refers to the state of mind that expresses satisfaction with the thermal environment. Because it affects children's

propensity to play, stay, and relax outdoors, it constitutes an important dimension of urban planning and design, especially in outdoor places intended for children's activities (Gu et al., 2022; Pardeep Kumar & Amit Sharma, 2020). This thesis distinguishes between *dynamic spatiotemporal factors* and *static spatial factors*. OTC parameters are treated as dynamic spatiotemporal factors because they vary across both *time and space*, influencing when and where children use outdoor spaces and which micro-locations become thermally favourable or unfavourable. By contrast, spatial configuration indices are treated as static spatial factors because they describe the relatively stable structural organisation of each site, including accessibility, visibility, connectivity, and movement potential, and therefore help explain where children are more likely to move, stay, or concentrate. Within this framework, OTC is approached as a key limiting factor in both summer and winter, shaping how spatial configuration influences CUL. GUD is not treated as a directly measured variable; rather, it functions as the overarching conceptual, planning, and design framework through which the two operational dimensions of this study, OTC and spatial configuration, are empirically examined and their implications for child-responsive and climate-sensitive urban design are interpreted.

Although numerous studies examine OTC and others analyse spatial configuration independently, no integrated analytical framework has yet been developed to evaluate their combined impact on CUL in semi-arid urban contexts. This thesis addresses that gap by developing an integrated approach that examines the interplay between spatial configuration and OTC, with the aim of informing the design of outdoor places that are thermally comfortable, spatially accessible, and genuinely supportive of children's needs.

Problem Statement

The accelerating pace of urbanisation, together with the intensifying effects of climate change, is reshaping the conditions under which children experience urban life. More than one billion children currently live in urban environments, and nearly 70% of the world's population is expected to reside in cities by 2050; yet urban planning frameworks still tend to treat children as secondary rather than central users of public space (Herbst, 2024). Rising temperatures, heat-retaining impervious surfaces, declining green areas, pollution, traffic risk, and overcrowding are progressively reducing children's access to safe, comfortable, and developmentally supportive outdoor environments (Turay, 2025; WHO, 2026). This trajectory is rendered all the more alarming by evidence that children's outdoor engagement has declined substantially in

recent decades, with Scott, Gray et al. (2022) reporting a marked reduction in time spent playing outdoors compared with previous generations (Scott, Gray, Charlton, & Millard, 2022). In urban contexts, this decline may be reinforced by deteriorating environmental conditions, traffic risk, safety concerns, and reduced access to suitable outdoor places. In Algerian residential neighbourhoods specifically, over 92% of children who do play outdoors do so exclusively in the evening, actively avoiding daytime hours due to unfavourable climatic conditions (Chibane & Hamouda, 2024). This is particularly critical because outdoor places are not merely recreational settings: they are fundamental to children's physical activity, social interaction, cognitive development, autonomy, and everyday well-being. Despite this importance, contemporary urban design practices continue to prioritise circulation efficiency, aesthetic coherence, and adult-oriented functionality, while the spatial, sensory, and climatic needs of children remain insufficiently addressed (Katsavounidou & Sousa, 2024a). As a result, many urban outdoor spaces fail to provide the safety, accessibility, and climatic comfort required for children's everyday use, contributing to socio-spatial exclusion and limiting opportunities for play, exploration, and social learning. In Algerian cities, this problem is particularly acute. Outdoor spaces in collective housing neighbourhoods are often marked by overcrowding, monotony, insecurity, and neglect, while child-oriented gardens and playgrounds have progressively disappeared from many urban plans (Hafnaoui, 2022). At the same time, child-responsive planning has not yet been systematically integrated into local urban policy, leaving planners without a clear operational framework for designing public spaces that are both climatically responsive and child-sensitive. This practical problem is reinforced by a disciplinary divide in urban research. On the one hand, OTC studies have expanded substantially in response to urban warming and climate change, focusing on environmental variables and mitigation strategies such as vegetation, surface materials, shading, albedo, and street-canyon geometry (Aghamolaei, Azizi, Aminzadeh, & O'Donnell, 2023; Y. Li et al., 2025b). However, this literature often pays limited attention to how the structural organisation of space itself conditions thermal exposure, movement patterns, and the actual usability of outdoor environments. On the other hand, spatial configuration research, particularly Space Syntax, provides tools for analysing accessibility, visibility, connectivity, and movement potential (Hillier et al., 1996). Yet these approaches generally focus on the social and functional logic of movement, while insufficiently integrating dynamic climatic variables such as thermal sensation, solar exposure, wind conditions, and seasonal variation, all of which can strongly affect whether an accessible space is actually used (Chiu, Wang, & Lin, 2023).

The central gap, therefore, lies not simply in the absence of combined studies, but in the limited conceptual integration between two fundamentally different types of urban parameters. Spatial configuration is a relatively *stable spatial property* embedded in the morphology of the built environment, whereas OTC is a *dynamic spatiotemporal* condition that varies across hours, seasons, shaded and exposed areas, and local microclimatic situations. This asymmetry is especially important for CUL. A highly accessible or visually integrated place may remain underused during periods of thermal discomfort, while a thermally favourable but less connected area may attract children when it provides shade, comfort, or protection from climatic stress (H. Luyao, L. Ling, L. Xinkai, & D. Junfeng, 2025). While some studies have examined the influence of OTC on CUL (Elnabawi Mahgoub et al., 2026), and others have assessed spatial configuration as a determinant of children's outdoor appropriation (Chibane & Hamouda, 2022; Guedouh, Khadraoui, & Seraoui, 2024), none has developed an integrated framework that treats OTC and spatial configuration as simultaneous and interacting co-determinants of children's outdoor behaviour. Existing research has therefore not sufficiently explained how static spatial and dynamic thermal conditions jointly shape children's occupation of outdoor spaces, particularly in semi-arid urban contexts. In Algeria, and specifically in semi-arid cities such as El Khroub, this gap has both scientific and practical significance. Existing local studies have generally examined thermal comfort, urban morphology, public-space quality, or spatial configuration separately, while empirical research integrating OTC and spatial configuration as co-determinants of children's use of outdoor spaces remains scarce. Consequently, urban designers and planners lack evidence as to whether CUL is primarily shaped by spatial configuration, by OTC, or by their interaction. This thesis addresses this gap by developing an integrated analytical framework that simultaneously evaluates OTC parameters and spatial configuration indices to examine their combined impact on CUL in three outdoor places in El Khroub. By doing so, it seeks to establish a stronger empirical basis for climate-responsive, child-sensitive GUD strategies in semi-arid Algerian cities.

Epistemological Positioning

This research is rooted in an interdisciplinary epistemological framework to explore the relationship between urban liveability, OTC, and spatial configuration (Figure 0.1).

On one hand, the concept of *Urban liveability* did not emerge until after the 1960s; it is often equated with the quality of life and well-being of urban residents, involving the interplay between people, the environment, and the built environment (Alijani, Pourahmad, Nejad, Ziari,

& Sodoudi, 2020; Saeed, Ahmad, Mohey-ud-din, Butt, & Ashraf, 2022). It has deep roots in various disciplines, including public health, urban geography, psychology, and behavioural sciences. Its origins trace back to 19th-century industrialisation, when poor living conditions among British labourers prompted urban reforms aimed at improving health and sanitation. Public health movements, such as the Sanitary Movement, led to legislative changes, including the Public Health Act (1875), which sought to create healthier urban environments (Yorulmaz, 2013). Urban geography expanded the concept through its analysis of space organisation as well as urban accessibility and city-based activity integration. Two influential planning models, Haussmann's renovation of Paris and the Garden City Movement, presented approaches to structured development based on green areas, social cohesion, and mixed land use. Psychology and behavioural sciences later contributed to the discourse by highlighting the human experience within urban spaces. Scholars like Kevin Lynch and Jane Jacobs argued that social interactions, safety, and a sense of place are crucial to liveability. Jacobs, in *The Death and Life of Great American Cities*, criticised rigid urban planning, advocating for diversity, mixed-use developments, and vibrant public spaces. Similarly, Lynch proposed five key criteria for successful urban places: vitality, identity, adaptability, accessibility, and control (Yorulmaz, 2013).

On the other hand, urban design specialists have recently begun to employ the concept of USC, particularly with the growth of theories of Space Syntax (Fezzai, 2018; Fezzai, Doulos, & Mesloub, 2025; Hillier & Hanson, 1989). Spatial configuration significantly affects the quality and identity of outdoor places. While USC is a key factor in assessing spatial quality, it must be considered alongside other physical, social, economic, and cultural components to understand its impact fully (Gümüş & Erdönmez, 2021). Space Syntax functions as an analysis method for spatial configurations to understand urban system operations through studying movement patterns and human activities and behaviours (Karimi, 2018; van Nes, 2021).

USC is directly connected to psychology through Kevin Lynch's theories of wayfinding. Kevin Lynch, a pioneer in urban planning, emphasised the importance of spatial cognition in understanding how people interact with urban environments through elements such as paths, nodes, and landmarks, shaping their interactions and experiences (Lynch, 2013). Additionally, the works of Jan Gehl (2011) show how behavioural psychology studies the impact of built environments on social behaviour and psychological well-being by creating outdoor places that encourage users to gather, interact, and engage with their surroundings (Veeroja et al., 2024).

Jean Piaget investigated the reciprocal connection between children and the physical environment within the field of developmental psychology. He argues that children's cognitive development shapes their behaviour through their early perceptions and interactions with the external world. Eventually, as they mature via continuous events, they form structured behavioural patterns that are reliant on specific schemata. He indicates that these structured behavioural patterns even help youngsters integrate with the constantly changing world around them and, depending on their age, gradually influence their thought processes more deeply (Çanakçıoğlu, 2015; Piaget, 2013b).

From an urban geography perspective, USC is based on spatial analysis and urban morphology, relying on Hillier and Hanson's theories, "Space Syntax", which is an approach for measuring and evaluating the connections between buildings and urban spaces. Since pedestrian movement is strongly correlated with spatial configuration, the Space Syntax theory can effectively analyse and forecast pedestrian movement density. Sociology reinforces USC by emphasising the social dimensions of space. Henri Lefebvre's work, particularly in "*The Production of Space*" (1991), argues that human interaction and social positions, along with power dynamics, actively create space into a formulation that extends beyond a physical entity. Space reflects both existing societal structures and established economic and political systems (Lefebvre, 2012).

When it comes to OTC, it is an interdisciplinary concept that emerges from the intersection of meteorology and climatology, human physiology, and geography/urbanism, reflecting its epistemological foundation in climate-sensitive urban planning and human-environment interactions. It describes "*the psychological state that expresses satisfaction with the thermal environment through a subjective assessment*." From a meteorology and climatology perspective, scholars such as Timothy Oke (1987) and Richard de Dear and Gail Brager (1998) contributed to understanding how urban climate influences OTC, notably by the urban heat island effect, where urban areas experience higher temperatures than surrounding rural areas due to factors like pavement, buildings, and human activities (Oke, 1995). In human physiology, OTC is based on the study of thermoregulation and physiological adaptation. The research by Peter Höppe (1999) on the Physiological Equivalent Temperature (PET) and by Povl Ole Fanger (1970) on the Predicted Mean Vote (PMV) presents significant findings about environmental stressors, which influence both human thermal perception and well-being. Vulnerable groups such as children and elderly adults experience higher death rates and unpleasant health conditions when facing extreme outdoor temperatures. Multiple factors

affecting their physiology, along with their social environment and outside circumstances make these groups most vulnerable to temperature effects. From a geographical and urbanism standpoint, spatial planning, and urban morphology influence OTC. Green infrastructure, shading solutions, and ventilation corridors play essential roles to create comfortable outdoor environments according to research findings and studies from this field.

This thesis is positioned at the intersection of urban liveability, OTC, and USC. Rather than treating CUL as a general quality-of-life issue, it is approached as a situated condition produced through the interaction between spatial configuration and OTC. Spatial configuration defines the potential for visibility, movement, accessibility, and social encounter, while OTC determines whether such spatial potential can actually be used under specific seasonal and hourly conditions.

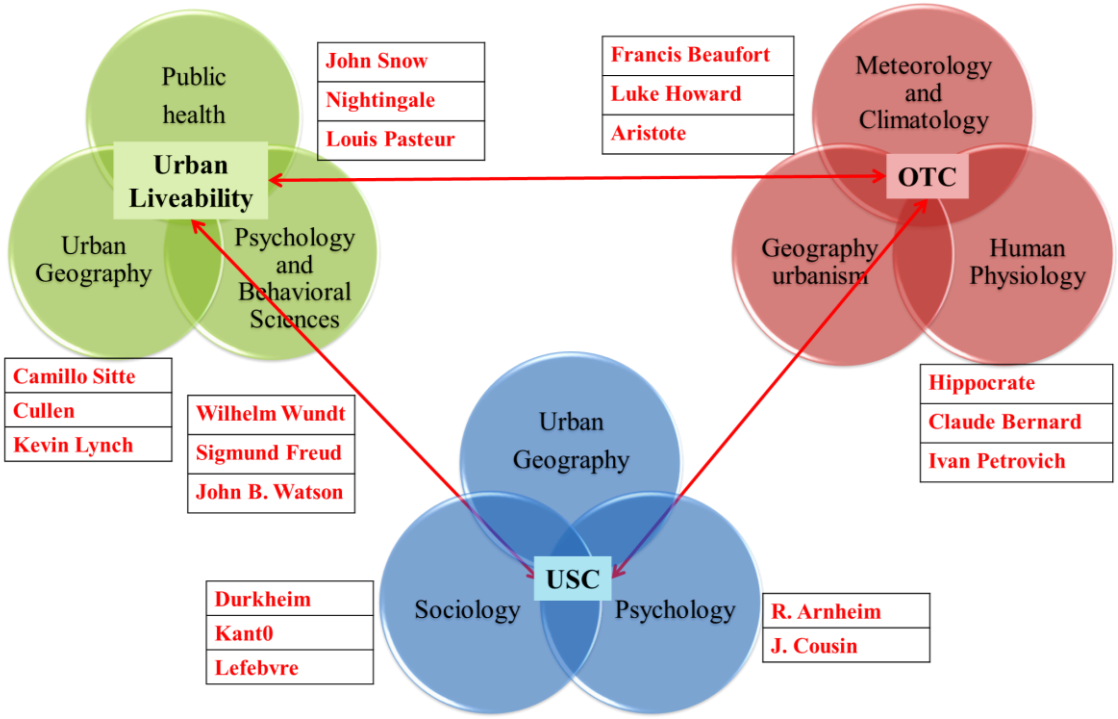


Figure 0. 1: *The Epistemological Foundations of Urban Liveability, USC, and OTC. Source: Author, 2024.*

Research Questions

The main research question of this thesis is:

- *How do outdoor thermal comfort and spatial configuration interact to influence children's occupation of outdoor spaces in a semi-arid context, and what Green Urban Design strategies can be drawn from this interaction to improve children's urban liveability?*

To address this central question, the thesis is guided by the following secondary questions:

- How do spatial configuration indices, particularly VI and TC, and OTC parameters, particularly UTCI and Ta, jointly shape CUL in El Khroub?
- How does OTC, as a dynamic spatiotemporal factor, condition the influence of static spatial configuration on CUL in both summer and winter?
- What GUD principles can be proposed to create thermally comfortable and spatially accessible outdoor places that support CUL in semi-arid contexts?

Hypotheses

The enhancement of CUL in semi-arid environments depends on children's ability to comfortably use outdoor spaces. Given children's physiological vulnerability to thermal stress and the seasonal variability of outdoor conditions, microclimatic conditions are expected to play a major role in shaping how children occupy the physical urban environment. This thesis distinguishes between spatio-temporal factors, related to *when* and *where* children use outdoor spaces, and spatial factors, related to *where* they concentrate within them. Accordingly, OTC parameters are treated as dynamic spatiotemporal parameters, represented by UTCI and Ta, whereas spatial configuration indices are treated as relatively static spatial parameters, represented by VI and TC. Within this framework, OTC is hypothesised to operate as the primary limiting factor in both summer and winter, shaping the extent to which spatial configuration influences CUL. On this basis, the hypotheses are formulated as follows:

- Children's occupation density and duration of stay decrease as UTCI values deviate from the thermally acceptable range in both summer and winter, indicating that outdoor thermal discomfort is associated with reduced use of outdoor space.
- Higher VI and TC are associated with greater behavioural clustering and movement density primarily under thermally acceptable UTCI conditions, indicating that static spatial parameters influence CUL when dynamic spatiotemporal parameters are thermally favourable.

Objective

The objective of this dissertation is to investigate how OTC parameters and spatial configuration indices jointly shape CUL in the three selected outdoor places of El Khroub, within a semi-arid context, in both summer and winter. More specifically, the study seeks to

determine the relative influence of dynamic spatiotemporal OTC parameters, and relatively stable spatial configuration parameters, on children's spatial occupation, movement patterns, and duration of stay. Using a hybrid methodology, this research aims to identify the thermal thresholds and spatial parameters that shape children's engagement with outdoor environments, and to develop an integrated OTC and spatial configuration framework to inform climate-responsive and child-sensitive GUD strategies in the semi-arid Algerian context.

Methodology

To address the research objectives, this study adopts a mixed-methods framework underpinned by a critical review of the literature. This initial phase synthesises the principal theoretical paradigms of GUD, spatial configuration, OTC, and CUL. Methodologically, GUD serves as the overarching interpretive and design framework of the thesis, whereas OTC and spatial configuration constitute the two operational analytical dimensions examined through empirical measurement, observation, simulation, and comparative analysis. Building upon this foundation, an empirical multi-case investigation was conducted across three distinct outdoor spaces in El Khroub, the Square, Martyr Plaza, and Snoberland, to enable a systematic cross-case comparison. Data collection was conducted on two selected investigation days in each outdoor place, within a typical summer week and a typical winter week, at one-hour intervals, in order to capture both diurnal and seasonal variations. The fieldwork protocol employed a triangulation of quantitative and qualitative techniques, including systematic behavioural mapping, questionnaire surveys with children and caregivers, and child-centred participatory drawing exercises. The questionnaires captured thermal perception, perceived safety, visibility, accessibility, attraction, and frequency of use, while behavioural mapping recorded children's presence, movement, activity type, and duration of stay. Concurrently, microclimatic monitoring was undertaken in each of the three outdoor places using a Lutron LM-8000 multifunction meter at a height of 1.2 m. This height corresponds to the approximate stature of the target population, children aged 6–12 years, with an average age of 9 years. Measurements were collected at four selected spots per site in order to capture localised spatial variations in thermal conditions. The recorded meteorological parameters, Ta, RH, and AV, established the empirical baseline for comparative thermal assessment. These measured data were then used as primary inputs in a Rhinoceros 3D/Grasshopper-based environmental modelling workflow, supported by Ladybug tools, to estimate UTCI as the principal thermal comfort indicator. In parallel, spatial configuration was analysed using DepthmapX. Visual Graph Analysis (VGA) was used to calculate VI, reflecting visual accessibility, while axial analysis was used to

calculate TC, reflecting through-movement potential. The resulting spatial configuration indices were compared with behavioural mapping outputs in order to examine whether children's spatial occupation corresponded to areas of higher visibility, accessibility and movement potential. Building directly upon the empirical data collected across the three sites, the analytical phase employs a statistical overlay approach alongside a comparative evaluation to elucidate the spatiotemporal interaction between spatial configuration, microclimatic conditions, and children's behaviour. The relationships between the average child presence per location and the corresponding spatial-thermal variables (UTCI, Ta, VI, and TC) were statistically explored using Pearson's correlation and linear regression models. Significantly, by systematically contrasting the three case studies, the research identifies whether distinct differences in spatial morphology and local microclimates produce divergent behavioural responses and comfort levels among children. This cross-case comparison evaluates how OTC and spatial configuration collectively influence CUL, ultimately generating evidence-based design strategies for climatically responsive and child-friendly cities.

Thesis structure

The thesis is structured into two distinct parts, while Figure 0.2 further subdivides the empirical component into two successive phases for clarity. The first part establishes the conceptual and theoretical foundations of the research, systematically examining the key paradigms underpinning GUD, OTC, spatial configuration, and CUL. The second part constitutes the empirical component of the thesis. It first presents the investigation framework, including the study area, case-study selection, fieldwork design, data collection procedures, and analytical tools. It then presents and discusses the results across the three outdoor sites in El Khroub, first in relation to OTC and then in relation to spatial configuration and its interaction with thermal conditions. The first part consists of four chapters:

- **Chapter I: Children's Urban Liveability: The Role of Green Urban Design**
  This chapter introduces GUD and its key principles, with a particular focus on OTC and spatial configuration, and outlines the planning conditions for GUD in Algeria. It further examines key concepts and theories related to outdoor places, exploring how safe and child-sensitive cities can be designed to respond to children's needs. Urban liveability is defined in the context of children, highlighting its connection to the built environment through a discussion of its criteria and dimensions.
- **Chapter II: Children's Comfort in Outdoor Environments**

This chapter explores the concept of OTC as it pertains to children, addressing key aspects such as thermal sensation, neutral temperature, and the parameters and indices used for its assessment. It further examines the relationship between OTC and CUL, demonstrating how the mitigation of heat and cold stress can enhance children's well-being in outdoor places.

- **Chapter III: Spatial Configuration and Children's Urban Liveability**

  This chapter defines the concept of spatial configuration and examines its significance for children's comfort and outdoor experience. The Space Syntax approach is introduced as the principal method for measuring spatial configuration, including its representational maps and key analytical tools. The chapter concludes by examining the relationship between spatial configuration and CUL, demonstrating how configurational parameters influence children's quality of life in urban outdoor spaces.

- **Chapter IV: Previous studies and methodology**

  This chapter reviews previous studies in related fields, comparing different approaches to assessing OTC and spatial configuration as co-determinants of CUL. It synthesises the principal ideas developed across the preceding chapters in order to consolidate the theoretical foundation of the research and justify the methodological framework adopted. Through the discussion of relevant empirical findings, the chapter establishes the conceptual and methodological basis for the empirical investigation.

The second part begins with the empirical investigation and methodological application:

- **Chapter V: Investigation**

  This chapter introduces the geographical location of El Khroub within the Constantine region, provides a climatic overview, and examines its urban outdoor spaces. The three selected case studies, the Square, Snoberland, and Martyr Plaza, are presented and contextualised. The objective is to establish the contextual foundation for the research by analysing the physical, climatic, and spatial characteristics of El Khroub, thereby justifying the selection of the case studies and providing a comprehensive understanding of the study area.

- **Chapter VI: Application of Analysis Methods and Tools**

This chapter presents the analytical methods and data collection tools employed in the research. Both quantitative and qualitative approaches are introduced, and the research population and investigation periods are defined alongside the criteria for site selection. The questionnaire surveys conducted with children and caregivers are detailed, covering thermal perception, perceived safety, visibility, accessibility, attraction, and frequency of use. The data collection techniques and analytical procedures are presented systematically, providing a structured methodological framework and a solid foundation for the interpretation of results in subsequent chapters.

The second phase of the empirical component presents the results and discussion:

- **Chapter VII: Results and Discussion: Outdoor Thermal Comfort and Children's Urban Liveability**

  This chapter presents and discusses the findings related to OTC and its influence on CUL across the three study sites. It opens with a descriptive reading of the sites through their child-centred qualities, behavioural observations, microclimatic conditions, and questionnaire results. Children's temporal patterns of presence and activity are then examined in relation to seasonal and hourly thermal variation, before measured and perceived thermal conditions are compared across the three sites. The chapter thus explains when, and under what thermal conditions, children occupy the spaces under study.
- **Chapter VIII: Results and Discussion: Spatial Configuration and Children's Urban Liveability**

  This chapter presents and discusses the findings related to spatial configuration and its influence on CUL in the three study sites. It examines users' perceptions of safety, visibility, accessibility, visit frequency, and attraction, and relates these to the results of the syntactic analysis and behavioural maps. It also includes a qualitative reading of children's cognitive drawings. The chapter concludes with a correlation between children's presence, spatial configuration, and OTC, presented as the synthetic ending of the empirical discussion. In this way, it explains where children tend to concentrate within the spaces under study and how spatial configuration shapes their patterns of use.
- **General Conclusion**

This chapter summarises the key findings of the research, highlighting their implications for CUL. It then provides recommendations for policy and practice, offering strategies to enhance outdoor places for children. Additionally, suggestions for future research are outlined to guide further exploration in this field. The chapter concludes with final reflections on the study's contributions and broader significance.

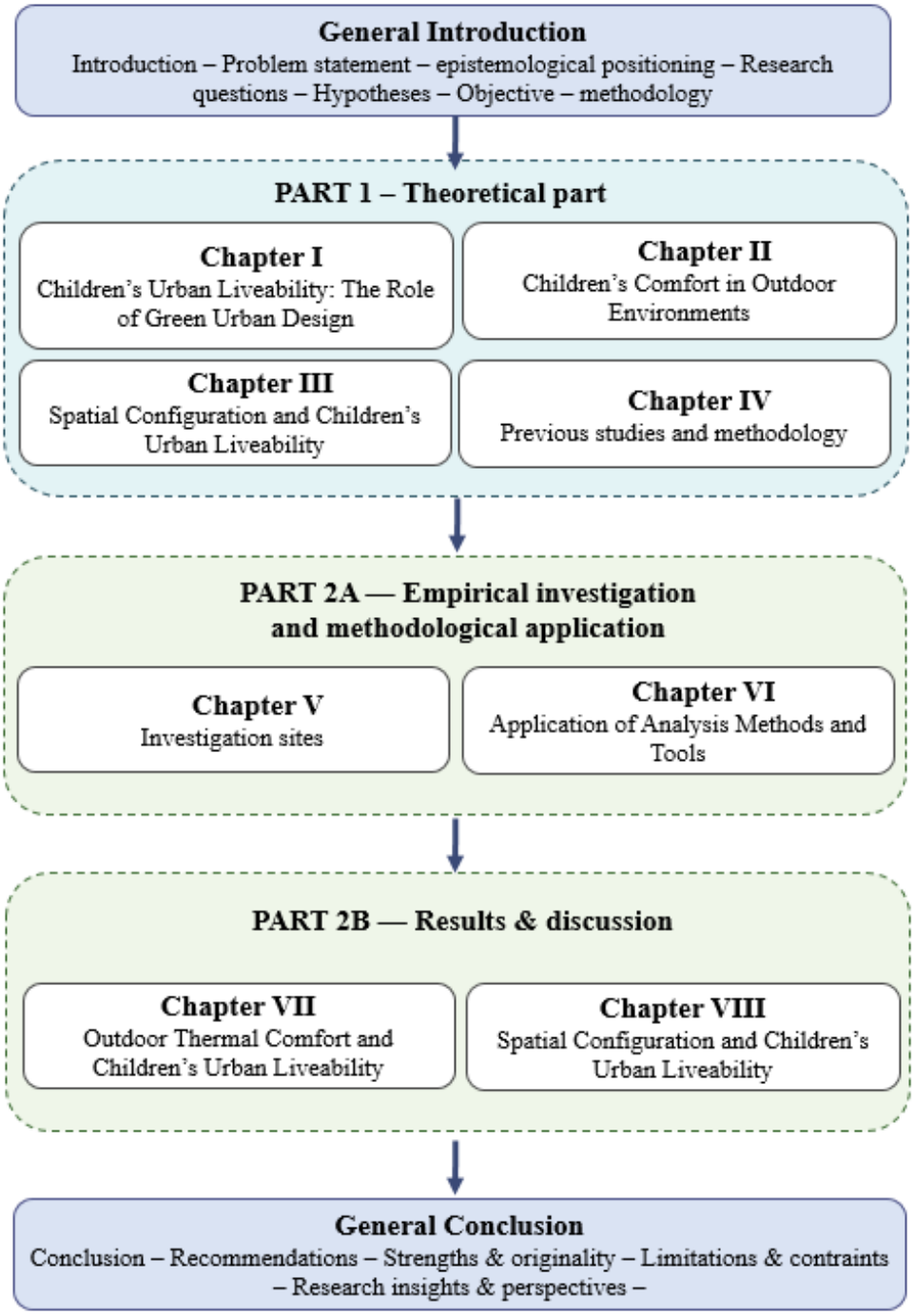


Figure 0. 2: *Structure of the thesis. Source: Author, 2025.*

CHAPTER I: CHILDREN'S URBAN LIVEABILITY: THE ROLE OF GREEN URBAN DESIGN

"*If a city is not good for children, it is not good for anyone*."

— Enrique Peñalosa, former Mayor of Bogotá (2000)

Introduction

The 21st century has become the century of the urban child. Yet for many children growing up in North African cities, urban life is experienced not as an opportunity but as exposure to thermal stress, spatial exclusion, and limited access to liveable outdoor spaces. In Algerian contexts, children's ability to use, enjoy, and benefit from urban outdoor space is strongly conditioned by two interrelated factors: *OTC* and *spatial configuration*.

This chapter establishes the theoretical and conceptual foundations of the study by examining CUL through the role of GUD. It is organised into five main parts, as illustrated in Figure 1.1. The first part introduces the concept of urban liveability, its historical evolution and its specific relevance to children. This provides the conceptual basis for understanding where CUL is experienced in the urban environment. The second part focuses on the particular needs of children in urban environments. It discusses children's psychological and physiological needs, functional needs, social needs and aesthetic needs. The third part presents the theoretical foundations that support this child-centred understanding of urban liveability. It draws on Vygotsky's sociocultural theory, Piaget's cognitive development theory, Bandura's social-cognitive theory, Bronfenbrenner's ecological systems theory and Erikson's psychosocial theory. The fourth part identifies the principal factors influencing CUL. These include sociodemographic conditions, environmental and climatic factors, spatial configuration and urban morphology, perceived environmental quality and place attachment, personal and behavioural factors, and policy and governance conditions. Particular attention is given to environmental and climatic factors and spatial configuration, because these two dimensions directly influence whether outdoor places are accessible, usable, comfortable and attractive for children. The fifth part then presents GUD as a framework for enhancing CUL. It defines GUD, reviews its main principles, examines its relevance for children, and considers its importance in the Algerian urban context.

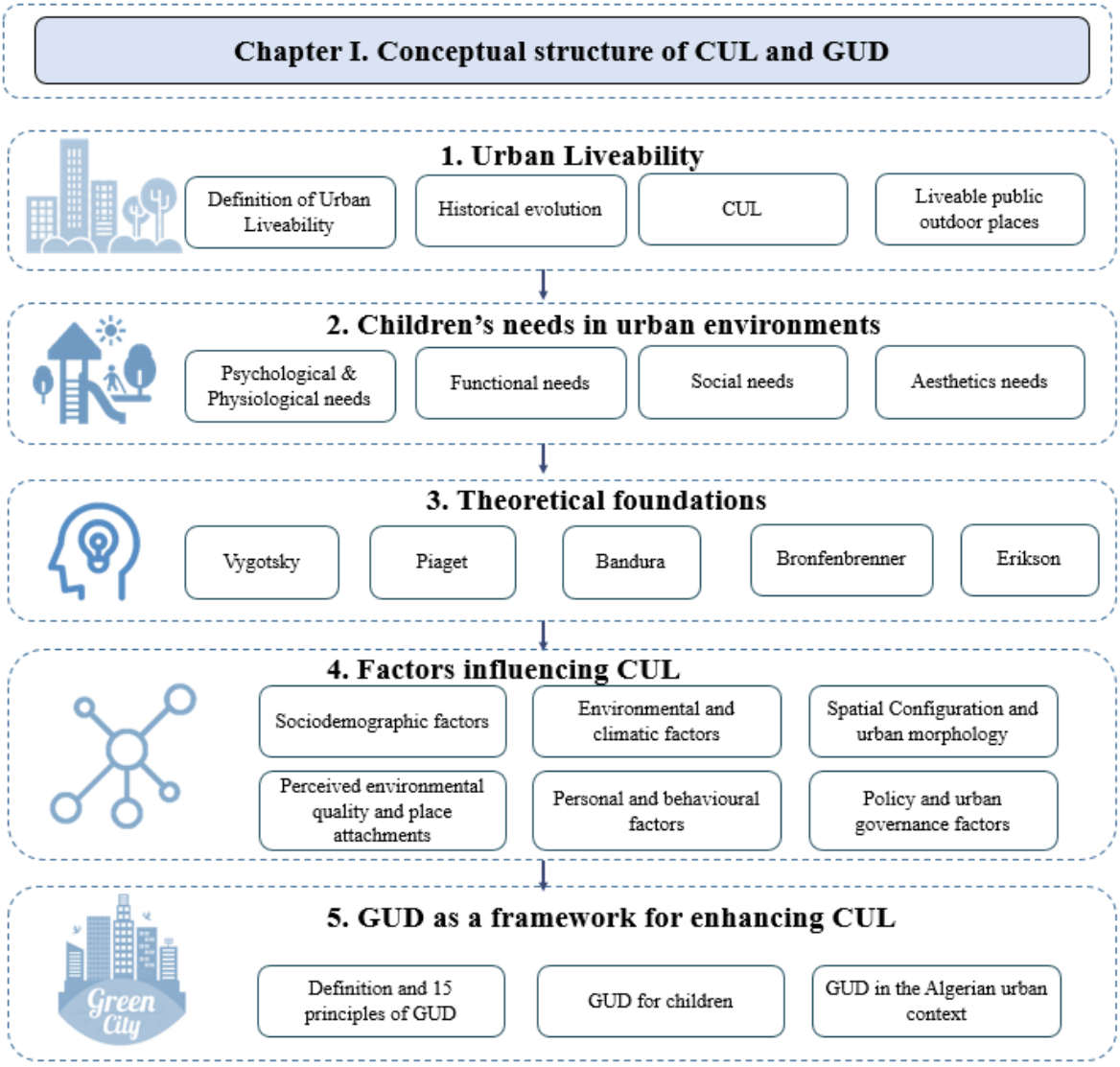


Figure 1. 1: *Structure of Chapter I. Source: Author, 2026.*

1. Urban Liveability

The human-centred understanding of urban liveability can be traced back to early urban planning thought, where the city was conceived as a setting that should respond to human needs, safety and development (A. Labdani, Fezzai, & Gherzouli, 2026). — *The city must guarantee everybody the best possible development under conditions of freedom and safety, and thus it becomes a specific goal to fit the city to man. We always have to think how the city can best be built to fit human needs.* C. A. Doxiadis, (cited in Pressman, N., 1981, p. i)

1.1. Definition of Urban Liveability

Urban liveability, which is associated with the study of human settlements, is a widely used yet complex concept without a single standardised definition (Kashef, 2016; Molaei Qelichi, Ghasemi, Tepe, & Murgante, 2025a; Saitluanga, 2014). Scholars have proposed varying interpretations of urban liveability, reflecting its multifaceted nature (Ghasemi, 2024). According to Ahmed et al (2019), the concept of "liveability" refers to the extent to which a place is habitable or suitable for human life. As an adjective, "liveable" describes an environment that is safe, comfortable, and conducive to living. However, perceptions of liveability vary depending on local economic, social, and cultural factors, as residents' personal preferences shape their evaluation of a place (McCann, 2007; P. W. Newman, 1999). Perceptions of liveability vary considerably across cultural and geographic contexts, shaped by local economic, social, and environmental priorities. Contemporary urban studies typically evaluate liveability based on three fundamental criteria: the health of the natural environment, the availability and quality of neighbourhood services and amenities, and the overall physical and mental wellness of inhabitants (Saitluanga, 2014). The International Making Cities Liveable Conference (IMCL) similarly frames liveability through urban design principles such as effective public transport, cycling infrastructure, mixed-use development, and child-accommodating environments. In this respect, Figure 1.2 provides an illustrative example of how inclusive and child-centred public-space design can embody these principles in practice. However, these general definitions remain insufficient for the present thesis because they often treat liveability as an adult-centred or city-scale quality. For children, liveability must be understood as a spatially and climatically situated condition. In this perspective, children’s liveability depends not only on whether public spaces exist, but on whether they are spatially accessible, developmentally supportive, and thermally tolerable in everyday conditions. A space may be publicly available in legal or morphological terms, yet remain effectively unliveable for children if its configuration restricts movement, visibility, and independent use, or if excessive heat, solar exposure, and inadequate shading discourage occupation. This distinction is particularly important because most conventional liveability frameworks remain adult-centred. They tend to prioritise mobility, services, or economic performance at the city scale, whereas children experience urban environments through a more immediate set of bodily, sensory, and developmental conditions that are directly mediated by the thermal quality and spatial configuration of the outdoor environments they inhabit.



Figure 1. 2*: Clemyjontri Park, Virginia: an inclusive play space exemplifying accessible urban design. Source: Adapted from (Ibáñez, 2016).*

1.2. Historical evolution of Urban Liveability

The concept of urban liveability has evolved from a broad normative ideal into a more structured framework for assessing urban quality. In the 1960s and 1970s, it emerged largely as a reaction against top-down urban renewal and car-dominated planning, with emphasis placed on human-scale environments and neighbourhood vitality (Molaei Qelichi, Ghasemi, Tepe, & Murgante, 2025b). By the late 20th and early 21st centuries, this normative ideal was progressively institutionalised as a cornerstone of international policy, formally embedded into overarching frameworks such as the 1996 UN Habitat II and the 2017 New Urban Agenda (Caliskan & Sevik, 2022). However, although these frameworks helped place human well-being at the centre of urban policy, they often remained focused on city-scale indicators and general population needs. As a result, the specific conditions through which liveability is experienced at the micro-scale of streets, squares, playgrounds and neighbourhood outdoor spaces were not always sufficiently addressed. The theoretical foundations for operationalising this spatial liveability were initially established by mid-century scholars such as Jane Jacobs and Kevin Lynch, who introduced systematic methodologies for evaluating spatial organisation, pedestrian scale, and neighbourhood vitality (Sree, 2022). Building upon these foundational spatial theories, modern liveability discourse has expanded to align with contemporary sustainable development goals, encompassing multi-dimensional metrics such as environmental health, public services, and

social equity (Kashef, 2016; Sheikh & Van Ameijde, 2022; Xiao, Li, Tang, Huang, & Wang, 2022). Yet, assessing these dimensions objectively requires moving beyond the historical, abstract definitions of liveability toward precise, quantifiable indices. This gap between historical aspiration and empirical operationalisation is particularly acute when the urban population under consideration is children, a group whose developmental, sensory, and physiological needs have been systematically absent from conventional liveability indices. In the context of this thesis, however, the historical debate on liveability must be extended in two directions. First, it must be reframed through a child-specific analytical framework, since standard liveability measures have tended to privilege adult concerns. Second, it must incorporate both spatial configuration and OTC as central analytical dimensions. This shift from general historical understandings to precise spatial and thermal evaluation is essential for examining CUL in a meaningful and context-sensitive way. Recent empirical scholarship validates the necessity of this modern dual approach, demonstrating that the physical form of neighbourhoods, analysed through spatial configuration metrics like visibility and accessibility, substantially conditions CUL (Chibane & Hamouda, 2022).

1.3. Urban Liveability for children: A special focus

CUL refers to the extent to which cities provide safe, healthy, accessible and inclusive environments that support children's physical, cognitive, emotional and social development (Wechsler, Toso, Toscano, & Wei, 2024; Wilhelmsen, Øvreås, Roll-Hansen, Bjerknes, & Thorrud, 2023). While this definition broadly aligns with general urban liveability frameworks, CUL constitutes a distinct analytical category, one that cannot be reduced to a scaled-down version of adult-oriented urban quality. Children experience the city through a fundamentally different set of physiological, sensory, and developmental conditions, conditions that standard liveability indicators, designed around adult mobility, employment, and service access, systematically fail to capture (Zhu, Xu, Lee, Lee, & Ory, 2025).

The distinction is not merely theoretical. Research consistently demonstrates that children require urban settings that enable meaningful interaction with nature, safe independent mobility, and access to play, conditions that are routinely subordinated to efficiency and adult convenience in conventional planning frameworks (J. Y. Lee, Lee, Lamichhane, Shrestha, Kim, Oh, Lee, Park, Hong, Park, et al., 2025). Traffic risk, air pollution, thermal stress, and poorly configured public spaces are not peripheral inconveniences for children; they constitute structural barriers to physical health, cognitive development, and social

participation, with consequences that extend well beyond childhood (J. Y. Lee, Lee, Lamichhane, Shrestha, Kim, Oh, Lee, Park, Hong, & Park, 2025; WHO, 2026). Children growing up in under-resourced urban environments face a compounded disadvantage, inadequate housing, disappearing play spaces, and environmental hazards that conventional liveability indices neither measure nor address (Organization, 2024). CUL therefore requires a specialised framework that recognises children as a distinct user group whose physiological, cognitive, and developmental needs differ fundamentally from those of adults (Kaplan, 2024). Their liveability depends on environments that actively support their evolving capabilities, mitigate their particular vulnerabilities, and respond to the specific ways in which they perceive, navigate, and appropriate urban space. In the context of this thesis, CUL is operationalised through two interacting dimensions: OTC, which governs children's physiological comfort and temporal patterns of outdoor use, and spatial configuration, which shapes their accessibility, movement, and spatial appropriation of outdoor environments.

2. Liveable public outdoor spaces: Concepts and classification

2.1. Conceptual distinction between urban space, public space and urban squares

2.1.1. Urban Space

Urban space constitutes the physical and social framework within which everyday life unfolds. From a design perspective, Krier (1979) distinguishes between *positive spaces*, enclosed, continuous and legible, and *negative spaces*, which are fragmented and spatially indeterminate, a distinction relevant to children's movement and outdoor engagement. Trancik (1986) further differentiates *hard spaces*, oriented towards gathering, from *soft spaces* such as parks, which fulfil recreational and ecological functions (Krier & Rowe, 1979; Trancik, 1986). Lynch (1969, pp. 47–48) complements these readings by identifying paths, edges, districts, nodes and landmarks as structural elements through which people, including children, navigate and relate to their environment (Lynch, 1969).

2.1.2 Public Space

Public space is distinguished from urban space by its social character: accessibility, collective use and openness to all. Gehl (2011) demonstrates that higher-quality public spaces attract more varied activity, serving social interaction, exchange and movement,

functions fundamental to children's outdoor engagement (Gehl, 2011). As illustrated in Figure 1.3, the Project for Public Spaces (PPS, 2009) evaluates public space quality through four interdependent attributes, *Sociability, Uses and Activities, Access and Linkages, and Comfort and Image*, connecting measurable indicators such as safety data and environmental conditions with experiential qualities relevant to CUL (Perakaki & Sinou, 2022; Reich, 2020).

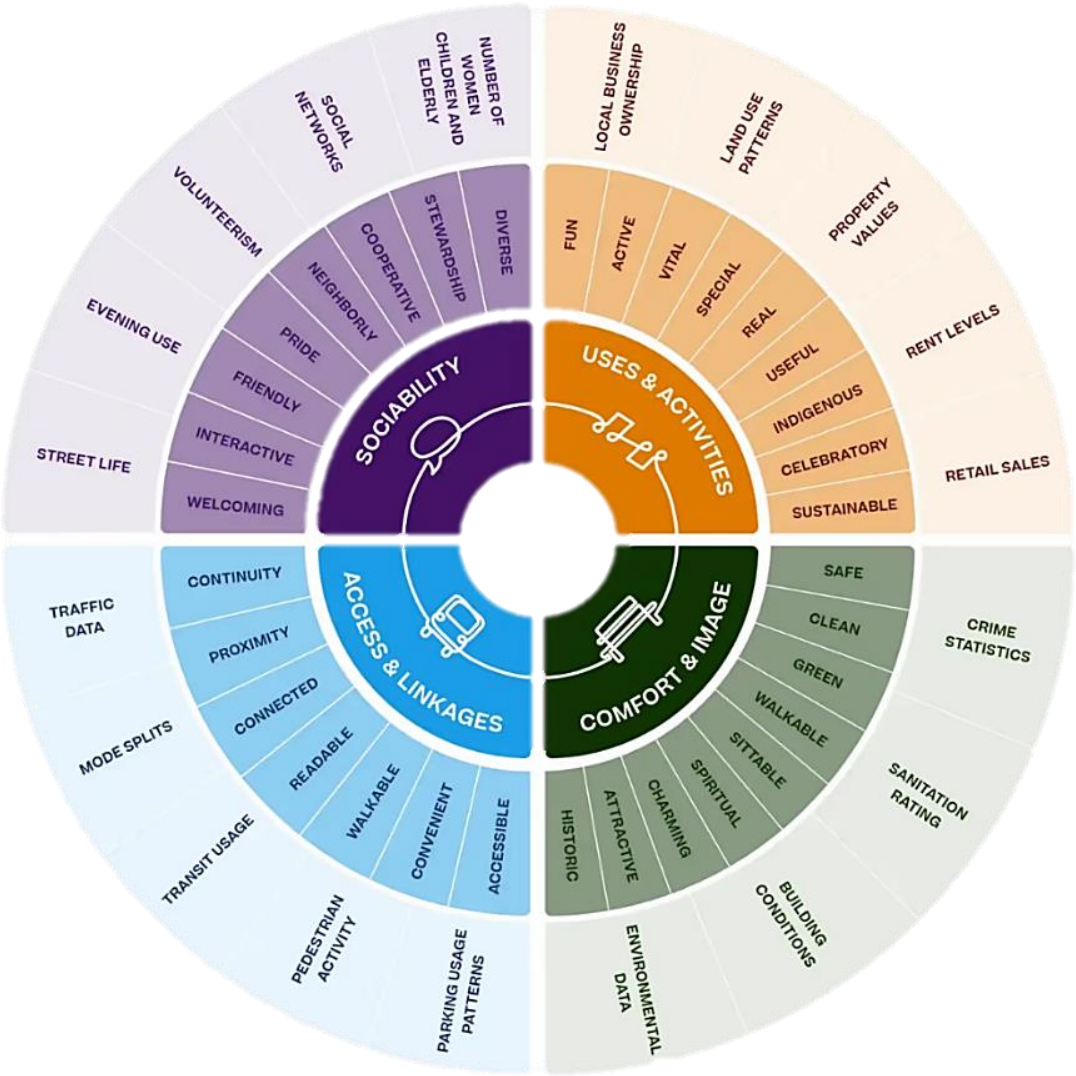


Figure 1. 3: *Place Diagram tool for public space evaluation developed by The Project of Public Spaces. Source: (Perakaki & Sinou, 2022).*

2.1.3 Urban Squares

Among public space typologies, urban squares are particularly significant to this thesis. Originating as civic nodes combining commerce, gathering and political life, they have evolved across historical periods while retaining their role as central, accessible and socially visible outdoor settings (Acar et al., 2020; Mumford, 1961). For children, squares are among the outdoor spaces most frequently encountered in everyday urban life, yet their openness also makes them especially exposed to solar radiation and surface heat, a dimension central to the analysis of CUL. It is within this conceptual framework that the following classification of liveable outdoor space typologies is situated.

2.2. Typology of liveable public outdoor places

2.2.1. Streets and pedestrian corridors

Streets are among the most fundamental components of the public realm, functioning as connective tissue that links all other typologies. UN-Habitat (2020) identifies streets as drivers of urban prosperity because they support social interaction, mobility and economic exchange simultaneously. For children, streets can support gradual independence and spatial learning, but they also become restrictive when dominated by traffic, poor walkability, or thermal discomfort. Recent evidence confirms that low traffic volumes, access to footpaths, and pedestrian amenities are positively associated with children's outdoor play (Gill, 2021).

2.2.2. Urban squares and plazas

Urban squares are among the most historically significant forms of public space, combining accessibility, civic life and social visibility. Acar et al. (2020) observe that urban squares function as key open spaces supporting social, cultural and recreational activities while contributing to the visual identity of the city. Their openness makes them important urban nodes, though it also increases exposure to solar radiation and surface heat, a dimension central to this thesis. For children, usability depends on shade, seating, safety, supervision and thermal comfort (Acar et al., 2020).

2.2.3 Parks and green spaces

Parks contribute to urban liveability through recreation, ecological regulation, social interaction and contact with nature, whilst improving microclimatic conditions through shade, vegetation and evapotranspiration. Research shows that parks prioritise *activities* as their dominant quality dimension, distinguishing them from squares, which emphasise

comfort and image. For children, parks are particularly important for physical activity, exploration, socialisation and sensory experience, but their liveability depends equally on accessibility, maintenance, spatial legibility and climatic comfort (P. Tang & Woolley, 2023).

2.2.4 Playgrounds and play areas

Playgrounds are outdoor spaces specifically designed to support children's physical, social and imaginative development. Research in Beijing confirms that whilst fixed play equipment and rubber surfacing enhance engagement and safety, realising the full potential of children's outdoor play spaces demands more inclusive design that accounts for age-specific spatial arrangements and adult supervision patterns. A playground is not automatically liveable simply because it contains equipment; its quality depends equally on shade, surface materials, safety, visibility, caregiver supervision and thermal comfort (M. Gao, Zhu, & Cheng, 2024).

2.2.5 Neighbourhood open spaces

Neighbourhood open spaces are everyday outdoor settings located close to residential areas that support informal play, waiting, social interaction and local community life. The Western Australian Classification Framework for Public Open Space (2020) identifies recreation spaces, which include amenity spaces and community gardens near dwellings, as providing settings for informal play, socialisation and physical activity accessible to all. For children, these spaces are important because proximity to the home may allow supervised or semi-independent outdoor activity, particularly in dense urban conditions (Rutherford, Carter, & Christidis, 2013).

2.2.6 Courtyards and semi-public residential spaces

Courtyards and semi-public residential spaces form transitional environments between private dwellings and the wider public realm. Recent research identifies key indicators of these spaces, including spatial enclosure, social visibility, accessibility and collective governance, as contributing to the social sustainability of multi-unit residential complexes (Amirjani, Tabrizi, & Kashi, 2025). For children, courtyards can provide relatively protected environments for play and social interaction, particularly when visible from surrounding dwellings and separated from traffic. Their liveability depends on enclosure, climatic protection and the balance between privacy and collective use.

2.2.7 Waterfronts and blue spaces

Waterfronts and blue spaces contribute to urban liveability through recreation, landscape quality, cooling potential and sensory experience. They provide visual relief, walking opportunities and improved environmental quality in dense urban settings. For children, blue spaces support exploration and sensory engagement, but require careful design in terms of safety barriers, accessibility, supervision and thermal comfort.

2.2.8 Civic forecourts and institutional open spaces

Civic forecourts are outdoor areas associated with public buildings, schools, cultural facilities, religious buildings or administrative functions. They support waiting, gathering, transition and social contact, and are often overlooked in liveability research despite their importance as everyday encounter spaces. For children, these spaces are important when located near schools or community facilities, but their liveability depends on whether they permit informal use rather than functioning only as symbolic or transitional areas.

2.2.9 Community gardens and pocket parks

Rooftop gardens, community gardens and pocket parks are increasingly recognised in the literature as distinct public space typologies, particularly relevant to densely built or underserved urban neighbourhoods. For children, they can provide scaled-down green spaces for sensory learning, gardening activities and informal social interaction when larger parks are inaccessible.

3. The particular needs of children in urban environments

A fundamental reciprocal relationship exists between children and their physical surroundings, through which young people develop cognitive capacities, social competencies, and behavioural norms. The urban environment functions simultaneously as a developmental context and a spatial constraint, shaping children's psychological, physiological, functional, social and aesthetic experiences (Dagher, Farouk, Refaat, & El Messeidy, 2022).

3.1. Psychological & physiological needs

Children’s psychological well-being in urban environments depends on their ability to explore, interact and gradually develop autonomy. Safe outdoor spaces allow children to expand their spatial knowledge, build confidence, negotiate social situations and develop

problem-solving skills through everyday movement and play (Buttazzoni, Doherty, & Minaker, 2022; Evans, 2017). However, such benefits depend on whether the urban environment provides conditions that children and caregivers perceive as safe, legible and supportive. Physiologically, children are more vulnerable than adults to environmental stressors because their bodies are still developing. Clean air, safe movement areas, protection from traffic and exposure to healthy outdoor environments are therefore essential conditions for CUL (Sugar, 2021).

3.2. Functional needs

Children's functional needs relate to the ability of urban spaces to support play, learning, movement and independent exploration. Functional public spaces for children should provide diverse opportunities for activity, including formal play, informal play, walking, resting, observation and social interaction. Research shows that children benefit from adaptable environments that offer more than standardised playground equipment, including safe walking routes, accessible amenities and contact with natural elements (Ataol, Krishnamurthy, & Van Wesemael, 2019; Elnesr, 2023; Katsavounidou & Sousa, 2024b).

3.3. Social needs

Urban spaces also support children's social development by providing opportunities for interaction with peers, caregivers and wider community members. Public outdoor environments can function as social learning settings where children encounter difference, negotiate rules, cooperate with others and develop confidence beyond the family context (Bhattacharya, 28 November 2024; Bourke, 2017). These interactions are particularly important because children's social development depends not only on formal institutions such as schools, but also on everyday contact in neighbourhood spaces, streets, parks, squares and playgrounds.

3.4. Aesthetic needs

Children's experience of urban space is also shaped by aesthetic and sensory qualities. Visual harmony, clear spatial organisation, colour, texture, natural elements and sensory comfort can help children understand, enjoy and navigate their surroundings. Beyond visual attractiveness, children's aesthetic experience also contributes to the formation of place attachment and memorable spatial experience. Rieh (2020) argues that childhood environments can shape children's sense of place, affect their present quality of life and contribute to long-term memories of place (Rieh, 2020). Previous studies suggest that

children respond positively to environments that are visually engaging but not overwhelming, especially when these include trees, flowers, animals and other natural features that contribute to pleasure, curiosity and attachment (Bourke, 2017). Aesthetic needs are therefore not limited to visual beauty. They are connected to spatial cognition, orientation, comfort, and emotional response.

4. Theoretical foundations

Children's relationship with the urban environment is not passive. The spaces they use influence how they move, interact, learn, feel safe, develop autonomy and construct meanings about the city. For this reason, the study of CUL requires a theoretical foundation that connects child development with the physical, social and environmental qualities of urban space. Theories of Vygotsky, Piaget, Bandura, Bronfenbrenner and Erikson are particularly relevant because they show that children's development is shaped through continuous interaction with social relations, spatial settings and environmental conditions. In this thesis, these theories are not used as independent psychological models, but as a conceptual basis for understanding why outdoor places matter for children. They help explain how spatial configuration can support or restrict children's movement, visibility, social learning and autonomy, while OTC can enable or limit their ability to remain active outdoors. Together, these theories justify the need to analyse CUL through both spatial and environmental dimensions.

4.1. Vygotsky's sociocultural theory

Vygotsky's sociocultural theory emphasises that children's learning and cognitive development are mediated through social interaction, language and shared activity. Development is therefore not only an individual process, but one that takes place within social and cultural environments (EDWARDS, 1992). Through interaction with peers, adults and surrounding users, children acquire language, behavioural norms, problem-solving strategies and the capacity to interpret their environment. This theory is relevant to CUL because public outdoor spaces provide everyday settings for social learning. Parks, squares, playgrounds and neighbourhood spaces allow children to observe others, communicate, negotiate rules, cooperate and gradually understand the social order of urban life. In this sense, outdoor places are not only physical settings for play; they are social learning environments where children's cognitive and behavioural development is shaped through interaction. For the present thesis, Vygotsky's theory supports the interpretation of

outdoor places as environments of mediated social experience. Spatial configuration influences the possibility of encounter, co-presence and interaction, while OTC affects whether children can remain in these settings long enough for social activity to occur. Therefore, CUL depends not only on the existence of public spaces, but on whether these spaces are accessible, socially active and climatically tolerable (Bannister, 2022).

4.2. Piaget's cognitive development

Piaget's theory of cognitive development highlights the role of active engagement with the physical environment in children's intellectual growth. Children construct knowledge through interaction with objects, spaces and situations, gradually developing mental structures that allow them to understand relationships, order, distance, direction and spatial organisation (Piaget & Cook, 1952; Schunk & Zimmerman, 2012).

This theory is especially relevant for children aged 6–12, who correspond broadly to Piaget's concrete operational stage. At this stage, children develop the ability to reason about tangible situations, classify objects, understand spatial relationships and coordinate different aspects of the environment. In urban contexts, this means that children begin to interpret routes, landmarks, boundaries, nodes, distances and the functional organisation of outdoor spaces (Piaget, 1970). For this thesis, Piaget's theory provides a foundation for examining spatial configuration. Children's ability to move through, understand and appropriate outdoor places depends partly on the legibility, visibility and accessibility of those spaces. Spatially confusing, fragmented or poorly connected environments may limit independent movement and reduce children's confidence, while more legible and accessible environments can support exploration, spatial learning and autonomy.

4.3. Bandura's Social-Cognitive theory

Bandura's social-cognitive theory explains behaviour through the interaction between personal factors, observed behaviour and environmental conditions. His concept of reciprocal determinism suggests that children are not only shaped by their environments, but also actively respond to and influence them through behaviour, observation and adaptation (Bandura, 1986a; Sree, 2022). This theory is relevant to children's use of urban spaces because much outdoor behaviour is learned through observation and imitation. Children observe how peers, caregivers and other users move, play, avoid danger, share equipment, occupy shaded areas or respond to environmental discomfort. Through these observations, they develop behavioural strategies and learn which spaces are socially

acceptable, safe, attractive or uncomfortable. In the context of this thesis, Bandura's theory supports the use of behavioural mapping. Children's occupation of outdoor places is not random; it reflects learned behaviours, environmental cues, social presence and repeated feedback from the physical setting.

4.4. Bronfenbrenner's Ecological Systems theory (EST)

Urie Bronfenbrenner's EST provides a broader framework for understanding children's development as the result of interactions between the child and multiple environmental systems. These systems include the immediate microsystem, such as family, school and peer settings; the mesosystem, which links these settings; the exosystem, including indirect social and institutional influences; and the macrosystem, which includes cultural values, policies and broader urban conditions (Bronfenbrenner, 1979). This theory is particularly important for CUL because it shows that children's well-being cannot be understood by examining the child alone. It is shaped by the quality of housing, schools, neighbourhoods, public spaces, mobility systems, environmental conditions and urban governance. Outdoor places form part of the child's microsystem because they are everyday settings where play, social interaction, movement and exposure to environmental conditions occur. Bronfenbrenner's theory justifies the integration of spatial, climatic and social dimensions. Children's outdoor use in is shaped not only by individual preference, but also by the accessibility of public spaces, the presence of caregivers, the safety of neighbourhood environments, seasonal thermal conditions and the planning decisions.

4.5. Erikson's Psychosocial theory

Erikson's psychosocial theory emphasises the role of social experience in the development of personality, autonomy, initiative, competence and identity. Across childhood, children pass through developmental stages in which they require opportunities to explore, act independently, interact with others and experience recognition from their environment (Erikson, 1994). This theory is relevant to urban liveability because outdoor spaces can either support or restrict children's psychosocial development. Spaces that allow safe exploration, play, social interaction and gradual independence can strengthen autonomy, initiative and competence. Conversely, environments marked by danger, exclusion, poor maintenance or environmental discomfort may limit children's confidence and reduce their opportunities for participation. In this thesis, Erikson's theory supports the argument that children's outdoor environments must be designed not only for physical access, but also for

developmental support. Therefore, children's ability to develop confidence and social competence in public space depends on both spatial and environmental conditions.

Taken together, these theories demonstrate that children's development is shaped through continuous interaction with social, spatial and environmental conditions. *Vygotsky* highlights the role of social interaction and mediated learning; *Piaget* explains the importance of spatial cognition and active exploration; *Bandura* shows how behaviour is learned through observation and environmental feedback; *Bronfenbrenner* situates the child within wider ecological systems; and *Erikson* emphasises autonomy, initiative and social competence.

5. Factors influencing CUL

The concept of CUL is shaped by an interplay of sociodemographic, environmental, spatial, and policy-related factors. Recent scholarship underscores the importance of holistic, child-centred approaches to urban planning, emphasising the need to move beyond health and education silos and integrate children's rights and well-being into the fabric of urban development (Cordero-Vinueza, Niekerk, & van Dijk, 2023). The following sections delineate the principal factors influencing CUL, drawing on contemporary research and international case studies.

5.1. Sociodemographic factors

Children's engagement with urban spaces is shaped by sociodemographic characteristics including age, gender, socioeconomic status and cultural background. Children from low-income households face systemic barriers to accessing green spaces, safe play areas and essential services, a disparity that is particularly pronounced in rapidly urbanising contexts where public investment is unevenly distributed (Unicef, 2022). Gender also mediates spatial experience: research indicates that boys tend to gravitate towards open, activity-oriented spaces, whilst girls more frequently prioritise enclosed, socially supportive environments (Cordero-Vinueza et al., 2023). Addressing these disparities requires participatory planning approaches that incorporate children's perspectives and respond to the varied needs of different age and gender groups.

5.2. Environmental and climatic factors

Urban environmental quality significantly affects children's health and outdoor activity. Exposure to air pollution, noise and extreme thermal conditions has been associated with

adverse developmental outcomes in children (Cocco-Klein, Chatterjee, & Sera, 2020). Urban heat islands, intensified by impervious surfaces and limited vegetation, are of particular concern in semi-arid and rapidly urbanising regions (Jodder, Hossain, & Thill, 2025; Yang et al., 2021). Tree-lined streets, riparian corridors and pocket parks can reduce surface temperatures through shading and evapotranspiration, whilst also supporting children's well-being through contact with natural environments (Yin, Kasraian, & van Wesemael, 2025). The COVID-19 pandemic further demonstrated the importance of accessible outdoor green spaces as essential infrastructure for children's physical and mental health during periods of restricted mobility (Katsavounidou & Sousa, 2024b).

5.3. Spatial Configuration and urban morphology

The spatial configuration of urban areas, encompassing density, land-use mix and pedestrian accessibility, directly influences children's autonomy and social interaction. Compact, mixed-use neighbourhoods with pedestrian-oriented design enable children to navigate their environments independently, supporting spatial learning and place attachment (Katsavounidou & Sousa, 2024b; Schindler & Dionisio, 2024). Conversely, car-dominated urban sprawl restricts mobility, limiting access to communal play spaces and reinforcing sedentary lifestyles (Cordero-Vinueza et al., 2023). Legible, well-connected public spaces that balance structured play with opportunities for informal exploration contribute to children's spatial confidence and social belonging (Yin et al., 2025).

5.4. Perceived environmental quality and place attachment

Children's subjective experience of urban environments plays an important role in their well-being. Perceived safety, visual coherence, and the presence of natural elements shape emotional engagement and encourage outdoor use (Katsavounidou & Sousa, 2024b; Yin et al., 2025). Micro-spaces such as street corners, community gardens and informal green areas can serve as significant sites for unstructured play and peer interaction, particularly in high-density settings where formal play infrastructure is limited. Child-centred design approaches that prioritise accessibility, sensory diversity and natural elements, such as shaded seating or water features, enhance the developmental and social value of outdoor spaces whilst also providing thermal relief (Cordero-Vinueza et al., 2023).

5.5. Personal and behavioural factors

Children's use of urban spaces is also mediated by parental perceptions of safety, cultural norms and the adaptability of the built environment. Concerns about traffic, stranger danger

or social conflict frequently lead caregivers to restrict children's independent outdoor mobility, increasing reliance on adult-supervised activities (Gill, 2021). However, communities that establish supportive social norms and that provide well-designed, visible and thermally comfortable outdoor spaces can enable children to use public environments more independently. Behavioural patterns in outdoor spaces are therefore not solely a product of individual preference, but reflect the interaction between perceived environmental conditions, social context and spatial design (Cordero-Vinueza et al., 2023; Katsavounidou & Sousa, 2024b).

5.6. Policy and urban governance factors

Transformative urban governance requires institutional commitment to child-centric policies, as advocated by UNICEF and UN-Habitat (Stiuso, 2024). This includes the equitable provision of safe outdoor infrastructure, climate-responsive green spaces and inclusive amenities adapted to children's developmental stages. Emerging practice increasingly emphasises participatory design approaches, including youth consultation processes and community co-design, that embed children's perspectives into planning decisions, ensuring that outdoor places reflect the actual needs and experiences of their users (Katsavounidou & Sousa, 2024b). In the Algerian context, this governance agenda is reinforced by recent work on CUL (A. Labdani, Fezzai, & Gherzouli, 2026) (see Appendix F, p, A-6). It highlights the structural and institutional gaps that constrain child-friendly environments, from fragmented housing and green-space provision to weak coordination between urban planning, education and health sectors.

6. GUD: A framework for enhancing CUL

6.1. Definition of GUD

GUD is understood in this thesis as an urban design approach that integrates ecological principles, green infrastructure, climate-responsive spatial design and biodiversity into the planning and shaping of outdoor urban environments, with the aim of improving environmental quality, social equity and human well-being (Hemmersam, 2010; Lehmann, 2010). Whilst the term remains inconsistently defined in academic literature, often conflated with broader concepts such as sustainable urbanism or eco-friendly planning, GUD is distinguished by its systemic integration of ecological, spatial and social dimensions rather than its focus on greening alone (F. Labdani, 2025). Several scholars have contributed to the conceptual development of GUD. Lehmann (2010) positions it as a framework for resource-efficient,

compact urban development that embeds renewable energy, green infrastructure and ecological resilience into urban form. Del Pulgar et al. (2020) extend this definition by emphasising GUD's role in expanding urban green infrastructure to improve public health, with particular attention to marginalised and vulnerable groups, including children (del Pulgar, Anguelovski, & Connolly, 2020). Moughtin and Shirley (2005) further characterise GUD as an approach that prioritises pedestrian accessibility, habitat preservation and mixed-density environments to foster socially and environmentally cohesive cities (Moughtin & Shirley, 2005). In the context of this thesis, GUD is not treated as a general sustainability concept. Rather, it is operationalised as the design response to the two empirically measured conditions, OTC and spatial configuration, that jointly determine whether children can safely and comfortably use outdoor places. Wang et al. (2024) confirm that GUD strategies involving vegetation, shading, material selection and climate-responsive public space design are directly effective in mitigating thermal stress and supporting children's outdoor activity (Yunjin Wang, Desha, Caldera, & Beer, 2024). Alias et al. (2024) define child-friendly urban environments as spaces that guarantee children's rights to safe, accessible, and playable outdoor settings, whilst incorporating children's perspectives into planning and governance processes. Similarly, Quan et al. (2024) highlight the strategic embedding of green spaces within urban morphologies as a key mechanism for improving children's environmental health and spatial quality (Z. Quan, M. B. M. Dali, & R. B. Zainol, 2024b).

6.2. Principles of GUD

The operationalisation of GUD requires translating broad sustainability principles into actionable urban design strategies. Beatley (2000, 2012), Lehmann (2010), and Newman and Matan (2013) collectively define GUD as a multidisciplinary approach linking ecological performance, urban form, mobility, public-space quality and social well-being. Beatley emphasises compact urban form, sustainable mobility, biodiversity and circular resource systems, showing that GUD operates mainly at the scale of streets, neighbourhoods and public spaces, which is also the scale at which CUL is experienced. Lehmann (2010) extends this through fifteen principles structured around urban planning and transport, water and biodiversity, energy and materials, and socio-cultural features (Lehmann, 2010). Newman and Matan (2013) further stress resilient, walkable and place-based urban structures that reduce automobile dependence and support local urban life (Beatley, 2012; Lehmann, 2010; P. Newman & Matan, 2013). As illustrated in Figure 1.4, this framework integrates climate-responsive design, urban density, green building standards, local

materials, renewable energy, governance, and cultural identity within a single model for sustainable urban transformation. Of these 15 principles, those most directly relevant to CUL are *climate and context*, *zero-carbon design*, and *the integration of green spaces and biodiversity*, since these are the principles that most directly determine the thermal quality and spatial accessibility of outdoor environments for children. Within this thesis, GUD is understood as enhancing CUL through two interrelated pathways. The first is a spatial pathway, related to street networks, pedestrian accessibility, open-space configuration, vegetation distribution and spatial legibility. The second is a thermal pathway, related to shade, vegetation, materials, urban geometry and microclimatic performance.

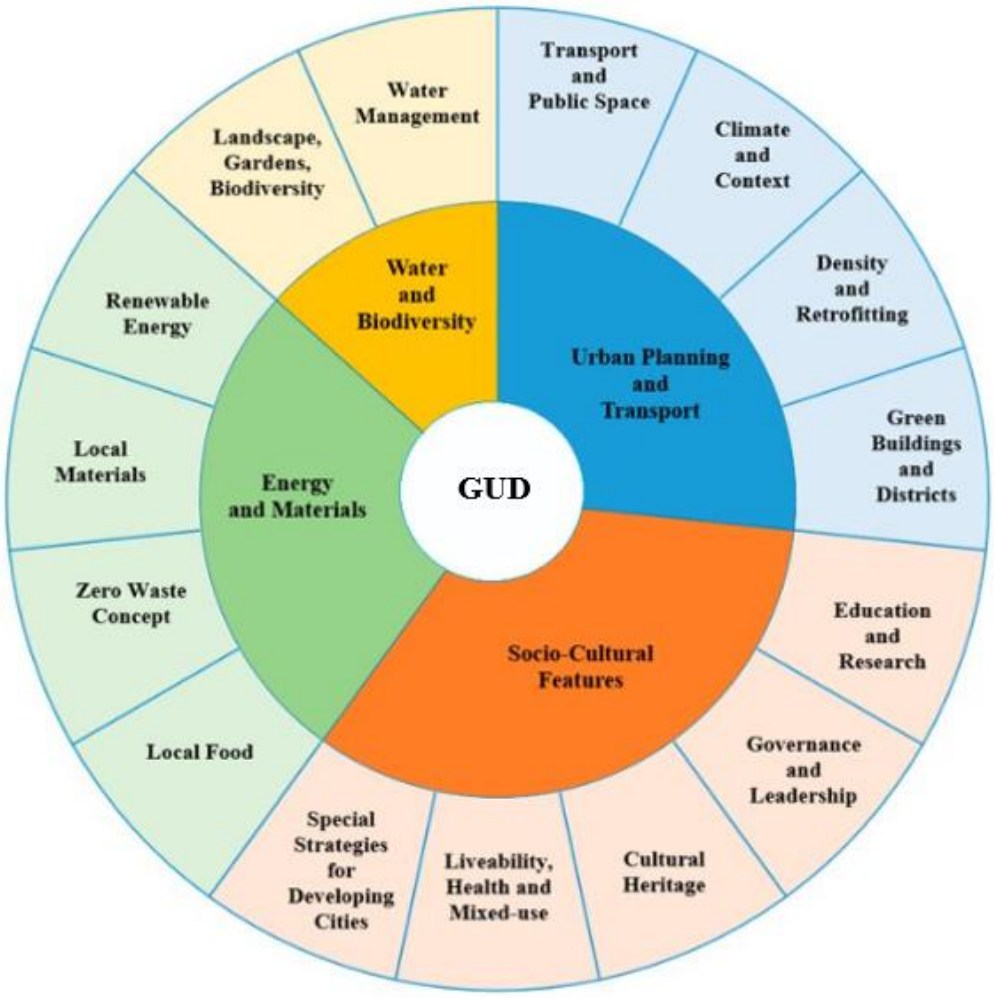


Figure 1. 4: *The four pillars and 15 principles of GUD. Source: Adapted from (Cuce, Cuce, & Santamouris, 2025).*

6.3. GUD for children

Lehmann's (2010) 15 principles constitute the most comprehensive and widely cited operationalisation of GUD in contemporary urban design scholarship. However, a critical analytical gap exists within this framework: The principles were conceived for city-scale ecological transformation and adult-oriented urban performance, with no explicit consideration of children as a distinct user group, no reference to children's physiological vulnerability to thermal stress, and no guidance on how GUD principles should be adapted to support children's development. This gap is not peripheral; it is structurally significant, given that children represent the urban population most directly affected by the quality of outdoor places and most physiologically sensitive to the thermal conditions those spaces produce (A. Labdani & Fezzai, 2024). This omission is consistent with a broader pattern in sustainable urbanism discourse. As Arup (2022) documents in *Designing for Urban Childhoods*, urban design frameworks, including those aligned with GUD and sustainable city principles, have systematically underrepresented children's needs, producing outdoor environments that prioritise ecological and economic performance metrics over the spatial safety, thermal comfort, and developmental accessibility that determine whether children can actually use those spaces (Voce, 2018). The consequence, as UN-Habitat and UNICEF (2023) confirm, is that the majority of urban children worldwide lack adequate access to safe, inclusive, and well-designed public outdoor spaces, not because green infrastructure is absent, but because it is not designed with children in mind. This distinction is analytically important: the presence of GUD elements does not automatically produce child-friendly cities. Addressing this gap requires overlaying Lehmann's GUD principles with a child-specific design framework. The 2026 joint guide by WHO, UNICEF, and UN-Habitat introduces the *SPACES framework, Child Health, Equity and Sustainability*, as an internationally validated set of criteria for child-responsive public space design (WHO, 2026). When mapped against Lehmann's 15 principles, this framework reveals which GUD dimensions are most directly relevant to CUL and which require child-specific supplementation (Table 1.1):

Table 1. 1*:Mapping of Lehmann's (2010) GUD Principles against the SPACES Framework. Source: Author, 2026.*

Lehmann's GUD Principle	**SPACES Dimension**	**Relevance to CUL**

Principle 1: Climate and Context	Child Health	Directly determines OTC conditions CUL
Principle 5: Landscape and Biodiversity	Play, Child Health	Shading, biophilic contact and thermal relief for outdoor activity
Principle 6: Sustainable Transport	Access, Safety	Pedestrian-priority design enabling children's independent mobility
Principle 10: Liveability and Mixed-Use	Access, Equity	Spatial accessibility and proximity of services for children
Principle 12: Cultural Identity and Place	Safety, Play	Place attachment, legibility and children's sense of belonging
Principle 14: Local Food and Urban Agriculture	Equity, Sustainability	Community cohesion and children's environmental engagement

6.4. GUD in the Algerian urban context

Algeria has undergone rapid and sustained urbanisation since the late twentieth century, with urban populations growing significantly in cities. This growth has been predominantly driven by housing production programmes, notably the AADL and LPP schemes, that have prioritised quantitative residential delivery over qualitative urban design (Larbi, 2019). As a result, the spatial quality of outdoor places has remained a secondary concern in Algerian planning practice, with limited attention paid to green infrastructure, thermal comfort, pedestrian accessibility, or child-sensitive design. High summer temperatures, intense solar radiation, low humidity, and seasonal thermal extremes create outdoor environments that are physiologically demanding for all users, and disproportionately so for children, whose thermoregulatory systems are still developing. Despite this, Algerian urban planning frameworks have not yet systematically incorporated OTC assessment, shade provision, or climate-responsive public space design as standard components of neighbourhood planning or public space. The integration of GUD principles into Algerian urban practice remains

non-existant. Whilst national environmental policy acknowledges sustainability objectives, including references to green spaces and biodiversity in the National Urban Development Framework, these commitments have not been consistently translated into the design and management of outdoor spaces at the neighbourhood scale. Existing outdoor places in Algerian cities, are frequently characterised by hard, sun-exposed surfaces, minimal vegetation, inadequate shading, and spatial configurations that offer limited legibility or accessibility for children (Larbi, 2019). This gap between international GUD frameworks and their application in the Algerian context constitutes the practical justification for the present thesis.

Conclusion

This chapter has established the theoretical and conceptual framework underpinning the present study through a critical examination of urban liveability, children's developmental needs and rights, and GUD as a relevant planning and design approach. It has been shown that urban liveability is a multidimensional concept whose meaning becomes more precise when examined through a child-centred perspective, a perspective that has often received limited attention within dominant planning frameworks. Although liveability has gained increasing prominence in international urban discourse, its interpretation and application have frequently remained broad in scope, adult-oriented, and insufficiently attentive to CUL. The chapter has also demonstrated that urban space, public space, and urban squares are central to this discussion because they constitute the settings in which children encounter, use, and interpret the city in everyday life. Their spatial organisation, social role, and environmental quality influence how children move, interact, play, and develop a sense of belonging within urban environments. In this respect, the review of developmental theories has reinforced the argument that children's experience of the built environment differs from that of adults and is shaped by developmental stage, social context, and the material and climatic characteristics of place. On this basis, the chapter has identified CUL as a condition shaped by the interaction of environmental and climatic pressures, spatial configuration, sociodemographic factors, and governance processes. Within this framework, GUD has been presented as a useful integrative approach for linking ecological, spatial, and social concerns with children's everyday urban needs, particularly through its attention to accessibility, biodiversity, spatial equity, and the quality of public space.

Building on this conceptual foundation, Chapter II focuses on one of the central concerns of the thesis: the conditions that shape children's comfort in outdoor urban settings.

CHAPTER II: CHILDREN'S COMFORT IN OUTDOOR ENVIRONMENTS

"The child is a thermometer of the city — where children thrive, the city thrives."

— Lady Allen of Hurtwood, Planning for Play (1968)

Introduction

OTC is a central dimension in the study of child-friendly and liveable outdoor environments, particularly under conditions of urban densification, climate variability, and increasing heat stress. In streets, parks, plazas and school-related outdoor spaces, thermal conditions influence not only physical comfort, but also patterns of use, duration of stay, play behaviour and social interaction. For children, this issue is especially important because their physiological characteristics, activity patterns, and dependence on adults make them more sensitive to thermal discomfort than adults. Therefore, understanding children's comfort in outdoor environments is essential for assessing how urban spaces can support CUL.

The objective of this chapter is to establish the conceptual and theoretical basis of children's OTC and to clarify how thermal comfort contributes to children's use and experience of outdoor urban spaces. The chapter defines the main concepts, theories, parameters, standards and indices required to understand OTC as a key component of CUL.

The chapter begins by introducing the notion of OTC, with particular attention to children and to the effects of thermal conditions on their behaviour. It then presents the main thermal comfort theories and discusses the perception of OTC through thermal sensation, neutral temperature, acceptability, and preference. The chapter subsequently reviews the principal thermal comfort standards, followed by the environmental, personal and local parameters that shape OTC. It then examines the main OTC indices, distinguishing between mechanistic and empirical models, before addressing the role of human heat balance. Finally, the chapter discusses the relationship between OTC and CUL and situates the topic within previous studies on OTC and children's OTC in Algeria.

The conceptual organisation of the chapter is summarised in Figure 2.1, which presents the progression from the definition of children's OTC to its theoretical foundations, perceptual dimensions, standards, parameters, indices, contextual evidence and contribution to CUL.

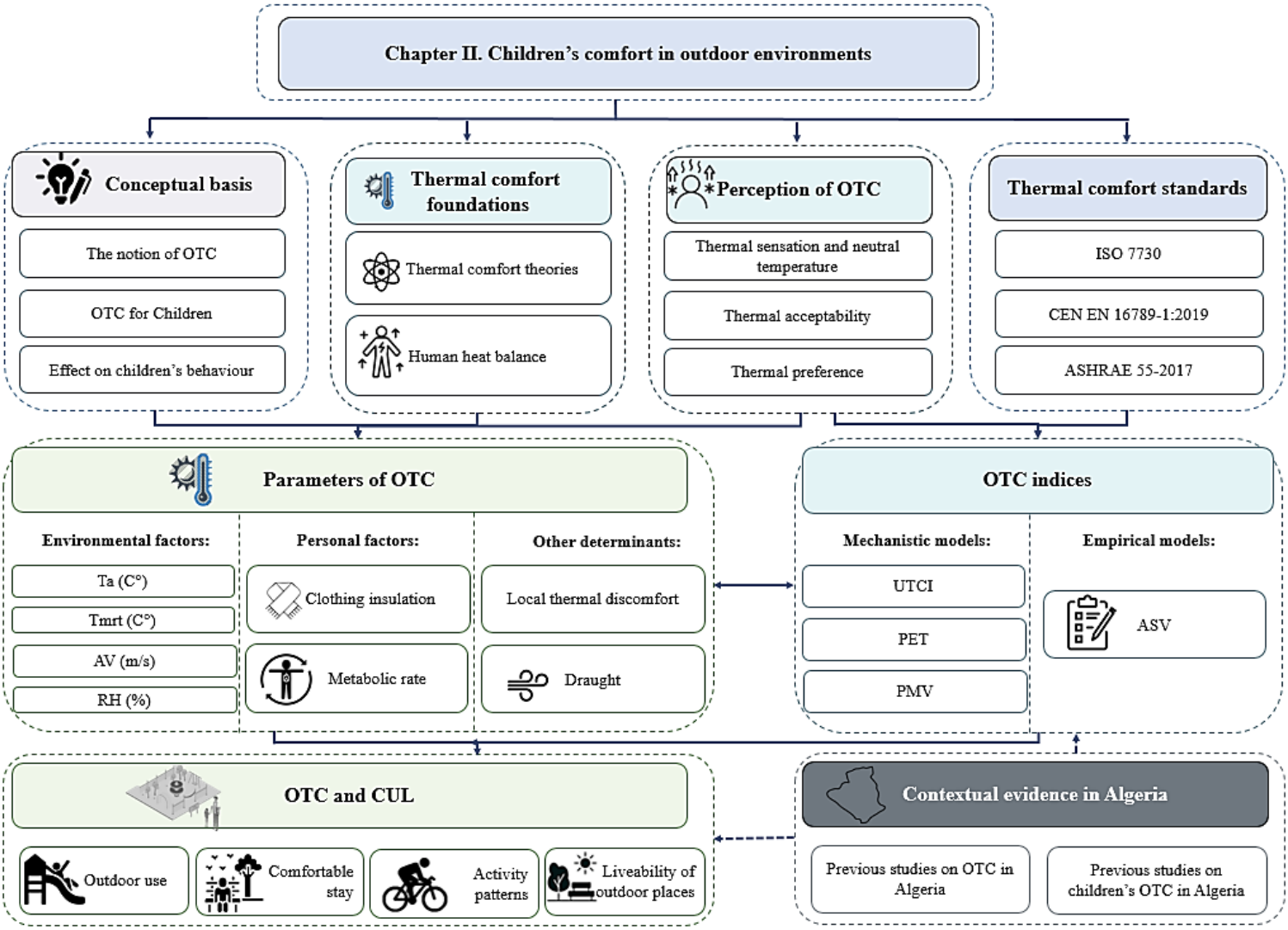


Figure 2. 1: *Structure of Chapter II. Source: Author, 2026.*

1. The notion of OTC

Modern comfort standards view thermal comfort as a subjective state. American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Standard 55, which is widely used in building sciences, defines thermal comfort as "the condition of mind that expresses satisfaction with the thermal environment" (Commission, 1987). Building-science literature describes thermal comfort as the degree of satisfaction or indifference a person feels towards their thermal environment. In a review of outdoor comfort in urban spaces, Liu & Li (2023) note that several organisations propose definitions, and that the ASHRAE definition is the most widely used (Z. Liu, Li, & Xi, 2023b). The International Union of Physiological

Sciences' glossary defines thermal comfort more simply as *"subjective indifference to the thermal environment"*, while Gagge et al. described comfort as a recognised state without an identifiable sense organ (A. P. Gagge, Stolwijk, & Hardy, 1967). These definitions underline that comfort is determined by what people feel, not by objective measures alone. OTC extends this subjective framework beyond the controlled interior environment into open-air settings, where the range and variability of influencing factors increase considerably. Unlike indoor environments, in which temperature, humidity, and air movement can be mechanically regulated, outdoor spaces are governed by dynamic, largely uncontrollable climatic forces, including solar radiation, AV, ambient Ta, and RH, all of which interact with urban morphology in complex, spatially heterogeneous ways. Figure 2.2 situates thermal comfort research within two broad domains: indoor thermal comfort and OTC.

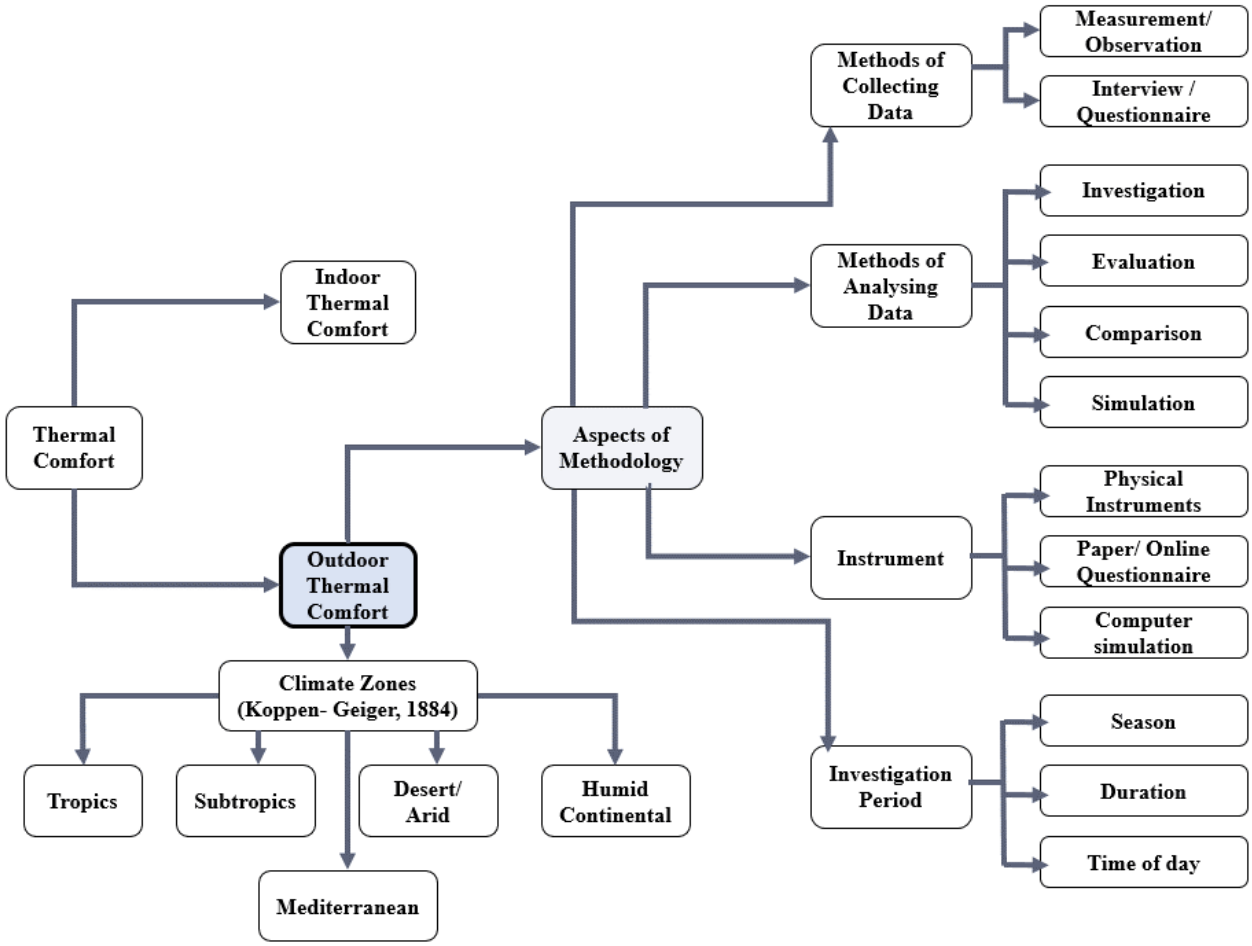


Figure 2. 2: *Conceptual positioning of OTC within thermal comfort research. Source: Adapted from (Dadang, 2022) and edited by Author, 2026.*

As the figure shows, OTC research is structured by both climatic and methodological considerations. It is examined across five major climate zones derived from the Köppen–Geiger classification (1884), namely tropics, subtropics, desert/arid, Mediterranean, and humid

continental climates. It further indicates that OTC research is methodologically organised around four interrelated dimensions: methods of data collection, methods of data analysis, the instruments employed, and the investigation period. Data may be collected through measurement and observation or through interviews and questionnaires, while analysis may involve investigation, evaluation, comparison, or simulation. These approaches are supported by physical instruments, survey tools, and computer-based modelling, and are further conditioned by the temporal scope of the study, including season, duration, and time of day.

1.1. OTC for children

Children's bodies differ physiologically and behaviourally from adults, making their thermal comfort thresholds distinct. OTC for children can be defined as the state in which a child feels thermally neutral or comfortably warm when engaging in outdoor activities, with their body able to maintain heat balance and without experiencing heat stress or cold discomfort. Achieving this state requires considering both micro-climatic conditions and child-specific factors such as age, metabolic rate, clothing, hydration, activity level, and the child's limited thermoregulation (H. Luyao et al., 2025; Ravanelli, Morris, & Morrison, 2023). This state of comfort is shaped by the distinct physiological characteristics of children, including their relatively higher surface-area-to-body-mass ratio and reduced thermoregulatory capacity compared with adults, rendering them more vulnerable to temperature fluctuations and thermal stress (N. Wallenberg et al., 2023). The assessment of OTC encompasses key environmental variables such as Ta, RH, AV, solar radiation, and surface temperatures, all of which collectively influence children's thermal perceptions and behavioural responses in outdoor settings. Table 2.1 provides a comparative summary of these physiological and developmental disparities. Ensuring such comfort is fundamental to promoting sustained outdoor activity, which in turn supports children's physical health, psychological well-being, and social development. A nuanced understanding of these dynamics is essential for the design of child-friendly cities, where strategic interventions in shading, natural ventilation, and material selection can safeguard children's health and enrich their urban liveability across diverse seasonal conditions (T. Guo et al., 2024).

Table 2. 1: *Children vs. Adult Thermal Physiology - Detailed Comparison. Source: Adapted from Antoniadis et al. (2020b).*

Physical Parameter	**Children**	**Impacts**

Thermal Perception	Lower	/
Heat transfer	Rapid	Development of heat stress conditions in a short time
Adaptive behaviour	Less adaptive	Less knowledge of sun protection
Thermoregulation	Lower Undeveloped sweat gland capacity Lower sweat rate	Lower evaporation heat transfer
Heat loss	Compared to adults, children dissipate heat more efficiently through convection than evaporation.	/
Physical activity	Superior	Increased metabolic heat production
Skin	More sensitive	/
Height	Lower height. The body is closer to the ground	Thermal effects of long-wave heat fluxes from high surface temperatures
Metabolic rate	Superior	Increased heat production
Surface-area-to-body mass ratio	Superior	Increased heat absorption

1.2. Effect of OTC on children's behaviours

The human body maintains a core temperature of approximately 37°C through continuous heat exchange with its environment, governed by four mechanisms: convection (C), radiation (R), conduction (K), and evaporative heat loss at the skin (E_{SK}) (Fu, Weng, Chen, & Luo, 2016). Total heat flux at the skin surface is expressed as:

$$Q_{sk} = C + R + K + E_{SK}$$

As illustrated in Figure 2.3, these four mechanisms operate simultaneously on the child's body, with solar radiation constituting the dominant external thermal load in outdoor semi-arid conditions. In outdoor environments, solar radiation, the dominant contributor to Tmrt, constitutes the primary thermal load, whilst AV and RH modulate the rate of heat loss (Zheng et al., 2024). Children's thermoregulatory systems respond to these conditions more vulnerably than adults. Their higher surface-area-to-body-mass ratio increases heat absorption, their lower sweat production rate reduces evaporative cooling capacity, and their immature hypothalamic regulation limits core temperature stabilisation under thermal stress (Ravanelli et al., 2023; N. Wallenberg et al., 2023). As thermal stress increases, children's duration of stay in outdoor spaces decreases, activity shifts from vigorous play to sedentary behaviour, and spatial distribution contracts towards shaded areas (X. He, Shao, Tang, & Wu, 2023; Hu Luyao, Lu Ling, Li Xinkai, & Dai Junfeng, 2025). Conversely, under thermally acceptable conditions, children demonstrate significantly greater outdoor engagement and spatial exploration (Siqi Liu & Jin, 2025).

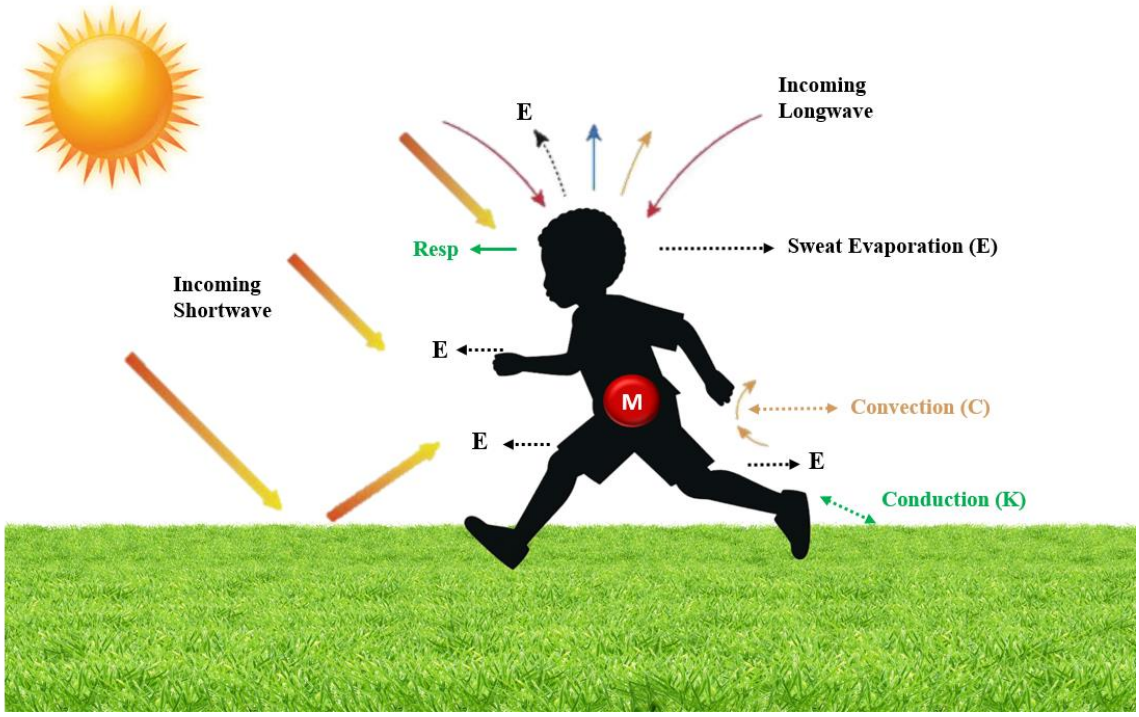


Figure 2. 3: *Heat exchange mechanisms between a child and the outdoor environment. Source: Author, 2026.*

2. Thermal comfort theories

Table 2.2 presents a synthesis of studies addressing the theories applied to OTC. Drawing on Bandura’s (1986) social cognitive theory, Shooshtarian (2019) proposed a classification of the

most influential theoretical approaches (Bandura, 1986b; Salman Shooshtarian, 2019). This categorisation identifies three interrelated mechanisms that govern the interaction between the urban environment, human behaviour, and perceptual development. The first mechanism, environmental drivers, encompasses spatial characteristics such as the presence of shade, as well as sociocultural factors including the materials, equipment, and cultural background associated with a place. The second, personal drivers, refers to individual conditions, encompassing physical, physiological, and psychological dimensions. Finally, behavioural drivers relate to the actions and practices of individuals, including the types of activities undertaken and their responses to thermal conditions. The relevance of these three mechanisms in shaping thermal satisfaction has been consistently highlighted in a wide body of research (M. H. Elnabawi & Hamza, 2019).

Table 2. 2*: Synthesis of studies addressing the theories applied to OTC. Source: Author, 2025.*

Mechanisms	Theory Description	References
	Alliesthesia	
Personal	Alliesthesia significantly influences OTC through temporal and seasonal dynamics. Temporal alliesthesia reflects how fluctuating outdoor conditions alter skin temperature and thermal sensation. Comfort preferences also shift seasonally: slightly warm sensations are favoured in cooler periods, while cooler sensations are preferred in warmer ones. In warm, humid climates, people tend to prefer temperatures below the neutral range, whereas neutral temperatures in winter are generally higher than those in summer. Applied to children, this perspective is especially important because their thermal sensations and preferences may shift more rapidly with exposure, activity, and season, making them particularly sensitive to outdoor microclimatic variation.	(Johansson, Yahia, Arroyo, & Bengs, 2018; Dayi Lai, Zhiwei Lian, et al., 2020; Lai et al., 2014; Lai, Zhou, & Chen, 2017; Spagnolo & De Dear, 2003; Yao, Yang, Zhuang, Shao, & Yuan, 2018)
	Environmental perception theory	
	The environmental perception theory posits that objects are not perceived merely through their physical attributes but through the meanings, actions, and behaviours associated with them. When individuals experience open spaces, they form mental “images” or “schemata” that reflect prevailing	(M. H. Elnabawi & Hamza, 2019; Gibson, 1978)

	environmental conditions. These schemata emerge either from repeated exposure to similar stimuli or from salient experiences that establish lasting perceptual biases. In the case of children, this theory helps explain how outdoor spaces are not experienced only as physical settings, but as environments interpreted through play, movement, familiarity, and perceived safety.	
	Ecological systems theory (EST)	
Environmental	EST, posits that human experience is shaped through nested, interacting environmental systems rather than by immediate physical conditions alone. Applied to OTC, EST reveals that children's thermal experience in outdoor spaces is not determined solely by microclimatic parameters, but is equally conditioned by proximal systems, family practices governing outdoor activity timing, school schedules that impose exposure during peak thermal stress hours, and neighbourhood spatial conditions that limit access to shaded or thermally comfortable areas. At the mesosystem level, inconsistencies between home, school and public space thermal conditions compound children's vulnerability by preventing consistent thermoregulatory adaptation. At the macrosystem level, urban planning policies and GUD investment decisions determine the thermal quality of the outdoor spaces children inhabit. EST therefore reframes OTC not as a purely physical measurement problem but as a multi-scalar condition.	(Bronfenbrenner, 1979)
	Theory of Semiotics	
	This theory concerns the study of environmental signs, functioning as an epistemological approach to understanding their existence within social life. It highlights sensory elements such as odours, sounds, light, and thermal conditions as central to shaping individuals' perceptions of their surroundings. At its core, the theory examines how meanings are generated and how these meanings are intrinsically connected to the physical environment. For children, such environmental signs may strongly influence whether a place is perceived as comfortable, welcoming, stressful, or unsuitable for play and social interaction.	(Peirce, 1934)
	Theory of Place	

	This theory conceptualises place as a multidimensional construct that extends beyond physical location to encompass social, cultural, emotional, and symbolic meanings derived from human experience. It is constituted through the interplay of three components: location, or the physical setting; locale, the material environment enabling social interaction; and sense of place, the affective and cognitive attachments individuals develop. Place identity is both personal and collective, shaped by emotional bonds, memories, and socio-cultural narratives that distinguish one place from another. This is especially pertinent to children, whose attachment to outdoor places is often closely tied to routine, memory, play, and the degree of comfort or discomfort experienced there.	(Ehrkamp, 2006; Proshansky, 1978; Relph, 1976; Tuan, 1977)
	Theory of Public Space and Public Life	
Behavioural	This theory frames public space as a vital social and physical domain where collective life unfolds, enabling democratic interaction, cultural expression, and community engagement (Habermas, 1962; Mitchell, 2003). Streets, squares, parks, and plazas function as commons in which individuals and groups negotiate norms, identities, and power relations, sustaining civic participation and social cohesion (Jacobs, 1961; Gehl, 2011). The spatial design and organisation of these environments shape patterns of interaction, inclusivity, and visibility, determining who participates in public life and how it is enacted. At the same time, the theory highlights tensions between openness and exclusion, as processes of privatisation, regulation, and design may restrict access and challenge democratic ideals (Mitchell, 2003; Low & Smith, 2006). In contemporary urban contexts, globalisation and commercialisation further transform these spaces, redefining their functions and meanings. From a child-centred perspective, this theory helps to assess whether public spaces are not only thermally tolerable, but also inclusive and supportive of children's everyday presence and activity.	(Habermas, 1991)
	Environmental Behavioural Learning Theory	
	Environmental Behavioural Learning Theory, rooted in behaviourism, explains human behaviour as shaped by conditioning processes arising from direct interactions with the environment (Watson, 1913; Skinner, 1938). It emphasises observable stimulus–response associations, where reinforcement	

and punishment determine the acquisition, modification, or extinction of behaviours. Incorporating classical conditioning, operant conditioning, and observational learning, the theory highlights how environmental contingencies initiate, sustain, or inhibit actions. Although originally downplaying cognitive processes, later interpretations recognise the role of environmental affordances in enabling perception, adaptation, and agency (Gibson, 1979). In relation to children, this suggests that repeated exposure to thermally comfortable or uncomfortable outdoor settings may shape their spatial behaviour, play patterns, and willingness to use particular spaces.

3. Perception of OTC

Researchers use a variety of methods to determine OTC, combining both subjective (how people feel) and objective (measured environmental) approaches. Children are generally less sensitive to changes in weather and have a higher tolerance for cold than adults (W. Chen, Deng, & Cao, 2022). Their neutral (most comfortable) temperature is often lower than that of adults. The most common methods include thermal sensation, thermal neutrality, thermal acceptability, and thermal preference, often used together for a comprehensive assessment.

3.1. Thermal sensation and neutral temperature

Thermal sensation constitutes a psychophysical construct denoting the subjective cognitive interpretation of ambient thermal stimuli, expressed through conscious recognition of warmth or coldness. This perceptual state arises from the integration of neurophysiological signals (cutaneous thermo receptor activation, core temperature fluctuations) and contextual cognition, representing the mind's qualitative assessment of net bodily heat exchange. Standardised quantification employs categorical scales, most notably the ASHRAE 7-point thermal sensation scale (–3 cold to +3 hot) – where the neutral midpoint (0) signifies absence of thermal desire, denoting neither impetus for behavioural thermoregulation nor conscious discomfort. Critically, this metric captures perceived thermal strain rather than objective physiological state, with responses mediated by expectancy, acclimatisation history, and cultural norms. Children’s thermal sensation responses on standard scales may be less reliable than in adults, as their capacity to consciously articulate thermal states is developmentally constrained.

3.2. Thermal acceptability

Thermal acceptability refers to occupants' willingness to tolerate or "accept" a given thermal environment even if it is not perfectly comfortable. Bordass & Leaman (1997) observed that occupants often "forgive" imperfections when they can exercise control over their environment; they may not be in an ideal state of comfort, yet still consider the conditions tolerable or not bad enough to complain (Bordass & Leaman, 1997; Dawe, Karmann, Schiavon, & Bauman, 2021). In thermal comfort standards, acceptability is quantified by occupant voting. ASHRAE Standard 55 (2017) stipulates that an environment is acceptable when at least 80 % of occupants vote within the three central categories of a seven-point thermal sensation scale (-1, 0, or +1), i.e., slightly cool to slightly warm. Earlier versions of the standard were stricter: in ASHRAE 55–2013, the neutral category (0) was the lowest threshold for a positive vote, whereas the 2017 revision equates even "slightly dissatisfied" (-1) with acceptability (Munonye, 2020). Children's acceptability thresholds differ from those encoded in ASHRAE 55, which was developed on adult populations, a limitation directly relevant to child-specific OTC assessment in outdoor environments.

3.3. Thermal preference

Thermal preference describes an occupant's desire to make the environment warmer, cooler, or to remain as it is. It differs from thermal sensation and comfort: people may feel slightly warm yet prefer the temperature to stay the same; conversely, they may feel cool but want it warmer. Schweiker et al. (2018) noted that the literature on human thermal perception uses several terms, including *thermal sensation*, *thermal preference*, *thermal dissatisfaction*, and *thermal comfort*, to describe related but distinct aspects (M. Schweiker, Huebner, Kingma, Kramer, & Pallubinsky, 2018). In their review, they stressed that thermal sensation and thermal comfort are not equivalent because a warm sensation can be judged comfortable or uncomfortable depending on context and personal preference. Children's thermal preferences are further mediated by activity level and play intensity, meaning their stated preference may shift rapidly within a single outdoor session.

4. Thermal comfort standards

Thermal comfort standards provide the regulatory and methodological foundation upon which assessment indices, measurement protocols and comfort benchmarks are built. The principal international bodies promulgating standards for indoor thermal environments are the

International Organisation for Standardisation (ISO 7730:2005), the Comité Européen de Normalisation (CEN EN 16798-1:2019) and ASHRAE 55-2017 (Munonye, 2020). While these standards constitute the foundational framework for indoor thermal assessment, their direct applicability to outdoor settings is limited. OTC occurs in the absence of equivalent internationally codified outdoor standards, relying instead on empirically validated indices such as UTCI, PET and SET (O. Potchter, P. Cohen, Tzu-Ping Lin, & A. Matzarakis, 2018). Critically, none of these standards were developed using child populations; their physiological reference models are based on adult metabolic rates and body dimensions, rendering their comfort thresholds structurally inappropriate for assessing children's OTC.

4.1. International Standard ISO 7730

ISO 7730:2005 specifies methods for assessing and designing indoor thermal environments based primarily on the PMV and Predicted Percentage Dissatisfied (PPD) indices. It sets acceptable limits for general thermal comfort and addresses local discomfort factors including radiant temperature asymmetry, draught and vertical Ta differences. While its PMV framework has informed the development of outdoor indices, its indoor derivation and adult-based metabolic reference values limit its direct application to children in outdoor environments (Alfano, Cannistraro, d'Ambrosio, & Rizzoa, 1996; Olesen & Parsons, 2002).

4.2. European Standard CEN EN 16798-1:2019

EN 16798-1:2019, which supersedes EN 15251:2007, specifies indoor environmental input parameters for building design and energy performance assessment, covering thermal comfort, air quality, lighting and acoustics (Olesen, 2015). It distinguishes between mechanically and naturally ventilated buildings and supports implementation of the Energy Performance of Buildings Directive. Like ISO 7730, its comfort criteria are derived from adult occupant populations and are not applicable to outdoor or child-specific thermal assessment without modification.

4.3. ASHRAE Standard 55-2017

ASHRAE Standard 55-2017 establishes the framework for evaluating thermal comfort in occupied spaces through two complementary approaches: the PMV-based predictive model and the adaptive comfort model. The adaptive model is particularly relevant to outdoor-adjacent research as it acknowledges that occupants in naturally ventilated conditions tolerate wider

thermal ranges than those in mechanically conditioned spaces (Munonye, 2020). However, the standard's adaptive model was calibrated on adult populations, and its comfort bands cannot be directly applied to children, whose thermoregulatory responses and adaptive capacity differ fundamentally from the reference adult assumed by the model (Zheng et al., 2024).

5. Parameters of OTC

To achieve acceptable OTC, it is essential to address both environmental and personal factors. OTC is primarily influenced by two categories of factors: environmental (including Ta, Tmrt, AV, and RH) and personal (notably clothing insulation and metabolic rate) (Fanger, 1970; Munonye, 2020; Szokolay, 2012).

5.1. Environmental factors

5.1.1. Air Temperature (Ta)

Ta: refers to the temperature of the air surrounding a person in an outdoor environment and is a primary factor influencing how users perceive the environment outside (Guangmeng Bian, Zihao Sheng, Ke Min, & Yan Zhao, 2025; M. Elnabawi & Hamza, 2020). It directly affects the body's heat exchange with the environment and, together with other parameters like RH, AV, and solar radiation, determines overall thermal sensation and comfort (O. Potchter et al., 2018). When Ta rises, users generally feel warmer and may reduce clothing, while lower Ta can lead to discomfort or even health risks such as hypothermia if not properly managed (Bian et al., 2023). Ta is often measured at a standard height (usually 1.5 metres above ground) to represent the conditions experienced by people (Jing, Qin, Mu, Ge, & Dong, 2024).

5.1.2. Meant Radiant Temperature (Tmrt)

Tmrt is defined as "*the uniform temperature of an imaginary enclosure made of black surfaces in which the radiant heat transfer from the human body (with emissivity ε=1) equals the radiant heat transfer in the actual non-uniform enclosure*" (Heating, Refrigerating, Engineers, & Institute, 2004). Tmrt accounts for all shortwave (solar) and longwave (thermal) radiation received by the human body from the sun, sky, ground, buildings, and other surrounding surfaces, making it a crucial parameter for assessing how people experience heat outdoors, especially under sunny conditions (Badino et al., 2021; Gál, 2020). Unlike Ta, which only measures Ta, *Tmrt* reflects the combined effect of all radiant energy sources and sinks, and can

vary significantly depending on shading, surface materials, and urban geometry (Manavvi & Rajasekar, 2020). The equation is provided below for reference:

$$Tmrt = \left[\left(T_g + 273.15\right)^4 + \frac{1.335 \times 10^8 AV^{0.71}}{\varepsilon D^{0.4}} \cdot \left(T_g - T_a\right) \right]^{\frac{1}{4}} - 273.15$$

Where:

Tg: Globe temperature

D: Diameter of the Globe Thermometer

ε: Emissivity of the Globe Sensor

5.1.3. Air Velocity (AV)

AV is defined as 'the average of the instantaneous AV over an interval of time' (ASHRAE, 2017). AV enhances heat loss from the body through convection and evaporation, making users feel cooler, especially in warm or hot conditions (Cen, Cheng, & Wong, 2023; X. Jia, Wang, Zhu, Ji, & Cao, 2022). Appropriate air movement can compensate for higher Ta, improving thermal comfort and expanding the range of acceptable OTC. However, in cold environments, high air velocity can increase heat loss and lead to discomfort or even cold stress (Guangmeng Bian et al., 2025). AV is typically measured in metres per second (m/s) at a standard height relevant to human experience, such as 1.5 metres above ground (Elraouf, Elmokadem, Megahed, Eleinen, & Eltarabily, 2022).

5.1.4. Relative Humidity (RH)

According to ASHRAE (2017), RH is the ratio of the existing water vapour pressure in air to the maximum possible water vapour pressure (saturation pressure) achievable at that specific temperature and total pressure. RH is influenced by both temperature and the amount of moisture in the air; warmer air can hold more water vapour, so RH decreases as temperature rises if the moisture content stays the same. This parameter is crucial in meteorology, building design, and health, as it affects comfort, the spread of infectious agents, and the integrity of materials and biological barriers in the respiratory system.

5.2. Personal factors

5.2.1. Clothing insulation

Clothing insulation quantifies how effectively garments resist heat transfer between the human body and the surrounding environment, and is expressed in clo units, where 1 clo represents the insulation required to maintain a resting adult in comfort at approximately 21°C in still indoor air. The insulation value of an ensemble depends on garment type, thickness, layering, and the volume of air trapped within and between clothing layers; these values can be measured for the whole body or specific body parts to account for localised thermal exposure (Y. Tang et al., 2023; Y. Tang, Yu, Zhang, Li, & Ye, 2022). In outdoor environments, two correction factors are critical: AV reduces effective clothing insulation by disrupting boundary air layers held against the body, whilst body movement, particularly walking or running, further compresses garments and reduces trapped air volume, with studies confirming reductions of 29–47% in total thermal insulation under realistic outdoor wind conditions (Havenith, 2007). Advanced measurement methods, including infrared cameras and thermal manikins, allow for accurate non-contact quantification of these dynamic insulation values under varying environmental conditions (J.-H. Lee, Kim, Kim, & Kim, 2016). Environmental factors like AV can greatly reduce the insulation provided by clothing, while Ta and RH have a more limited effect (Zemzem, Hallé, & Vinches, 2022). Children in outdoor playground settings typically wear low-insulation summer clothing (0.3–0.5 clo), consistent with warm-season outdoor activity, yet they possess a fundamentally limited capacity to voluntarily self-regulate clothing in response to changing thermal conditions, unlike adults who adaptively add or remove layers (O. Potchter et al., 2018; Zheng et al., 2024).

5.2.2. Metabolic rate

In OTC assessment, metabolic rate quantifies the rate of internal heat production by the human body and is expressed in *met* units, where 1 met represents the energy expenditure of a seated adult at rest, equivalent to approximately 58 W/m² of body surface area (Fanger, 1970). Activity level is the principal determinant of metabolic rate in outdoor settings: light walking corresponds to approximately 2.0–2.5 met, whilst children engaged in active play, running, climbing, or vigorous outdoor activity, typically operate between 3.0 and 5.0 met, substantially exceeding the sedentary adult reference value assumed by standard thermal comfort models (Fanger, 1970; Szokolay, 2012). This elevated internal heat production increases the body's thermoregulatory demand and heightens vulnerability to heat stress under equivalent environmental conditions. Children's higher metabolic rates per unit body surface area,

resulting from their greater surface-area-to-mass ratio relative to adults, amplify this effect further, as proportionally more heat is generated relative to the body's capacity to dissipate it (Zheng et al., 2024).

5.3. Other determinants of comfort

Beyond the primary environmental and personal determinants of occupant environmental acceptance discussed previously, research identifies additional variables potentially influencing thermal comfort perception. Studies indicate factors like workplace design elements (view quality, privacy, cleanliness, aesthetics, and layout), strongly linked to overall satisfaction, may also affect thermal perception. Furthermore, building type, occupant characteristics (nationality, age, menstrual cycle), behaviours (smoking, coffee consumption), psychological factors (job stress), and environmental control capacity have been cited as thermal comfort influences (Munonye, 2020). Field studies may yet uncover other undiscovered variables affecting this perception. Additional known factors impacting occupant comfort include:

5.3.1. Local thermal discomfort

Local thermal discomfort refers to the sensation of discomfort experienced in specific parts of the body due to uneven or inadequate thermal conditions, rather than a general feeling of being too hot or cold overall (Liang, He, Li, Yin, & Hu, 2024; Lijuan Wang, Chen, & Chen, 2019). In outdoor environments, this discomfort arises when exposed body parts, particularly the head, face, hands and lower limbs, are subjected to intense solar radiation, cold wind, or hot surface radiation from ground materials such as asphalt or concrete, even when overall ambient temperature remains moderate (Manavvi & Rajasekar, 2020). This is particularly significant for children in playground settings, whose shorter stature places their head and limbs in closer proximity to heat-radiating ground surfaces, intensifying local radiant exposure relative to adult users at the same location (J. K. Vanos, 2015). Research confirms that cold discomfort tends to have a more localised bodily origin, whilst warm discomfort is perceived more globally across the body, and that discomfort in even a few key body regions can significantly reduce overall thermal comfort ratings (Liang et al., 2024). Addressing local thermal discomfort in outdoor space design therefore requires attention to surface material selection, shading geometry, and wind exposure patterns at child height rather than standard adult measurement levels (Z. He, Zhao, Yin, & Chen, 2023).

5.3.2. ‘Draft’ or Draught

Draft’ or Draught refers to the sensation of unwanted or excessive air movement that causes local thermal discomfort, particularly when it cools specific body parts more rapidly than the rest of the body. Whilst moderate air movement in outdoor environments can enhance thermal comfort by increasing convective and evaporative heat loss during warm conditions, draughts become problematic when wind speed is high, cold, or gusty, producing discomfort even when overall ambient temperature is acceptable (Cen et al., 2023). In urban outdoor spaces, wind patterns are directly shaped by building geometry, street canyon orientation, vegetation density, and open area configuration, creating localised zones of elevated AV that disproportionately affect users at lower heights, including children whose full body is exposed within the most turbulent near-ground wind layer (Pardeep Kumar & Arun Sharma, 2020; Z. Liu, Li, & Xi, 2023a; S. Shooshtarian, Lam, & Kenawy, 2020). Managing draught conditions is therefore a critical design consideration in outdoor places, particularly playgrounds.

6. OTC indices

Evaluating OTC relies on a range of indices that help interpret environmental conditions. Potchter et al. (2018) showed that four models dominate the field: PET, PMV, UTCI, and SET, together accounting for over half of the studies reviewed (Dayi Lai, Zhiwei Lian, et al., 2020). Although these indices were largely developed for the general population, they remain relevant to this thesis because they provide a basis for assessing the OTC experienced by children, while also requiring careful interpretation in light of children’s greater sensitivity and more limited adaptive capacity. OTC models may therefore be grouped into two main categories: *mechanistic* and *empirical*.

6.1. Mechanism models

Mechanism models, which can be further divided into equivalent temperature and thermal load models, are based on the human thermal balance (Dayi Lai, Zhiwei Lian, et al., 2020). The concept of equivalent temperature constitutes the predominant modelling paradigm within outdoor thermal comfort research. Numerous established models, such as the PET, UTCI, SET, and its outdoor variant OUT_SET (Pickup & de Dear, 2000), fundamentally represent forms of equivalent temperature. This metric is formally defined as the Ta within a standardised indoor environment that would elicit identical physiological responses, including skin temperature,

core temperature, and skin wetness, as those observed under the actual, complex outdoor conditions being assessed. The principal distinction between various equivalent temperature indices resides in the specific human thermophysiological model employed to calculate these underlying physiological responses. For instance, PET utilises the two-node Munich Energy-balance Model for Individuals (MEMI) (Höppe, 1993), whereas SET and OUT_SET are derived from the two-node model originally developed by Gagge et al. (1971).

6.1.1. Universal Thermal Climate Index (UTCI)

UTCI is a bioclimatic index that was established by a multidisciplinary group (Błażejczyk et al., 2010), designed to assess the thermal stress experienced by humans in outdoor environments. It is based on Fiala's advanced multi-node model of human thermoregulation (Fiala, Havenith, Bröde, Kampmann, & Jendritzky, 2012), which simulates the dynamic physiological response of the human body, including factors like core and skin temperatures, sweat production, and blood flow, to the combined effects of Ta, AV, RH, and radiation (Di Napoli, Pappenberger, & Cloke, 2018). Besides using an advanced multi-node human heat transfer model, UTCI has made other improvements, such as employing a self-adaptive clothing model.

$$UTCI = f(Ta\ ;\ Tmrt;\ AV;\ vp) = Ta + Offset(Ta\ ;\ Tmrt;\ AV;\ RH)$$

f: UTCI uses a big 200-term polynomial approximation. This polynomial was derived from thousands of simulations with the Fiala human energy balance model and survey results of adaptive clothing behaviour in the outdoors.

6.1.2. Physiological Equivalent Temperature (PET)

PET is a thermal comfort index derived from the human energy balance. It translates the combined effects of meteorological variables, such as Ta, RH, AV, and radiation, on humans into an equivalent temperature value (°C) that reflects the thermal stress or comfort experienced by a person (Jing et al., 2024). Whilst both the PET and the SET are predicated upon a two-node thermophysiological model, a fundamental distinction resides in their operational parameters. SET is derived following the imposition of steady-state comfort conditions upon the model, whereas PET may be employed to evaluate both stable and transient thermal environments. The primary objective of PET is to ascertain the air temperature within a standardised indoor setting that would elicit an identical physiological response to the complex

outdoor environment under analysis. Building upon this principle, the MEMI, which serves as the foundation for PET, formulates the human body's fundamental energy balance through the following equation (Ulu, 2023):

$$M + W + R + C + E_D + E_{Re} + E_{Sw} + S = 0$$

(M = metabolic activity, W = physical effort, R = body net radiation, C = Convective heat flow, ED = latent heat flow, ERe = sum of heat flows for heating, ESw = heat flow due to sweat evaporation.)

Thermal load: In these models, "thermal load" refers to the net heat stress on the body, the difference between the heat the body produces and the heat it can lose to the environment. This determines whether a person feels hot, cold, or comfortable (Holopainen, 2012; Ji, Song, & Shen, 2022). The most traditional thermal load model is the PMV, which calculates comfort based on the balance between the body's heat production and heat loss to the environment. PMV assumes the human body is a passive recipient of thermal stimuli and does not account for active thermoregulation (Holopainen, 2012).

6.1.3. Predicted Mean Vote (PMV)

PMV is an internationally recognised thermal comfort index that predicts the average thermal sensation of a large group of people in a specific environment. PMV is calculated based on a combination of environmental factors, Ta, RH, AV, and Tmrt, and personal factors such as metabolic rate and clothing insulation. The index is quantified on the standardised ASHRAE scale (ranging from -3, denoting cold, to +3, indicating hot), anticipated from a cohort of occupants within a given thermal environment. This index is intrinsically linked to the PPD, a metric expressing the estimated proportion of individuals likely to experience thermal dissatisfaction (Coccolo, Kämpf, Scartezzini, & Pearlmutter, 2016). The underlying methodological framework governing PMV and PPD is comprehensively delineated within ISO 7730:2005. Originally conceptualised and validated for indoor applications by Fanger (1970, 1972), the PMV-PPD paradigm has subsequently been adapted for outdoor thermal assessment. This adaptation requires the incorporation of meteorological data inputs, specifically integrating shortwave and longwave radiative flux densities, along with detailed anthropometric data related to occupant activity levels and clothing insulation. As illustrated in Figure 2.4, each PMV value can be approximately mapped onto equivalent PET and UTCI ranges and onto a

defined thermal perception category. This correspondence is descriptive rather than a calibrated conversion, since PMV, PET, and UTCI are based on different assumptions regarding clothing, metabolic rate, and the time resolution of the thermal balance.

PMV	PET (°C)	UTCI (°C)	Thermal Perception	Grade of Physiological stress
-3	< 4	< -40	Very Cold	Extreme cold stress
-2.5	4-8	-40 to -27 -27 to -13	Cold	Strong cold stress
-1.5	8-13	-13 to 0	Cool	Moderate cold stress
-0.5	13-18	0 to +9	Slightly Cool	Slight cold stress
0	18-23	+9 to + 26	Comfortable	No thermal stress
0.5	23-29		Slightly Warm	Slight heat stress
1.5	29-35	+26 to +32	Warm	Moderate heat stress
2.5	35-41	+32 to +38	Hot	Strong heat stress
3	>41	+38 to +46 >46	Very Hot	Extreme heat stress

Figure 2. 4: *PMV's association with OTC and its relationship with PET and UTCI. Source: Adapted from (Ulu, 2023).*

6.2. Empirical models

Empirical models in OTC are statistical or data-driven models developed from field measurements and subjective surveys, designed to predict or assess human thermal sensation and comfort in outdoor environments by capturing the observed relationships between environmental variables and human responses, often tailored to local conditions and populations (Z. Fang et al., 2020; Y. Liu et al., 2022). Studies have shown that empirical models may outperform traditional theoretical indices (like PMV or PET) in predicting actual outdoor thermal sensation, especially when local adaptation and specific environmental factors are significant. Empirical models are constructed using statistical methods (e.g., multiple linear regression) that relate measured microclimatic variables and subjective comfort votes from field surveys to predict thermal sensation or comfort levels (Z. Fang et al., 2020; Y. Liu et al., 2022). These models often reflect local climatic conditions and population adaptations, providing more accurate predictions for specific regions or populations than universal theoretical indices (Onteiro & Peinado, 2011). A nomenclature of empirically derived regression models has been advanced in the scholarly literature to quantify outdoor thermal perception. These include

regionally-specific indices, such as the Turkish Outdoor Comfort Index (TOCI) proposed by Canan et al. (2019), the Mediterranean Outdoor Comfort Index (MOCI) developed by Salata et al. (2016), and the Thermal Comfort Index for Cities of Arid Zones (IZA) conceived by Ruiz and Correa (2015) (Canan, Golasi, Ciancio, Coppi, & Salata, 2019; Ruiz & Correa, 2015; Salata, Golasi, de Lieto Vollaro, & de Lieto Vollaro, 2016). Furthermore, perceptually oriented models have been formulated, exemplified by the Actual Sensation Vote (ASV) by Nikolopoulou (2004) and the Thermal Sensation (TS) model, with subsequent iterations by Givoni et al. (2003) and Cheng et al. (2012) (Givoni et al., 2003; Nikolopoulou, 2004). In a synthesising endeavour, Golasi et al. (2018) consolidated regression models from an array of international studies to construct an overarching Global Outdoor Comfort Index (GOCI) (Golasi, Salata, de Lieto Vollaro, & Coppi, 2018). It is pertinent to note that the predominant methodological framework for these predictive tools is multivariate linear regression.

6.2.1. Actual Sensation Vote (ASV)

ASV is an empirical thermal comfort index created under the RUROS (Rediscovering the Urban Realm and Open Spaces) project. It differs from predictive models like the PMV because it is based on observations rather than simulation. ASV combines direct microclimatic measurements with subjective survey data to capture how people actually feel in outdoor environments; it thus relies on both on-site meteorological readings and responses to questionnaires collected across multiple European countries (Kalogeropoulos, Dimoudi, Toumboulidis, & Zoras, 2022). Participants are asked to rate their perceived thermal comfort on a five-point scale: −2 for "very cold," −1 for "slightly cold," 0 for "comfort," 1 for "slightly warm," and 2 for "very warm"(Kalogeropoulos et al., 2022). By using these votes alongside measured variables, researchers derive linear regression equations that estimate the actual sensation vote. For example, Nikolopoulou's 2004 formulation expressed ASV as a function of Ta, the difference between globe (TGA) and Ta, AV and RH (Nikolopoulou, 2004):

$$ASV = 0.061Ta + 0.091TGA - 0.324AV + 0.003RH - 1.455$$

7. Human heat balance

Human heat balance refers to the dynamic equilibrium between the heat generated within the body, primarily through metabolism and physical activity, and the heat dissipated to the surrounding environment via radiation, convection, conduction, and evaporation (Cramer,

Gagnon, Laitano, & Crandall, 2022; Cramer & Jay, 2016; A. Gagge & Gonzalez, 2011; Kenny & Jay, 2013). This equilibrium is regulated by physiological mechanisms, particularly changes in skin blood flow and sweating, controlled by the hypothalamus through a negative feedback system. When heat production exceeds heat loss, body heat storage increases and core temperature rises; conversely, when heat loss surpasses production, core temperature falls. Maintaining this balance, known as thermal homeostasis, is essential for sustaining core body temperature within a safe range and for understanding human responses to environmental stress, especially during physical exertion or exposure to extreme temperatures (Oded Potchter, Pninit Cohen, Tzu-Ping Lin, & Andreas Matzarakis, 2018; Sakoi, Kurazumi, Apriliyanthi, Sawada, & Gao, 2023; S. Zhang et al., 2022). In children, this balance is particularly significant, as they generally have a higher surface-area-to-mass ratio, a less efficient sweating response, and activity patterns that may intensify heat exposure while limiting self-regulation. Moreover, accurate assessment of heat balance underpins the development of thermal comfort indices, occupational safety regulations, and practical guidance concerning clothing, hydration, and activity across different climates (Cramer & Jay, 2019). From an urban and environmental perspective, it is further influenced by climatic factors such as solar radiation, AV, RH, and Ta, as well as personal factors including clothing and activity level (Kurazumi et al., 2019; Z. Liu et al., 2023a).

8. The Relation between OTC and CUL

OTC is increasingly recognised not simply as an environmental attribute of CUL, but as a basic condition that shapes whether children can safely, regularly, and meaningfully use outdoor places at all. Recent research in schoolyards, preschool yards, and children's parks shows that thermal stress reduces activity intensity, discourages use of exposed areas, and increases reliance on shaded settings, whereas vegetation, tree canopy, and other cooling measures help sustain play and outdoor stay for longer periods (Antoniadis, Katsoulas, & Papanastasiou, 2020; Lanza et al., 2022). Child-specific thermal comfort studies further suggest that adult-based benchmarks are not fully adequate for assessing CUL, because children have distinct physiological responses, different neutral and acceptable thermal ranges, and, in some situations, greater outdoor heat risk than adults (Cheng & Brown, 2020; Huang, Hong, Tian, Yuan, & Su, 2021). However, the relationship is not deterministic. A thermally moderated space is not automatically liveable for children if it lacks play affordances, spatial diversity, safety, or opportunities for social interaction. Evidence from schoolyard design studies indicates that

shade and cooling matter most when they are integrated with child-centred layouts that support varied and socially inclusive forms of use (Raney, Daniel, & Jack, 2023). OTC should therefore be understood as an enabling but insufficient condition of CUL: it influences when, where, and how children occupy outdoor space, but its contribution to liveability depends on how thermal moderation is combined with design quality, usability, and everyday child experience (N. Wallenberg et al., 2023).

9. Previous studies on OTC in Algeria

Interest in OTC research has expanded significantly in recent decades, reflecting a growing concern with the liveability and sustainability of urban environments. As cities worldwide experience rapid population growth and densification, the need for well-designed outdoor spaces that promote comfort and well-being has become increasingly urgent (Ayyad, 2020; L. Chen & Ng, 2012; Honjo, 2009). OTC studies have been conducted across diverse climatic contexts, including temperate (Lindqvist, Thorsson, & Lindqvist, 2004; Nikolopoulou & Lykoudis, 2006), subtropical (Lin, 2009), hot-humid (K. S. Ahmed, 2003; Johansson, 2006), cold (Xi, Wang, Qin, & Jin, 2020), and hot-arid regions (Ali-Toudert & Mayer, 2006; Yahia & Johansson, 2014), demonstrating the global significance of microclimatic research in guiding urban planning and design. Algerian scholarship mirrors this global trend (Table 2.3). Subsequent studies in Mediterranean and semi-arid cities extended the agenda: Annaba field campaigns and ENVI-met/RayMan simulations compared sites with and without vegetation, quantified neutral PET, and showed that compact form and trees reduce Ta and Tmrt and shift neutral comfort towards safer ranges (Boussaidi, Djaghrouri, Benabbas, & Altan, 2023). In Guelma, species/layout parameterisation demonstrated that Ficus nitida and a central row of Washingtonia can reduce Ta by up to 1.8 °C and UTCI by up to 3.5 °C during peak hours, evidencing the microclimatic leverage of tree choice and layout (Sayad et al., 2021). The work of Boukhelkhal and Bourbia (2016) in Tafilelt, Ghardaïa, was among the first Algerian studies to combine ENVI-met simulation with PMV and COMFA/Thermal Balance (TB) indices to quantify the impact of urban geometry and shade-tree configuration on OTC (Boukhelkhal & Bourbia, 2016). In the Righ Valley, Ahriz, Fezzai et al. (2019) used the SPUCAL_oec simulation model to assess the oasis effect in Djamaa city and Mazher oasis, showing that palm-grove configurations can reduce Ta by up to 6 °C and increase RH by up to 12% (Ahriz, Fezzai, & Mady AA, 2019). Long-term analyses in the Tolga oases quantified a ~76% rise in heat-stress exposure PET between 2003–2017, underscoring climate-change vulnerability and the mitigating role of palm-grove green infrastructure (Matallah, Alkama, Teller, Ahriz, & Attia,

2021). In Algiers, UTCI predicted OTC well but required sociocultural calibration of the stress scale versus a locally derived APCI (Average Perceived Comfort Index) (Talhi, Barlet, Bruneau, & Aichour, 2020). Overall, Algerian work increasingly triangulates indices (PET, UTCI, SET, PMV, mPET, MOCI) with measurement/simulation and surveys. The literature also shows that OTC is not determined by climate alone, but by the interaction between urban morphology, shading, vegetation, and locally calibrated assessment tools.

Table 2. 3: *Overview of selected studies on OTC in Algeria. Source: Author, 2025.*

Authors/ Year	**Climate**	**Location**	**Thermal index/method**	**Key results**
(Ali-Toudert, Djenane, Bensalem, & Mayer, 2005)	Hot-arid	Beni-Isguen	PET; field measurements	Deep, shaded canyons and materials reduce heat stress.
(Boukhelkhal & Bourbia, 2016)	Hot-arid	Ghardaïa	ENVI-met 3.0 simulation, combined with PMV and COMFA/TB	Urban geometry strongly influenced OTC, with design improvements increasing comfort time from 18% to 42% using PMV and from 39% to 62% using COMFA/TB
(Ahriz et al., 2019)	Hot-arid	Djamaa city and Mazher oasis, Righ Valley	Microclimatic simulation method based on SPUCAL_oec	The oasis effect improved the microclimate, reducing Ta by up to 6°C and increasing RH by up to 12%.
(Talhi et al., 2020)	Mediterranean	Algiers	UTCI vs APCI; "micrometeorological walks."	UTCI predicts well but needs local stress-scale adjustment.
(Sayad et al., 2021)	Semi-arid	Guelma	UTCI; ENVI-met + on-site data	Ficus nitida & central Washingtonia rows cut UTCI up to 3.5 °C.

(Matallah et al., 2021)	Arid (oases)	Tolga	PET; ENVI-met + RayMan; long-term	Heat-stress exposure to ~76% (2003–2017); oasis greenery mitigates.
(Boutellis & Bouchair, 2022)	Mediterranean	Jijel	PET, PMV, SET*, UTCI, PT, mPET, MOCI; RayMan/Townscope + survey	Neutral Ta ≈ 19.8–20.4 °C; index calibration advised.
(Boussaidi et al., 2023)	Mediterranean	Annaba	PET, SET*, UTCI; ENVI-met + 336 surveys	Lower vegetation & compactness

10. Previous Studies on Children's OTC in Algeria

In Algeria, research on children's OTC remains absent from the published literature, representing a critical and unaddressed gap in national OTC scholarship. The sole study identified that examines children's thermal conditions in an Algerian context is Sebaihi and Khadraoui (2023), which investigated the thermal and psychological comfort of autistic children in school buildings in Béjaïa. Using a combination of field measurements, questionnaires, and dynamic thermal simulations (ArchiWIZARD–EnergyPlus), the authors demonstrated that indoor conditions in schools frequently fell outside the comfort band of 20–25°C; up to 98% of children reported thermal dissatisfaction in summer, while staff ranked the thermal environment (95.7%) as the most influential factor on well-being. Their simulations confirmed that insulated facades and ventilated wall systems significantly improve comfort and reduce energy demand (Sebaihi & Khadraoui, 2023). While this study addresses a distinct population, autistic children, and an indoor setting, its core finding is consistent with broader evidence on child thermoregulation: children's thermal sensitivity consistently exceeds the thresholds captured by adult-calibrated assessment standards, regardless of whether the environment is conditioned or outdoor, and regardless of neurodevelopmental profile. The demonstrated link between thermal comfort, psychological well-being, and functional outcomes in Algerian school environments reinforces the case for child-specific thermal assessment in outdoor settings, where play, physical activity, and social interaction generate comparable, and often greater, levels of thermophysiological demand.

The limited evidence available on children's thermal conditions in Algeria further confirms that younger users constitute a critical and underserved population through which to assess the adequacy of outdoor public spaces. The absence of any published outdoor child-specific OTC study in Algeria constitutes the primary research gap this thesis addresses.

Conclusion

This chapter has established OTC as a key dimension of urban liveability and a particularly important issue in relation to children. It has shown that OTC is shaped by the interaction of environmental conditions, personal characteristics, and behavioural responses, and that children experience these conditions differently from adults because of their greater physiological sensitivity, distinct behavioural patterns, and more limited capacity for independent adaptation. In this sense, the chapter has demonstrated that a child-centred understanding of OTC is necessary for interpreting how outdoor environments support or constrain children's well-being, activity, and everyday use of urban space.

The review of concepts, theories, and indices further showed that OTC cannot be understood solely as a physical or climatic phenomenon. Rather, it is also mediated by perception, behaviour, social context, and the meanings attached to place. The discussion of thermal sensation, comfort standards, environmental and personal parameters, and human heat balance highlighted the complexity of evaluating OTC, whilst the review of mechanistic and empirical indices showed the importance of context-sensitive approaches, particularly in relation to children and to locally specific climates. The chapter also demonstrated that OTC has direct implications for urban liveability, as thermally supportive outdoor environments encourage use, play, movement, and social interaction, whereas thermally stressful conditions may discourage outdoor activity and heighten vulnerability. Within the Algerian context, the review revealed a growing body of OTC research, but also a clear gap regarding children's specific experience of outdoor thermal environments. This gap confirms the need for research that links thermal comfort more explicitly to CUL.

On this basis, Chapter III shifts the discussion from thermal comfort as a conceptual and environmental issue to the spatial conditions through which liveability is produced in practice. Its objective is to examine how *spatial configuration* shapes children's access to, use of, and experience within outdoor environments, and to clarify why the physical structure of urban space is central to understanding CUL in climate-responsive cities.

CHAPTER III: SPATIAL CONFIGURATION AND CHILDREN'S URBAN LIVEABILITY

"Nothing is experienced by itself, but always in relation to its surroundings."

— Kevin Lynch, The Image of the City (1960)

Introduction

Whilst Chapter II established OTC as a fundamental enabling condition of CUL, the quality of outdoor space is equally shaped by its spatial organisation, how places are connected, configured, and made accessible within the urban fabric. For this reason, the present chapter focuses on spatial configuration as another fundamental dimension of GUD. While OTC explains the environmental suitability of outdoor places, spatial configuration explains how urban space is structured, connected, perceived and accessed. In this thesis, USC is used as a broad concept referring to the organisation of streets, open spaces, green areas, neighbourhood routes and access to amenities. Within this wider field, the chapter focuses specifically on *spatial configuration* as the most relevant dimension for analysing children's movement, perception and spatial experience.

The objective of this chapter is to establish the theoretical and analytical foundation for examining how spatial configuration contributes to CUL. Particular attention is given to the role of Space Syntax theory and methodology in analysing configurational properties such as connectivity, integration, choice, depth, visibility and legibility. These properties are especially relevant to children because their use of outdoor space is strongly influenced by accessibility, visual clarity, route simplicity, safety perception and opportunities for play and social interaction.To guide the reader, Figure 3.1 presents the organisation of the chapter. It summarises its overall structure by showing the progression from the broad concept of spatial configuration, to its main configurational measures and analytical tools, and finally to its implications for children's responses and urban liveability. In this way, the figure serves as a visual synthesis of the chapter's internal logic.

The chapter is organised into four main parts. First, it introduces the concept of USC and clarifies why spatial configuration is adopted as the specific focus of the study. Second, it presents the theoretical and methodological foundations of Space Syntax, including its main concepts, tools and configurational measures. Third, it discusses the relevance of spatial configuration to CUL, particularly in relation to children's movement, safety perception, cognitive mapping and spatial experience. Finally, it reviews previous studies on spatial configuration, including studies undertaken in Algeria as well as studies specifically concerned with children's use and perception of urban space. Through this structure, the chapter

establishes the theoretical basis for the later empirical analysis of spatial configuration in relation to CUL.

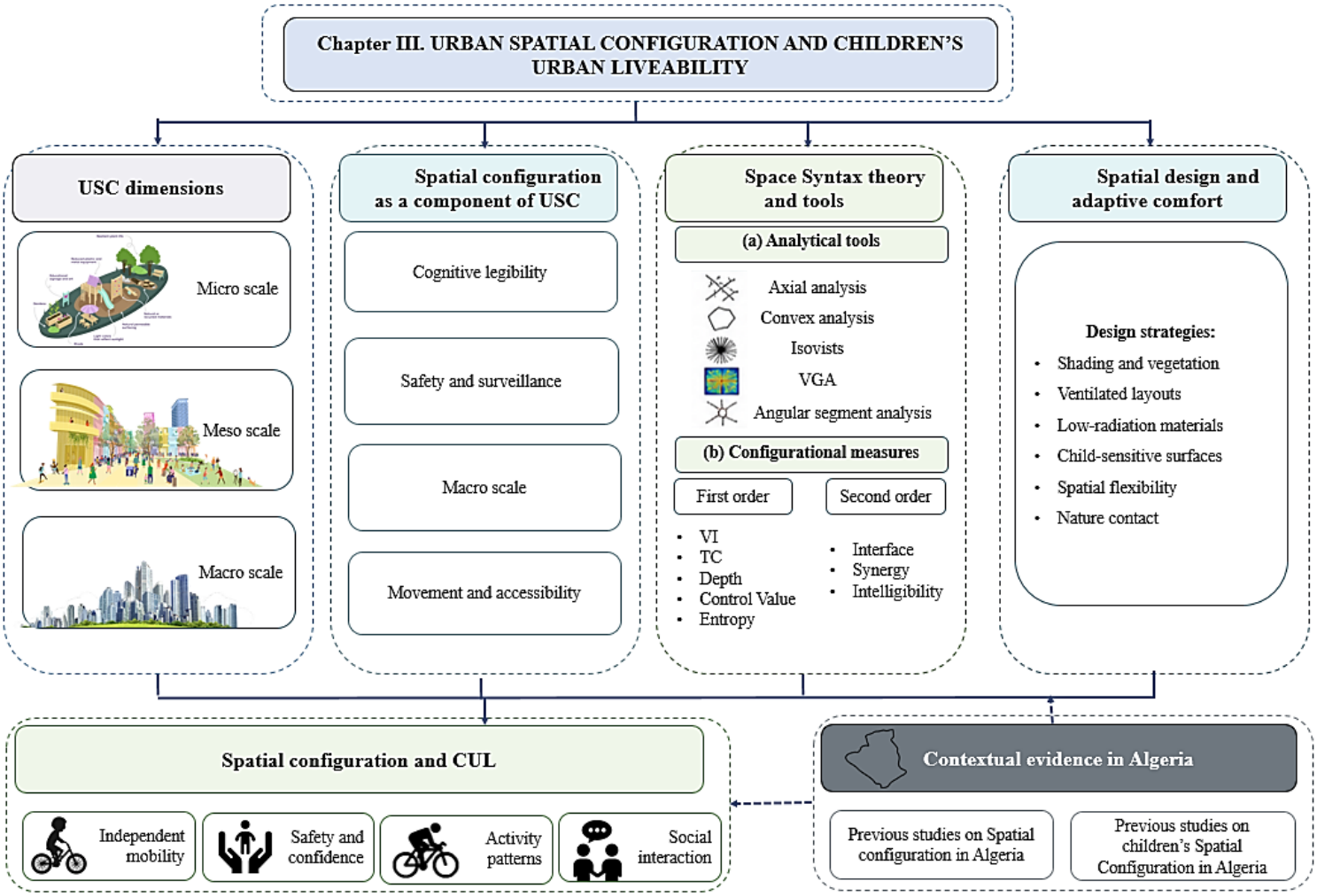


Figure 3. 1: *Structure of Chapter III. Source: Author, 2026.*

1. Notion of USC

Defining USC with analytical precision is necessary before it can serve as an operational framework for evaluating children's spatial experience, as the term encompasses dimensions ranging from macro-scale land-use patterns to micro-scale street-level conditions. Recent research on urban morphology stresses that urban form should be read as a *multi-scalar system* rather than as a set of isolated objects. Zhang, Ghosh, and Park (2023) identify major dimensions of urban morphology, while Wu et al. (2025) stress that cities are shaped by structured relationships across scales. Thus, USC can be understood as the overall organisation of urban elements and their interrelations from the micro- to the macro-scale (Wu, Wang,

Wang, Biljecki, & Kraak, 2025; P. Zhang, Ghosh, & Park, 2023). This broader notion is important because USC shapes not only physical form, but also movement, access, and everyday urban liveability. Contemporary configurational studies show that liveable urban environments depend not simply on density, but on how streets and open spaces are arranged and connected. Van Nes (2021) argues that walkability and urban compactness depend on integrated street networks, short blocks, and active building–street interfaces (van Nes, 2021). Similarly, Pellicelli et al. (2025) show that neighbourhood accessibility is shaped by both the distribution of facilities and the quality of pedestrian networks. Other studies further suggest that built-form characteristics such as street width, trees, building composition, and height influence perceived liveability and overall well-being (Pellicelli, Marinelli, Caselli, Zazzi, & Rossetti, 2025). For child-oriented urban research, this umbrella concept is especially useful because it connects the physical structure of the city with children's inclusion in public life. Ding, Carstensen, and Jørgensen (2024) show that children's spatial inclusion in urban public spaces depends on both *spatial connection* and *visual connection* between playgrounds and surrounding public spaces (Ding, Carstensen, & Jørgensen, 2024). Likewise, Félix and Organista (2023) find that the configuration and legibility of neighbourhood in-between spaces affect use, social interaction, security, and habitability (Félix & Organista, 2024). USC may therefore be understood as the wider framework through which the city organises visibility, accessibility, sociability, and environmental opportunity. Within this broad framework, *spatial configuration* can then be treated as one component of USC and, in the present thesis, as the principal analytical focus at the local scale.

1.1. Spatial Configuration as a component of USC

1.1.1. Definition and importance

Within this broader USC framework, *spatial configuration* refers specifically to the relational pattern of spaces that structure movement and co-presence (Bill & Julienne, 1984; Fezzai, Fares, Boutouata, & Benachi, 2020). Viewed from this perspective, it becomes possible to examine how the physical form of urban areas influences the social activities that occur within them. Jacobs (1961) captures this connection by arguing that lively street environments, supported by deliberate spatial design, are essential to the vibrancy and well-being of urban neighbourhoods (Jacobs, 1961). Building on this, Gehl (2010) highlights the importance of a human-centred approach to urban design, calling for environments that enhance pedestrian comfort and encourage active engagement (Gehl, 2011). This viewpoint is particularly relevant to discussions of walkability, as it underscores the need for cities to be not only reachable on

foot but also appealing to those who walk. Likewise, Whyte's (1980) studies of small urban settings demonstrate that even subtle spatial arrangements can strongly shape how people experience and move through the urban realm (Whyte, 1980). For children, spatial configuration carries additional significance: their lower physical stature alters VI within street networks, their restricted independent mobility radius makes local connectivity particularly determinant of spatial access, and their dependence on legible, safe, and socially supervised spaces makes configurational clarity a prerequisite for independent outdoor activity (Ding et al., 2024).

1.2. Spatial Configuration factors for CUL

The importance of spatial configuration for CUL stems from several key factors:

1.2.1. Cognitive Legibility

This concept, grounded in the developmental psychology of Piaget and Inhelder (1967), posits that the emerging spatial intelligence of the child requires environments with a decipherable order (Piaget, 2013a). Such legibility is achieved through clear structural hierarchies, recognisable patterns, and consistent landmarks. These elements provide the necessary perceptual framework for constructing accurate cognitive maps, thereby scaffolding wayfinding competencies. The resultant mastery not only facilitates practical navigation but also cultivates a sense of autonomous agency and confidence within the urban setting.

1.2.2. Safety and Surveillance

This principle, foundational to defensible space theory Newman (1999) and Jacobs' (1961) critique of urban planning, asserts that spatial morphology is instrumental in enabling informal social control (Jacobs, 1961; P. W. Newman, 1999). The configuration of boundaries, pathways, and activity nodes dictates the potential for natural surveillance, the capacity for residents to casually observe public and semi-public spaces. For children, whose independent mobility is contingent upon perceived security, environments with high visual permeability are paramount. Designs that strategically optimise sightlines and visual connectivity between dwellings, streets, and play areas facilitate this informal monitoring, thereby reducing perceived risk and fostering safer conditions for autonomous exploration.

1.2.3. Social Affordances

This concept, extending from Gibson's ecological psychology and central to Gehl's (1987) analysis of public life, describes the actionable social possibilities that a physical environment

presents to its users (Gehl, 1989). The spatial configuration of thresholds, edges, and gathering nodes critically shapes the socio-spatial dialectic, determining the likelihood of chance encounters, informal interaction, and the organic development of community networks. For children, whose social competencies are cultivated through repeated, often unstructured peer engagement, a socially catalytic design is essential. Environments that provide a gradient of settings, from clearly defined activity zones to ambiguous, flexible spaces, facilitate both formal play and spontaneous sociability. This careful orchestration of proximity and visibility fosters the development of social capital, cooperative skills, and a sense of embeddedness within a peer community.

1.2.4. Movement and Accessibility

This principle addresses the fundamental conflict between the efficient, linear movement paradigms of adult-centric urban design and the circular, exploratory, and often interrupted mobility characteristic of childhood. Children's movement is not merely utilitarian but is intrinsically linked to play, discovery, and social interaction (Dodd, FitzGibbon, Watson, & Nesbit, 2021). Therefore, spatial configuration must accommodate a wider modal range, from running and cycling to skipping, dawdling, and imaginative play, within the public realm. This requires a layered network of pathways that integrates clear, legible primary routes with a rich sub-structure of secondary and tertiary paths, and shortcuts (Zhou, Wang, Lin, & Qian, 2022). The critical design challenge lies in maintaining an intelligible circulatory hierarchy for safety and orientation, while simultaneously providing the spatial porosity and tactical variety that invite exploration, support developmental needs, and ultimately nurture a child's independent engagement with their neighbourhood.

1.3. Multi-Scalar dimensions of Spatial Configuration in urban space

In architectural and urban design discourse, spatial configuration operates at multiple scales simultaneously: from the micro-scale arrangement of rooms within buildings, to the meso-scale organisation of streets and public spaces within neighbourhoods, to the macro-scale structure of entire urban systems (Batty, 1997). As illustrated in Figure 3.2, these micro-scale arrangements aggregate to form neighbourhood structures and, ultimately, the broader urban system. Each scale contributes to the overall spatial experience and influences how users, particularly children, inhabit urban space.

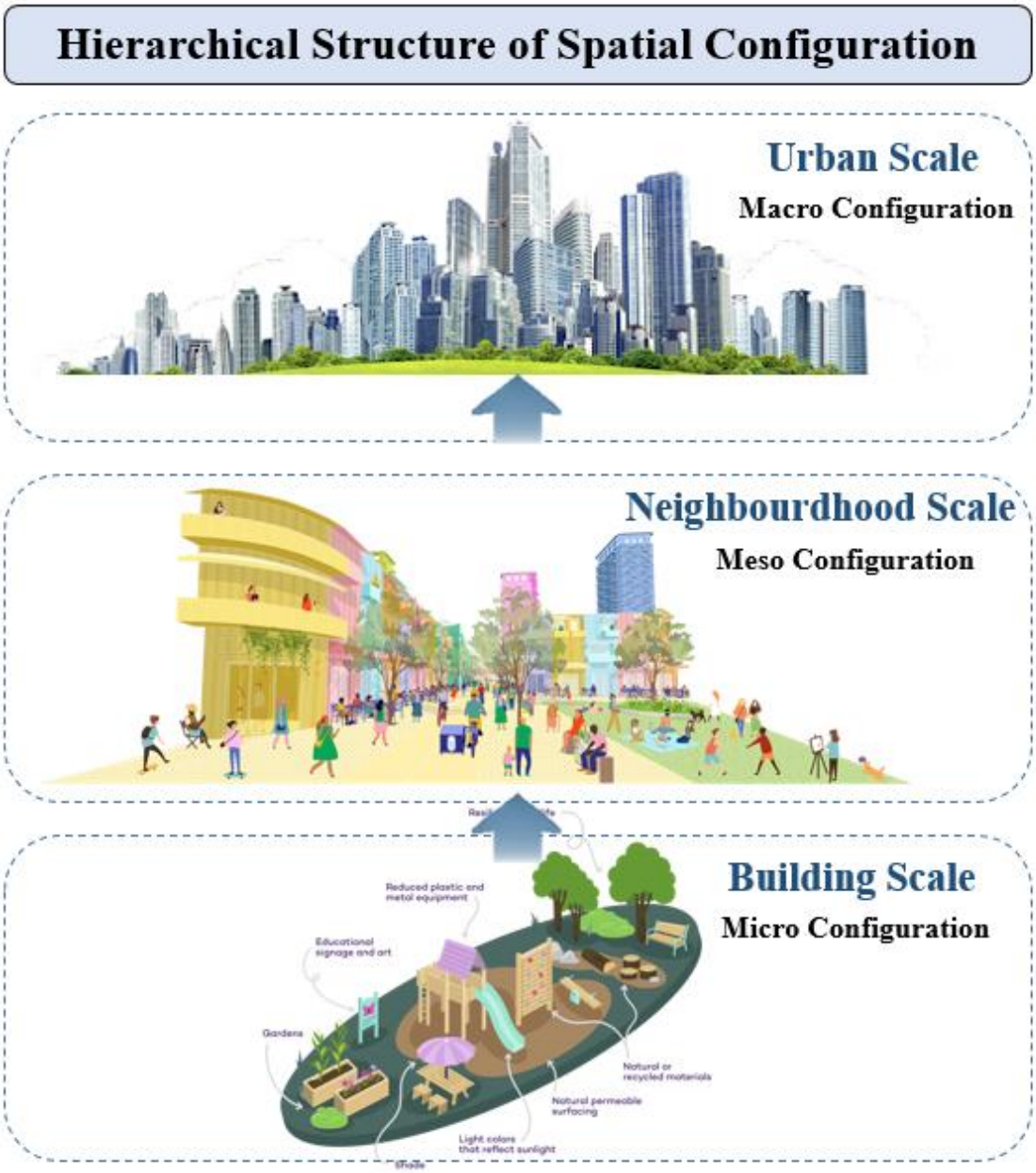


Figure 3. 2: *Multi-scalar dimensions of spatial configuration in urban space. Source: Edited by Author, 2026.*

1.3.1. Micro-Scale Configuration

At the level of proximate spaces such as playgrounds or courtyards, configuration pertains to the precise arrangement of fixed and loose elements, equipment, topography, seating, and enclosures. This detailed morphology directly shapes the affordance structure, governing peer

interaction dynamics, the ease of passive adult supervision, and the potential for children to develop a sense of territorial attachment or ownership (Moore, 1986). Effective micro-design creates a legible yet complex field for social and imaginative play.

1.3.2. Meso-Scale Configuration

At the neighbourhood scale, the connective tissue of streets, paths, and blocks is critical. The spatial configuration of this network, its permeability and integration, fundamentally shapes the safety and complexity of children's daily routes and the extent of their independent mobility. Contemporary analysis, such as the study of children's cognitive maps using justified permeability graphs, shows that well-connected, fine-grained local networks significantly deepen children's environmental experience and spatial understanding (Çanakçıoğlu, 2015). The concept of environmental affordances remains central; a permeable network maximises what children can safely do and access, from reaching friends and parks to fostering autonomous learning (D. Guo, Shi, & Chen, 2023).

1.3.3. Macro-Scale Configuration

City-wide configuration analysis examines how key destinations like parks and civic facilities are integrated into the urban grid, determining the equity of spatial capital for children across districts. Studies show that higher-density districts often face a significant mismatch between the supply and demand for child-friendly space (Su et al., 2025). Comparative analyses indicate that cities with highly integrated public space networks and equitable green infrastructure correlate strongly with greater independent child mobility. By recognising this multi-scalar nature, planners and designers can avoid the pitfall of treating child-friendly design as a matter of isolated playgrounds or token interventions. Instead, spatial configuration encourages a systemic approach, embedding children's needs into the structure of urban life.

2. Space Syntax theory and tools

2.1. Theoretical foundations

Space Syntax, as applied to urban environments, is a relational analytical framework that emerged from morphological studies (Fezzai, 2024; Hillier, 1987). The approach was originally formulated by Bill Hillier and Julienne Hanson during the 1970s at the Bartlett Unit for Architectural Studies, University College London, with support from the Science Research Council (Hillier, 1989). Conceived as a socio-spatial morphology, it links the formal organisation of built form with the social processes that shape, and are shaped by, spatial

configuration (Hillier & Leaman, 1972). The term "*Syntax*", which underpins the name of this socio-spatial theory, is understood as "a set of combinatory structures that order the world while enabling us to construct descriptions of it" (Bill & Julienne, 1984). Contrary to traditional social science perspectives in which the built environment is merely a backdrop, Space Syntax treats spatial form as a generator of social behaviour (Hillier, 1987; Vurucular & Ciravoğlu, 2011). It evaluates space according to how its configuration affects movement, co-presence, and the intensity of use. According to Peponis and Wineman (2002), Space Syntax rests on two main ideas: space is an active component of human activity, not merely a background, and human spatial experience is shaped by relationships between spaces rather than by isolated units. Movement, interaction and vision therefore have distinct spatial geometries: linear movement, convex spaces for social interaction, and variable visual fields from each observation point, all understood through the concept of "*Configuration*" (Peponis & Wineman, 2002). According to Hillier (2007), people move in linear paths, interact within convex settings, and perceive space through isovists (Figure 3.3). Each of these modes of spatial use forms a possible basis for configurational analysis (Safia, 2023). Space Syntax's capacity to quantify VI and movement potential is particularly relevant to child-centred analysis, as children's spatial behaviour, characterised by exploration, play-driven movement, and reliance on visual surveillance, maps directly onto the linear, convex, and isovist properties that the theory measures (Ding et al., 2024; Refshauge, Stigsdotter, & Cosco, 2012). Computing advances enabled the extension of the method from building and settlement scales to the analysis of large cities, metropolitan regions, and entire territories (Hillier & Tzortzi, 2006). Its application in urban studies generally involves defining spatial units, analysing urban space as a network shaped by building placement and orientation, and relating spatial structure to pedestrian flows, land use, crime, property values, and social differentiation (Hillier, Penn, Hanson, Grajewski, & Xu, 1993). It also supports theories on how urban space reflects and produces social, economic and cognitive processes (Hillier & Tzortzi, 2006). Analytically, Space Syntax measures to-movement potential through integration/closeness and through-movement potential through choice/betweenness, using metric, topological or angular distances across multiple radii (Hillier & Iida, 2005). While it does not directly assess place identity or aesthetic quality, it remains a powerful method for evaluating accessibility and predicting movement patterns (Van Nes & Yamu, 2021).

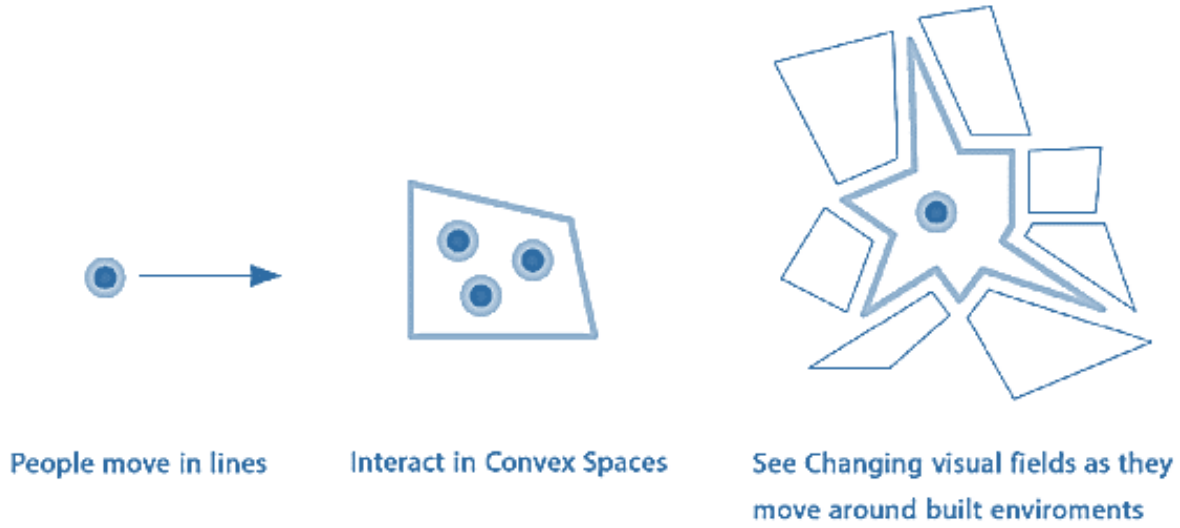


Figure 3. 3: *Space is intrinsic to Human activity, not a background to it. Source: Adapted from (Hillier, 2007).*

2.2. Spatial Configuration within the Space Syntax theory

In Space Syntax, *spatial configuration* refers to the relational structure through which spaces are connected, sequenced and accessed within a spatial system. Drawing on graph theory, spatial layouts can be transformed into justified graphs, where spaces are represented as nodes and their connections as links. This allows different configurational logics to be compared, such as shallow, ring, circuit and tree structures.

As shown in Figure 3.4, a shallow configuration reduces depth and supports easier access; a ring configuration provides alternative routes; a circuit configuration increases movement flexibility through multiple connections; while a tree configuration creates a more hierarchical and sequential layout with fewer route choices. For children, these differences are important because they influence orientation, independent mobility, visibility, safety and opportunities for social interaction.

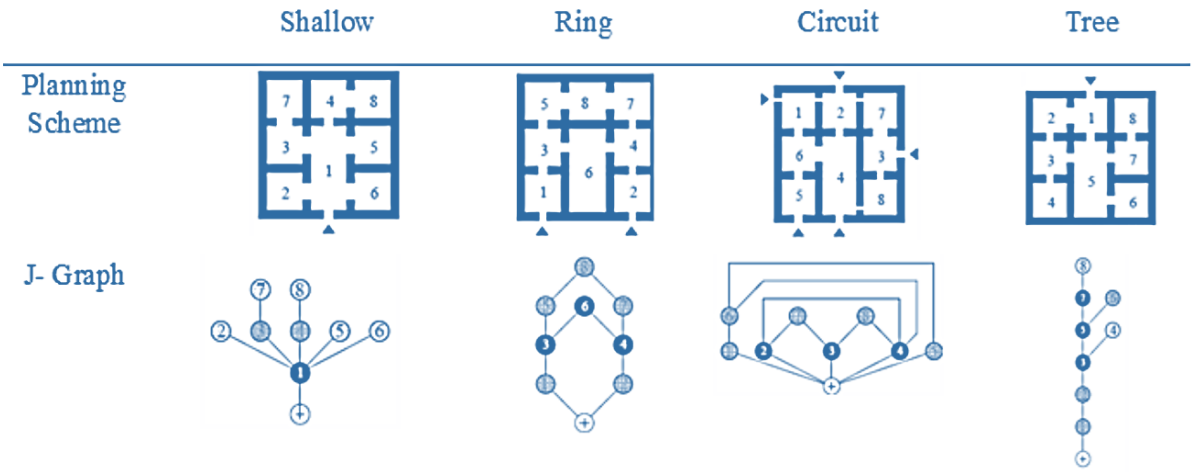


Figure 3. 4: *Different types of Configurations represented through justified graphs. Source: Adapted from (Younis & Ahmed, 2024), based on (Bill Hillier, 1996.p21).*

2.2.1. Basic configurational notions

In Space Syntax theory, architectural reality is understood through a set of fundamental concepts, which form the basis for its analytical framework.

2.2.1.1. The concept of Permeability

In Space Syntax theory, permeability is defined as a property that depends on the direct relationship between two spaces. Figure 3.5 illustrates a cell divided into three spaces, where space (a) is connected to space (b), and space (b) is connected to space (c) through an opening. This opening establishes what is referred to as a relationship of permeability. For children, physical barriers, ungated thresholds, discontinuous paths, and car-dominated junctions, have been identified as primary constraints on independent mobility, with automobile-centric spatial design shown to systematically exclude children from active, unsupervised outdoor movement even across short distances (Ibrahim, Harumain, & Rosni, 2024).



Figure 3. 5: *Permeability. Source: Adapted from (Hillier B, 1987 et Hanson, 1998).*

2.2.1.2. The concept of Depth

A core metric in Space Syntax theory, the minimum number of topological steps (changes of spatial segment) required to move from one space to another within a configured system. It is a measure of topological remove, not metric distance. Low depth indicates an integrated, permeable system conducive to movement and encounter; high depth denotes a segregated, sequential layout (Klarqvist, 2015). Studies of children's cognitive mapping demonstrate that those living in spatially deep, segregated layouts produce systematically narrower mental maps with predominantly sequential rather than integrated spatial representations, confirming that topological depth directly constrains children's environmental knowledge and spatial confidence (DEMİRKUŞAK, ŞAHİN, & ÇANAKÇIOĞLU, 2025).

3. Conventional approaches to Space Syntax

The spatial structure of a configuration can be syntactically modelled through three primary representations. The *convex map* decomposes a layout into the fewest mutually adjoining convex polygons that cover the plan, with a specialised interface map detailing permeable relations between outdoor convex spaces and building entrances. The *axial map* identifies the smallest set of straight lines that collectively cover all convex spaces and their connections. Finally, the *isovist map* delineates the visible area, or field of view, from any given convex space or axial line. Each representation can be translated into a graph for subsequent quantitative analysis of connectivity, integration, and depth (Klarqvist, 2015).

3.1. Axial analysis

3.1.1. Analytical instruments: the axial map and the axial graph

Hillier (1996) and Turner (2005) define the all-line axial map as "*a set of lines made up of all lines drawn tangent to vertices that can see each other*" (Van Nes & Yamu, 2021). The all-line axial map is derived from publicly accessible spaces, which are treated as a single spatial system while accounting for physical barriers. In neighbourhoods where the distinction between public and private realms is weak, such as in many modernist developments, the all-line axial map is particularly useful at the local scale. In such contexts, producing an axial map based on the minimum number of sightlines is generally challenging; however, the all-line approach enables a comprehensive representation of all open spaces between detached structures. Using the Space Syntax software DepthmapX, an all-line map can be efficiently generated, including integration values for each axial line. Conversely, a conventional axial map may also be produced from the all-line axial map, a method that is frequently employed by archaeologists when examining excavated urban settlements (Figure 3.6). Research applying Space Syntax

axial analysis to child walkability assessment confirmed that integration values reliably identify spatial barriers to children's independent movement within residential street networks (Gorrini, Presicce, Messa, & Choubassi, 2023).

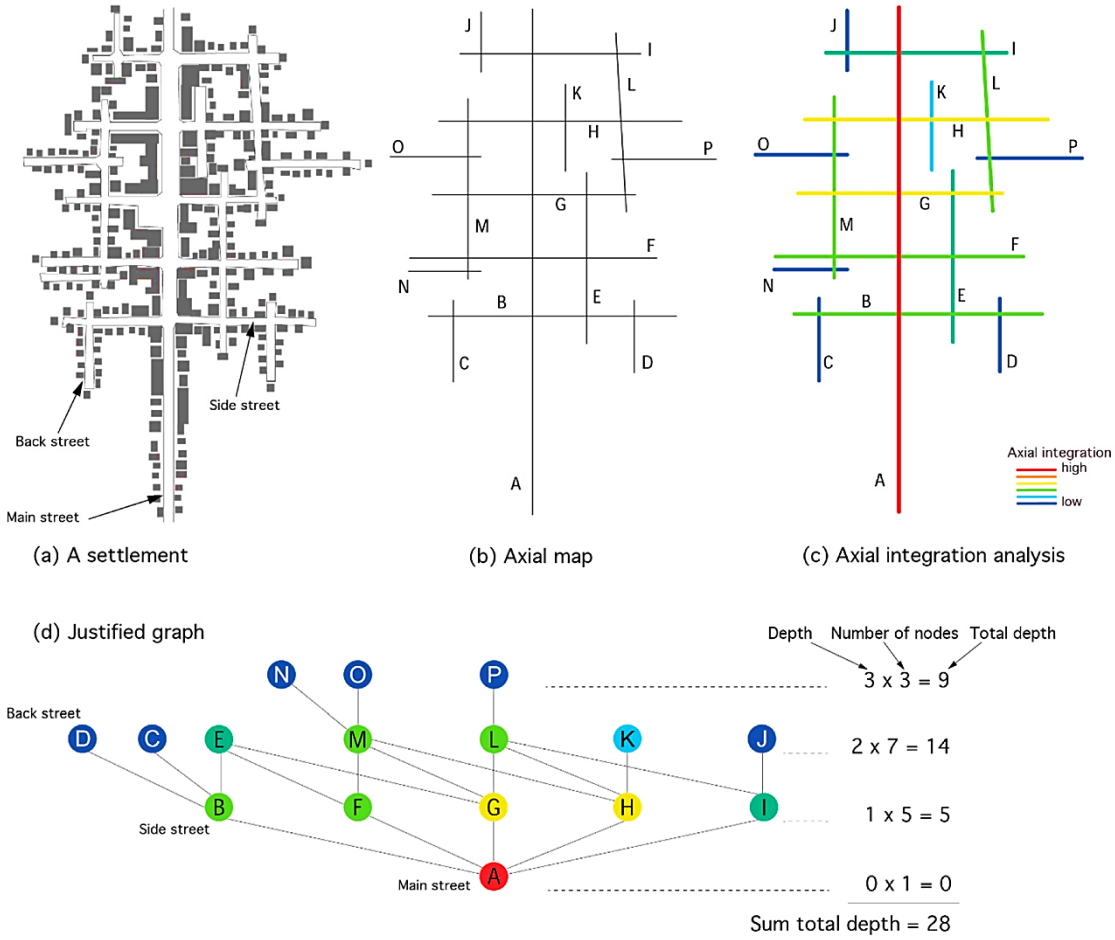


Figure 3. 6: *Axial representation, global integration analysis, and justified graph of a settlement. Source: Adapted from (Van Nes & Yamu, 2021).*

At the beginning of axial map analysis, it is appropriate to employ a simplified conceptual model (Figure 3.7a). The following stage consists of identifying and drawing the smallest possible number of the longest movement lines, or lines of sight, within the spatial system. In order to represent all potential routes of movement, these lines must cover the entire space, thereby producing an axial map (Figure 3.7b). Quantitative calculations are then performed on the resulting configuration, in which the principal elements are the nodes and the intersecting axial lines. From this axial representation, a graph of accessibility or connectivity can be generated (Figure 3.7c). This two-dimensional graph illustrates the accessibility relationships between all axial spaces within the layout. Axial lines, which represent spatial units, are depicted as nodes, while their intersections are shown as links connecting these nodes, with the nodes numbered according to the corresponding axial lines (Figure 3.7c). The number of

directly connected neighbouring nodes constitutes a local measure of connectivity. The graph is subsequently redrawn as a justified graph, in which the selected reference space is positioned at the base and referred to as the root space (Figure 3.7d). At the first level above the root space, all spaces located one syntactic step away are placed; at the second level, spaces two steps away are shown, and so on. Justified graphs thus provide a visual representation of the overall depth of a spatial layout when viewed from a specific point within the system (Figure 3.7d) (Weronika Dettlaff, 2014).

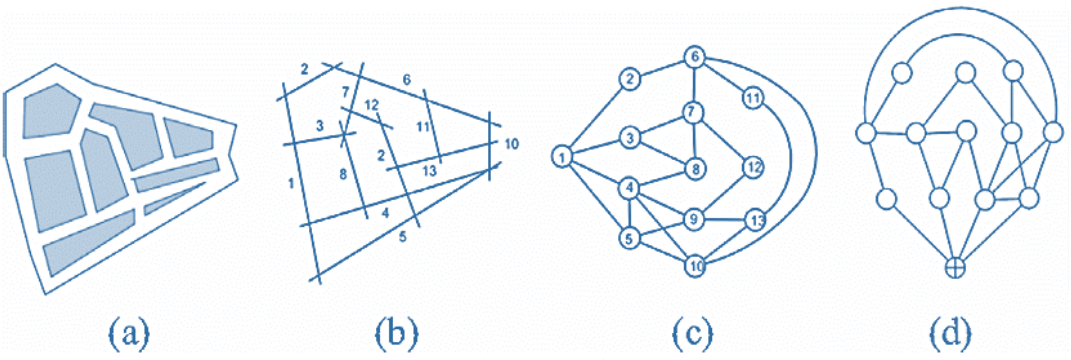


Figure 3. 7*: (a) Hypothetical urban system; (b) axial representation; (c) connectivity graph; (d) justified graph. Source: Adapted from (Jiang & Claramunt, 2002; Mustafa & Rafeeq, 2019).*

3.2. Isovist analysis

The isovist, as a method for representing the visible area from a single, clearly defined position in space, has attracted sustained interest among scholars across a wide range of academic disciplines (Conroy Dalton, Dalton, McElhinney, & Mavros, 2022). According to Benedikt, an isovist is: "*the set of all points visible from a given vantage point in space and with respect to an environment*" (Benedikt, 1979). It provides a visual representation of the panoramic field of view experienced by an observer standing at a particular location in the built environment. The boundaries of this panoramic field are determined by physical elements such as walls and freestanding objects, including trees, shrubs, and statues, that occupy the spatial setting. As an individual moves through a built environment, both the form and extent of the isovist continuously change. This dynamic nature allows sequences of views, or successive panoramic fields, to be visualised from selected points along movement paths. Isovist fields have a wide range of applications. As illustrated in Figure 3.8, isovists may be constructed to represent either a 180-degree or a 360-degree field of vision. A 180-degree isovist corresponds to the visual field experienced, for example, when entering a park, whereas a 360-degree isovist represents the view obtained when rotating on the spot at a fixed position. In the scenario shown, person A enters a public space with the intention of gaining an overview of the area, while person B

stands concealed behind a building. Due to their respective positions, the two individuals are not mutually visible. As a moves into the park, a 180-degree isovist is generated to represent the immediate forward view. In contrast, person B requires awareness of visibility from all directions, and therefore, a 360-degree isovist is constructed from that location. The isovist field associated with person A is larger, as this position offers a broad visual overview of the park. Conversely, person B's isovist is more restricted due to obstructions such as buildings, fences, and vegetation. Constructing isovists from specific viewpoints thus provides a means of visualising spatial conditions related to visibility and concealment. Space Syntax research confirms that low VI in playground settings correlates with reduced adult surveillance capacity and lower rates of children's active use (Hafnaoui, 2022).

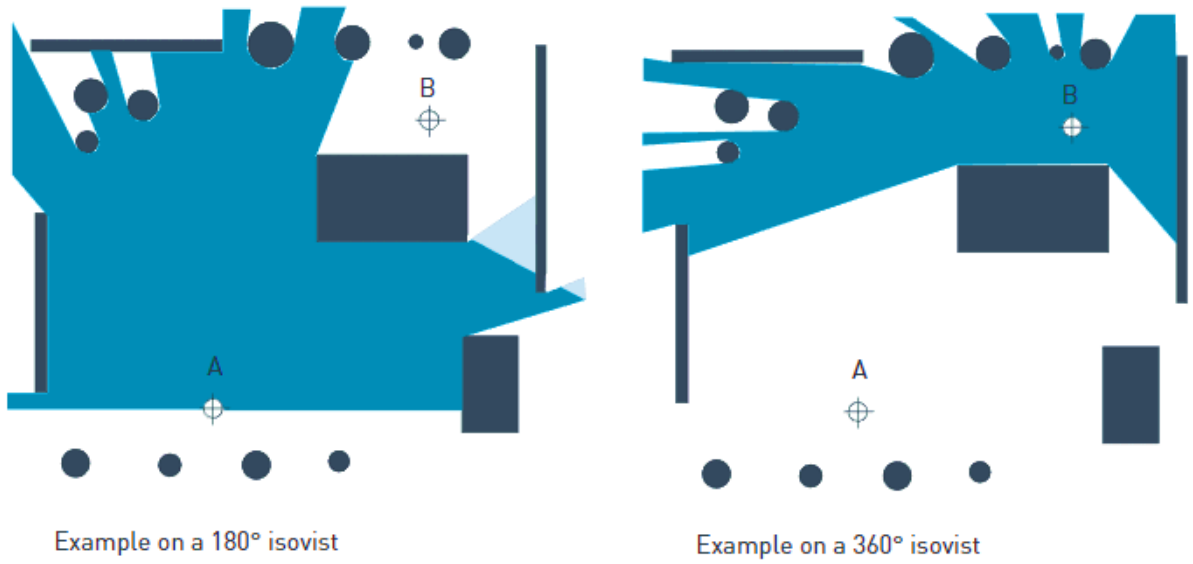


Figure 3. 8: *Example of a 180- and 360-degree isovist. Source: Adapted from (Van Nes, 2011).*

3.3. Convex analysis

The mathematical definition of convexity states that an object is convex if, for any pair of points (A, B) within the object, the line segment connecting A and B lies entirely within the object (see Figure 3.9). In Space Syntax, convexity is adapted from this mathematical foundation to describe spatial openness and visibility. A convex space is defined as a spatial unit where, from any position within the space, every other point is directly visible, and there are no internal obstructions blocking sightlines (Yamu, Van Nes, & Garau, 2021). Consequently, all boundaries of the space are visible, resulting in complete inter-visibility (Djeridi & Aiche, 2019). Convex spaces are often used in Space Syntax analysis to represent the largest possible areas of unbroken visibility, such as open rooms, plazas, or wide streets. Hillier and Hanson (1984, p. 98) define a convex space as "one space where all points within this space are visible

to one another (Bill & Julienne, 1984). The rule of thumb is to subdivide a space into the least number of convex spaces. The degree of convexity in an environment reflects how open or enclosed a space feels, influencing movement, social interaction, and spatial perception (W. Dettlaff, 2014). For example, a highly convex space, such as a square, allows for easy visual contact and movement, while a less convex space with many partitions restricts visibility and interaction.

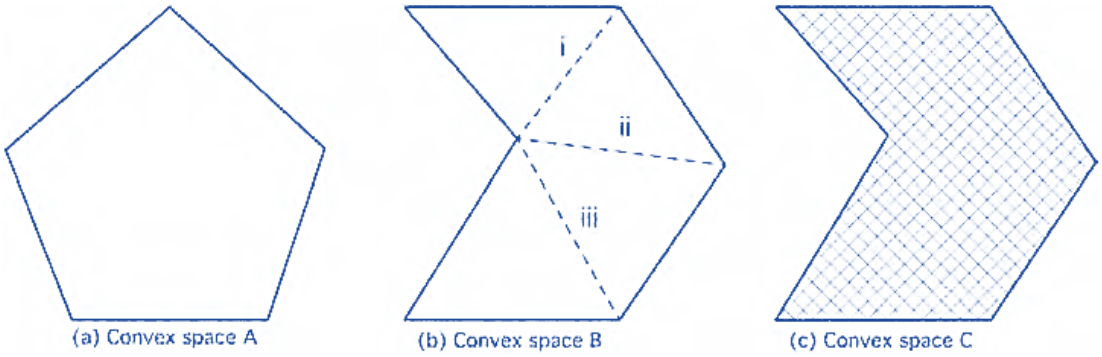


Figure 3. 9*: Different types of fundamental spatial units for two-dimensional analysis: (a) a single undivided convex space, (b) a space with three possible subdivisions creating two convex spaces, and (c) a space overlaid with a grid. Source: Adapted from (Van Nes & Yamu, 2021).*

In practice, Space Syntax uses convex maps to analyse and compare the openness of different spaces. These maps help identify areas where people can see and interact with each other freely, supporting studies of social behaviour, accessibility, and urban design. Studies of play area configurations confirm that children spontaneously concentrate social activity within the largest mutually visible convex zones, whilst fragmented layouts reduce opportunities for peer interaction (Hafnaoui, 2022).

3.4. Visual Graph Analysis (VGA)

Unlike isovist analysis, which focuses on visual information from a single observation point, VGA considers all available isovist fields simultaneously across multiple observation points. It facilitates the understanding of urban space by examining its inter-visibility relationships. The method is based on a raster representation composed of small pixels or ‘cells’. Each cell is evaluated in relation to all other cells within the analysed grid to assess topological visibility, with the centroid of each cell serving as the reference point. Similar to other Space Syntax techniques, VGA does not account for physical obstacles such as fences or walls; rather, it examines the topological relationships between all cells in the system in terms of visual connectivity within the studied area (Hafnaoui, 2022; Turner, 2007). VGA can be employed to

assess the visibility of key entry points into public squares and to determine optimal locations for features such as monuments, fountains, or temporary structures. At the architectural scale, VGA is valuable for locating exits, fire staircases, or anchor stores in shopping centres, based on their visual exposure from façades (See Figure 3.10). The method also illustrates how new urban interventions may enhance or obstruct existing sightlines. In landscape architecture, VGA can support the design of outdoor spaces, parks, and gardens by identifying visually overlooked areas, or 'hidden corners', which may be prone to criminal activity. This approach aligns with Bill Hillier and Simon Shu's concept of natural surveillance (2000) and Jane Jacobs' principle of 'eyes on the street' (1960), contributing to the creation of safer urban environments. Empirical studies confirm that children's activity density in outdoor play areas correlates significantly with VGA VI values, the most visually connected zones consistently attract the highest concentrations of active play (Hillier & Shu, 2000; Jacobs, 1961).

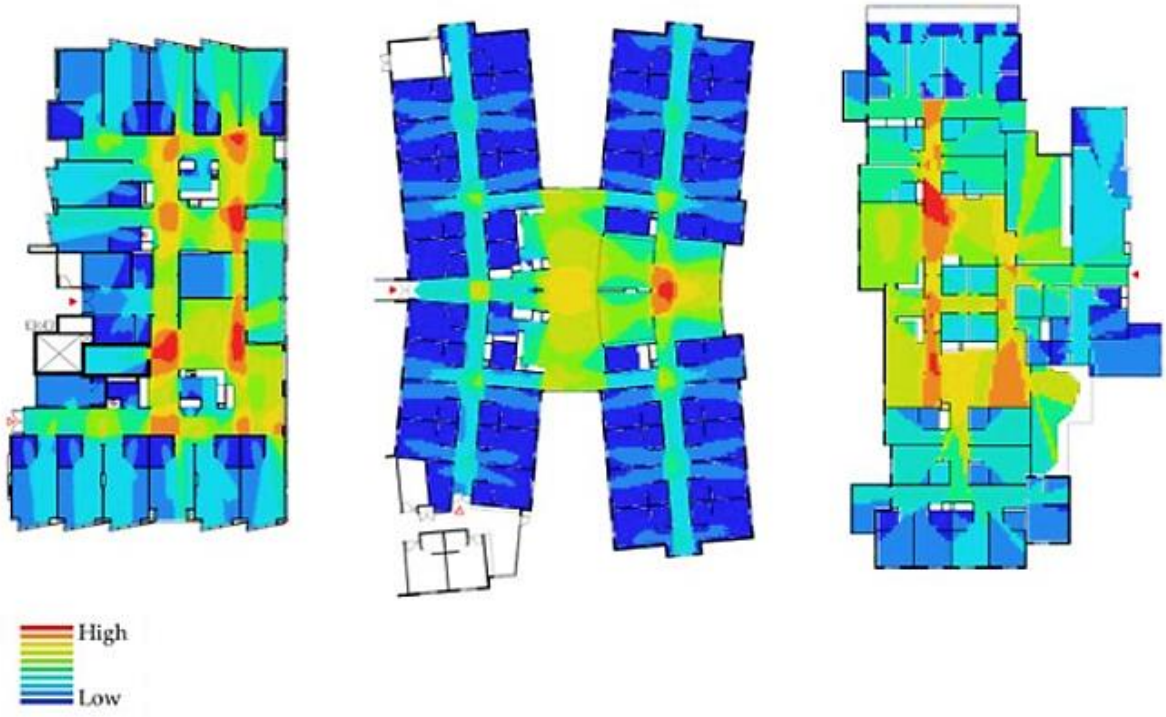


Figure 3. 10*: A representation of VGA. Source: Adapted from (Chau et al., 2018).*

3.5. Angular Segment analysis

Angular Segment Analysis subdivides axial lines into segments and evaluates the cumulative angular change required to move between them. This angular change represents movement cost, allowing identification of least-cost routes within the network. The method aims to optimise urban layout logic by highlighting paths with greater accessibility and efficiency. Turner (2007) formalised this approach through the metric of 'choice' (intermediation) in Space Syntax.

Within this methodology, analytical results are conventionally visualised using a colour gradient. Warm colours, such as red and orange, represent longer segments and higher levels of accessibility, whereas cooler colours, including blue and green, indicate shorter segments typically associated with irregular or poorly structured urban layouts. The analysis relies on Road-Centre Line (RCL) maps derived from sources such as OpenStreetMap or official datasets, which effectively represent street networks for spatial analysis (Dhanani, Vaughan, Ellul, & Griffiths, 2012). Studies show strong correlations between Angular Segment Analysis on RCL maps and vehicular movement patterns (Kolovou, Gil, Karimi, Law, & Versluis, 2017). The original concept of Angular Segment Analysis was introduced by Hillier and Iida (2005) and was subsequently implemented in the software DepthmapX (Turner, 2007). the method converts axial maps into segment maps defined by intersections. Movement cost is calculated as cumulative angular deviation, where turns are weighted according to their angle (e.g., 0 for straight movement, 1 for 90°, 2 for 180°) (Hillier & Iida, 2005). The weighting system assigns a value of 1 for a right-angle (90°) turn, 2 for a 180° turn, and 0 when no angular deviation occurs (dos Santos Oliveira & Fontgalland, 2021). Children with access to spatially well-connected, low-cost movement networks accumulate significantly more moderate-to-vigorous physical activity daily than those in restricted environments, making least-cost route identification directly relevant to children's outdoor mobility assessment (Bhosale, 2015).

3.6. Configurational measures

Space Syntax is grounded in a range of calculations derived from graph theory that are used to express social and spatial relationships. Collectively, these calculations produce a set of measures that characterise the spaces under investigation. However, it is important to note that spatial representation measures in Space Syntax are commonly classified into two categories: *first-order measures* and *second-order measures*.

3.6.1. First-order measures

3.6.1.1. Global Integration

Global integration assesses the accessibility of a street relative to all others in the network, representing the total number of directional changes required to traverse a system (Fezzai, 2018; Hillier, 1987). In the context of children's mobility, high global integration often indicates a street network that is easily navigable and highly accessible, potentially supporting independent movement. Conversely, low integration values, or spatial segregation, may limit a child's ability to reach public amenities without adult supervision (Van Nes & Yamu, 2021).

3.6.1.2. Global Choice

Global choice is a dynamic, system-wide measure that captures the potential flow of movement through a space. A space exhibits a high choice value when it lies on a large proportion of the shortest paths linking all spaces within the system (Klarqvist, 2015). For children, routes with high choice values may correlate with high-traffic corridors; while these routes are well-connected, they may present safety challenges due to vehicular volume, requiring planners to balance accessibility with traffic-calming measures. It therefore serves as an indicator of what Space Syntax researchers refer to as *through-movement*.

3.6.1.3. Depth

Depth between two spaces is defined as the least number of syntactic steps in a graph that are needed to reach one from the other (Klarqvist, 2015). Mean Depth (MD) is calculated by assigning a depth value to each node in the justified graph, which is obtained by counting the number of spaces that separate it from the initial, or root, space (Djeridi & Aiche, 2019). MD is a critical metric for children, as it defines the "syntactic distance" between a residential dwelling and a safe play area; shallow systems are generally more conducive to children's independent exploration and daily activity.

3.6.1.4. Control value

Control value is a dynamic local measure that evaluates the extent to which a space regulates access to its immediate neighbouring spaces, while accounting for the number of alternative connections available to each of those neighbours (Klarqvist, 2015). This is particularly useful for identifying "gatekeeper" spaces, urban pockets that allow a child to reach multiple play areas from a single, safe node.

3.6.1.5. Entropy

In Space Syntax, entropy serves as a measure of the distribution of spatial depth, specifically how locations are distributed relative to a given starting space. It is calculated by applying Shannon’s formula to the frequency distribution of point depths within the system. Low entropy signifies an asymmetric distribution where many locations are clustered close to the root space, indicating a highly legible and accessible environment. Conversely, higher entropy reflects a more evenly distributed (or disordered) depth, which may present a more complex environment for a child to navigate. For a child, a high-entropy environment may feel less predictable,

potentially increasing the cognitive load required to navigate from home to a play area or school (El-Khouly, 2012).

3.6.2. Second-order measures

3.6.2.1. Interface

The interface represents the relationship between integration and choice, expressing the degree of accessibility of a given space. Integration is commonly associated with the movement patterns of users who have limited knowledge of the urban layout and therefore tend to select the most accessible routes. By contrast, choice reflects the movement behaviour of inhabitants who possess a detailed understanding of the spatial configuration and consequently opt for the shortest paths. The correlation between integration and choice thus indicates the level of interface between residents and visitors within an urban space (Djeridi & Aiche, 2019). For children, understanding this interface is vital to identifying whether their local neighbourhood routes are purely functional or social in nature.

3.6.2.2. Synergy

Synergy characterises the co-variation between local-scale (radius 3 or similar) and global-scale integration within a neighbourhood or city district. It indicates the extent to which the local street network is aligned with the wider urban structure, essentially measuring how well the "part" fits into the "whole." Research indicates that synergy is a reliable indicator of urban vitality and stability. For children, high synergy is vital; it ensures that the local play environments (local scale) are physically and visually connected to the broader city infrastructure (global scale), promoting a sense of place and enabling safer, more intuitive movement across different urban scales (Soltani, Javadpoor, Shams, & Mehdizadeh, 2022).

3.6.2.3. Intelligibility

Intelligibility refers to the capacity of a spatial structure to convey information at the local level about the organisational role of spaces at the global level. The intelligibility of a system is defined by the co-variation between the connectivity of individual axes and their global spatial integration within the study site. This co-variation is calculated for each space and represented graphically in a scatter plot, from which a correlation coefficient (R^2) is derived. When R^2 exceeds 0.50, the resulting point cloud approximates a 45° line, indicating an intelligible system, where spaces that are well connected locally are simultaneously well integrated within the overall system. Conversely, if R^2 falls below 0.50, the system is considered unintelligible,

meaning that global-scale patterns cannot be inferred from the local scale. Research has shown that high intelligibility tends to reinforce overall spatial dynamics.

4. The relation between Spatial Configuration and CUL

Spatial configuration is not simply the backdrop to CUL; it is one of the principal mechanisms through which liveability is produced. By organising connectivity, integration, visibility, permeability, and the location of everyday destinations, urban form shapes whether children can move independently, encounter others, reach spaces for play and learning, and feel secure enough to use them. Recent socio-spatial research on child-friendly cities argues that the physical environment operates as a platform through which children's rights and everyday capabilities are realised, while neighbourhood-scale reviews show that play, active mobility, public realm, nature, and learning are interconnected socio-spatial conditions rather than separate policy objectives (Cordero-Vinueza et al., 2023; Pia & Bezboruah, 2025). More specifically, street-network studies indicate that intelligibility and integration are positively associated with children's walking to school because more legible and coherent networks make routes easier to understand and use (Soltani et al., 2022). Research on children's independent and autonomous mobility likewise shows that opportunities to move through the neighbourhood, whether for travel or informal play, are closely related to socio-emotional wellbeing, spatial knowledge, confidence, and a sense of control (Weir, 2023). Yet child-friendly configuration is not achieved by maximising movement everywhere. What matters is a calibrated structure: well-connected routes to schools, parks, and local services, combined with quieter residential streets, safe crossings, low-speed edges, and continuous pedestrian links that reduce traffic conflict while preserving opportunities for play, encounter and everyday exploration (K. Fang, Azizan, & Huang, 2024; Ferreira, Fornara, Pinna, Manca, & Guicciardi, 2024; Zhou et al., 2022). In this sense, the relationship between spatial configuration and CUL is both causal and multi-scalar: configuration shapes patterns of access, visibility and co-presence, and these in turn condition the safety, independence, sociability, play and learning opportunities that make cities genuinely liveable for children.

5. Spatial design and adaptive comfort opportunities

Adaptive comfort offers a useful framework for understanding how spatial design can respond to children's changing needs in outdoor places. Rather than aiming for a single fixed condition, it treats environmental experience as dynamic and shaped by movement, exposure, perception,

and the degree of control children have over their surroundings (S. Gao, Oh, Lin, & Feng, 2024a; Qian et al., 2025; Zheng et al., 2024). In spatial terms, this suggests the need for environments that provide varied conditions and allow children to adjust their experience through choice, for example, between sun and shade, open and sheltered settings, or direct and exploratory routes. From this perspective, child-friendly cities should not be designed around one optimum state, but around a range of spatial and environmental possibilities that support adaptation in everyday use. Evidence from outdoor places suggests that shading, vegetation, ventilated layouts, lower-radiation materials and child-sensitive surface design can significantly improve OTC, while spatial flexibility, contact with nature, and indirect supervision also contribute to comfort by enhancing inclusion, confidence and perceived control (Fatahi, Bahrami, & Aminpour, 2025; Hu Luyao et al., 2025; Yu Wang et al., 2024). Adaptive comfort is therefore not only thermal but also behavioural, perceptual and social: children are more likely to remain outdoors, play and explore when space offers legible alternatives, manageable sensory conditions and opportunities for self-directed adjustment (Ding et al., 2024; T. Guo et al., 2023). From a design perspective, the key task is to provide gradients of exposure, enclosure and connectivity across everyday routes and destinations. Configurational tools such as Space Syntax can support this by identifying route choice, visual connection and degrees of spatial integration, helping designers create legible and varied settings; however, these tools should be combined with microclimatic analysis, since shade, radiation and heat risk cannot be inferred from configuration alone (Karimi, 2023). Under this view, a resilient child-friendly space is not one that delivers a single optimum condition, but one that enables children to move, choose and adapt across a diverse field of spatial and environmental possibilities. For the purpose of this research, this adaptive framework serves as the primary design benchmark for evaluating the outdoor play environments and pedestrian routes, where the interplay between configurational connectivity and microclimatic variation determines the children's daily capacity for outdoor engagement.

6. Previous studies on Spatial Configuration in Algeria

Algerian urban research has increasingly shifted from descriptive morphology to configurational diagnostics. While early studies focused on historical centres (Fezzai, 2024), recent scholarship has tested Space Syntax against modern planning outcomes, often exposing significant failures in post-independence urban design (B. Ahmed & Boudjemaa, 2023; Tedjari & Abbaoui, 2023; Zerouati & Bellal, 2020). Studies have demonstrated that the functionalist hierarchy inherent in modern Algerian districts, characterised by disconnected, dendritic road

networks, creates significant structural barriers to natural movement (Djenaihi, Zemmouri, Djenane, & Van Nes, 2021). Unlike pre-colonial fabrics, which exhibit high syntactic integration, these modern interventions often decouple land use from street logic, leading to zones of urban "periphery" that possess architecture but lack urbanity (Femmam, Boukhabla, Mazouz, & Fammam, 2023). Furthermore, configurational assessments in Constantine and Biskra have provided quantitative evidence that global integration remains the primary predictor of pedestrian vitality, proving that where networks are poorly integrated, no amount of architectural development can compensate for the resulting spatial isolation (Djenaihi et al., 2021; Fareh & Alkama, 2022). The critical consensus is that Algerian urban planning is currently trapped between the high legibility of historical fabrics and the dysfunctional compartmentalisation of modern units, with current research calling for a shift toward "configurational performance" in future master plans (FAREH, 2023; Kelkoul & Chougui, 2022).

7. Previous studies on children's Spatial Configuration in Algeria

The application of configurational analysis to CUL in Algeria is an emerging yet critical field that highlights a persistent disconnect between planning policy and the child's reality. Research consistently demonstrates that for the child, the "play area" is not a bounded physical container, but a node within a larger, often hostile, residential network. A critical finding in Oum El Bouaghi is that the site's "embedding", defined by building orientation and visual connectivity, is a far stronger determinant of children's play activity than the quality of the play equipment itself. Studies in Batna and Sétif have further substantiated that children's independent mobility is severely curtailed by "configurational enclosure," where residential units are physically proximal to main circulation routes but are spatially segregated by inefficient threshold design. The literature confirms that Algerian collective housing design frequently neglects the "transition zones" (thresholds, paths, and building fringes) that children use as primary playgrounds. There is a demonstrable research urgency to move beyond the design of fenced, isolated play areas toward an integrated, network-based understanding of the child's city, where configurational accessibility is recognised as a fundamental component of the child's right to the city. This shift in scholarly focus is summarised in Table 3.1, which highlights the transition from isolated observational studies to integrated, network-based analytical models in recent Algerian research.

Table 3. 1: *Overview of selected studies on children's spatial configuration in Algeria. Source: Author, 2026.*

Authors/ Year	Location	Methods	Critical argument
(Chibane & Hamouda, 2022)	Oum El Bouaghi	SS + Snapshot	Spatial embedding of residential buildings governs child activity intensity.
(RAHMANI-KELKOUL, Zerouati, & Tedjari, 2025)	Sétif	SS + Observation	Connectivity gaps in urban fabric are primary drivers of social segregation.
(Guedouh, Khadraoui, & Saraoui, 2024)	Batna	SS + GIS	Layout disconnection directly impedes independent mobility; safety is a configurational outcome.
(ChiIbane, 2023)	Batna	Mixed Methods	Need for network-based accessibility models to replace isolated "play area" planning.

Conclusion

This chapter has demonstrated that spatial configuration as one of its key components, plays a major role in shaping CUL. It has been shown that the arrangement and interrelation of streets, open spaces, activity settings, and visual connections are not neutral physical conditions, but active determinants of how children perceive, navigate, and appropriate urban environments. In this sense, CUL is closely related to the configurational qualities of urban space, particularly in terms of legibility, accessibility, safety, social interaction, and opportunities for play and everyday environmental learning. The chapter has also established that spatial configuration operates across multiple scales of urban space. At the micro-scale, it influences the immediate affordances of play and interaction; at the meso-scale, it structures neighbourhood movement, permeability, and independent mobility; and at the macro-scale, it affects the distribution and accessibility of child-relevant destinations across the wider urban system. This multi-scalar perspective highlights that CUL cannot be reduced to the design of isolated spaces, but must instead be understood in relation to the broader spatial organisation of the city. In addition, the chapter has shown that Space Syntax provides a relevant theoretical and analytical framework for investigating these relationships. Through its configurational concepts and measures, such

as VI, TC, depth, connectivity, and visibility, it offers a means of examining how urban form may influence children's movement patterns, spatial cognition, and everyday experiences. The chapter has further indicated that the value of this approach can be strengthened through complementary methods, including behavioural observation, movement tracking, and participatory techniques that bring children's own spatial experiences into the analysis. Overall, the chapter has provided the conceptual foundation for understanding the relationship between spatial configuration and CUL, while also clarifying the relevance of a syntactic approach for the present research. While the configurational measures and relationships outlined in this chapter provide the necessary theoretical framework, their practical execution requires a robust set of computational and empirical tools. The transition from abstract configurational theory to the measurable reality of CUL relies upon a methodological synthesis that can capture both structural potential and lived practice. Building on this foundation, the next chapter, *Previous Studies and Methodology*, reviews previous studies on OTC, CUL, and spatial configuration.

CHAPTER IV: PREVIOUS STUDIES AND METHODOLOGY

"In research, the most dangerous phrase is: we have always done it this way."

— Grace Hopper (1982)

Introduction

Chapters I, II and III established the theoretical foundations of this research by defining CUL, OTC, and spatial configuration. Within this thesis, OTC and spatial configuration are not treated as separate concerns, but as two complementary dimensions through which CUL can be enhanced. While OTC influences the thermal suitability of outdoor places and affects when children can comfortably use them, spatial configuration shapes accessibility, visibility, movement potential and the spatial conditions that influence where and how children occupy urban space. Together, these two dimensions provide the basis for understanding how outdoor places can become more liveable, comfortable and child-responsive.

Building on this theoretical foundation, the objective of the present chapter is to introduce the previous methodologies used to assess CUL, OTC and spatial configuration, in order to identify the most relevant methods that will be adopted and applied in this study, as presented in Chapter VI.

The chapter is organised into four parts (Figure 4.1). The first part discusses analytical frameworks for assessing CUL, with particular attention to indicator-based approaches and their limits. The second part reviews previous methodological approaches used to assess children's OTC, including quantitative, qualitative, subjective and emerging tools. The third part examines the methods used to analyse children's spatial configuration, including configurational, observational, participatory and technologically advanced approaches. The final part considers studies that have attempted to relate spatial configuration to OTC and other sensory environmental conditions, highlighting the need for a more integrated methodological perspective.

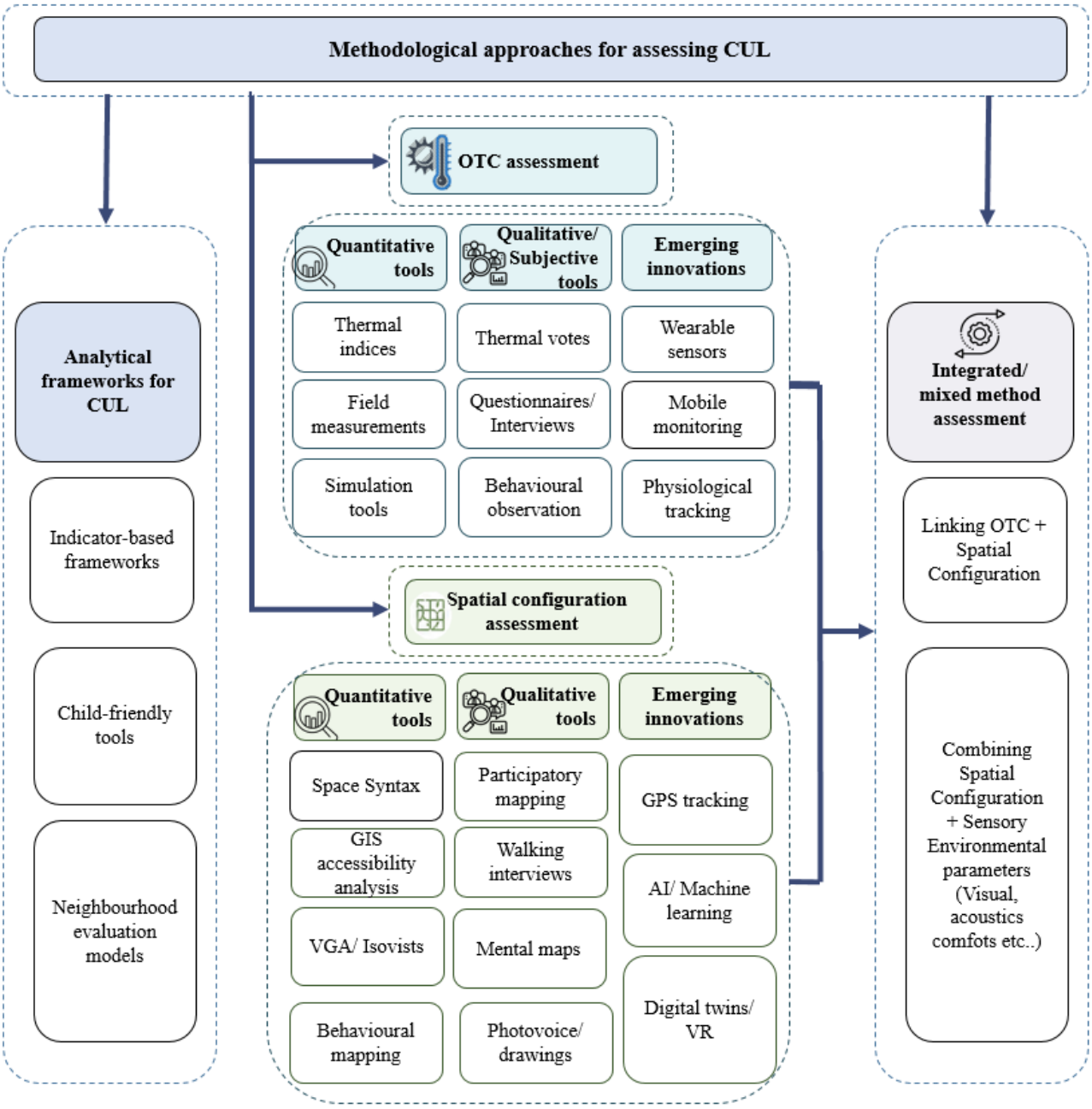


Figure 4. 1: *Structure of Chapter IV. Source: Author, 2026.*

1. Analytical frameworks for assessing CUL

1.1. Indicator-based frameworks

The assessment of CUL has increasingly shifted from broad policy ideals to the application of structured, indicator-based frameworks designed to translate children's needs into measurable urban planning criteria. These frameworks typically operationalise liveability by quantifying access to health, education, and play infrastructure within specific spatial radii, frequently

employing the "15-minute city" model to benchmark neighbourhood walkability and facility distribution (Badland, Villanueva, Alderton, Davern, & Goldfeld, 2023). Current literature identifies several prominent assessment models, ranging from the *Neighbourhood Early Childhood Development Framework* to multidimensional scales such as the *Child-Friendly City Scale-Child Form*. These tools seek to quantify quality by aggregating indicators, such as traffic safety, public transport connectivity, and public open space quality, into composite scores of child-friendliness (Z. Quan, M. B. M. Dali, & R. Zainol, 2024a; Rakhimova, McAslan, & Pijawka, 2025). While these frameworks have proven effective for high-level policy benchmarking, their methodological utility for detailed urban design analysis is limited by several critical factors:

- *Reliance on Predefined Indicators:* Many existing tools rely on administrative datasets (e.g., distance to schools) that, while useful for policy, often fail to capture the nuanced, micro-scale "lived experience" of the child, such as the perceived safety of a street corner or the comfort of a specific play node.
- *The "Average Child" Fallacy:* Many indicators assume uniform mobility and physiological responses, often failing to account for the diverse developmental needs, socio-economic contexts, and varying degrees of independent mobility across different urban populations.
- *Decoupling from Physical Morphology:* Crucially, the majority of indicator-based tools remain "aspatial" in their structural logic; they measure the *presence* of facilities without critically interrogating the configurational connectivity (the ease or difficulty of the path) that dictates whether these facilities are actually accessible to a child in practice.

Therefore, indicator-based frameworks provide an important starting point for assessing CUL, but they function more as administrative audits than as design instruments.

1.2. Limits of CUL assessment tools

CUL assessment tools have contributed significantly to making children more visible in urban policy, but their limits become evident when they are used to explain children's everyday spatial experience. Reviews of existing assessment tools show that most of them are designed to evaluate whether cities meet general CUL criteria, often following UNICEF-inspired dimensions such as safety, participation, access to services, public space and environmental quality. Quan, Dali and Zainol's review, for example, compares several prominent tools and

shows that although they share the objective of promoting child-friendly environments, they differ in scope, indicators and sensitivity to local context (Quan et al., 2024a).

The first limitation is that many tools privilege availability over usability. They can identify whether a park, playground or school exists within a given radius, but they rarely explain whether the route is safe, shaded, legible, socially accepted or comfortable for a child. The second limitation is their frequent reliance on expert or institutional evaluation, which risks reproducing adult assumptions about children's needs. Even when children are the intended beneficiaries, their own perceptions of fear, attraction, boredom, comfort or exclusion are often insufficiently integrated into the assessment process. The third limitation is climatic. Many tools treat environmental quality mainly through the presence of greenery or open space, whereas CUL in hot or semi-arid cities depends strongly on OTC, surface materials, ventilation, seasonal use and shaded microclimates.

For these reasons, CUL assessment tools should not be treated as complete models. Their main strength lies in diagnosing structural inequalities and supporting strategic planning. Their main weakness lies in explaining the situated relationship between children, spatial configuration, sensory comfort and behaviour. A more convincing assessment of CUL must therefore move from static indicators to an integrated methodological approach capable of linking what exists, how it is spatially configured, how it feels, and how children actually use it.

2. Methodological approaches to children's OTC

2.1. Quantitative assessment

Quantitative assessment of children's OTC has developed largely through the adaptation of thermal indices and simulation platforms originally designed for adults. Most studies rely on indices such as PET and UTCI because they allow complex outdoor conditions, including Ta, Tmrt, AV, and RH, to be synthesised into interpretable comfort categories, while simulation tools such as ENVI-met, RayMan, and Rhino–Grasshopper workflows extend this analysis by modelling how urban form, vegetation, materials, and shading influence local thermal environments. These approaches are valuable because they provide measurable and spatially explicit evidence for design evaluation, especially where alternative scenarios must be compared before implementation (H. Luyao et al., 2025; H. Zhao, Duan, Wang, & Li, 2026).

Their methodological limitation, however, is equally clear. As stated in Chapter II most indices are still calibrated around adult physiological assumptions, and even when applied to children,

they often require interpretative caution or local adjustment to reflect children's metabolic rate, body proportions, activity intensity, and behavioural adaptation more accurately. Quantitative assessment therefore offers analytical precision, but not full representational adequacy; it is strongest when used to identify relative thermal patterns and design sensitivities rather than to claim universally valid child-specific thresholds (S. Gao et al., 2024a; Qi, Wang, Zhai, Wang, & Jin, 2022).

2.2. Qualitative and subjective assessment

Qualitative and subjective approaches address a key limitation of numerical thermal indices: children's OTC is not only a physical condition, but also a perceptual, behavioural, and context-dependent experience. Recent studies therefore combine child-reported thermal sensation, comfort, preference and acceptability with caregiver/teacher assessment, behavioural observation, visual tools and participatory methods. These tools are important because children's perception may differ from calculated thermal stress and from adult interpretations, particularly during play and schoolyard activities (Y. Li et al., 2024; Qi et al., 2022). Table 4.1 summarises the main qualitative and subjective tools used or recommended in children's OTC assessment.

Table 4. 1: *Main qualitative and subjective tools used in children's OTC assessment. Source: Author, 2026.*

Tool / method	**Role in children's OTC assessment**	**References**
TSV	Measures whether children feel cold, neutral, warm or hot. It is the most common subjective tool.	(Gu et al., 2022; Huang et al., 2021; Kitaura, Munawaroh, Iwata, & Nagai, 2026; Yu Wang et al., 2024)
Thermal Comfort Vote (TCV)	Measures whether children feel comfortable or uncomfortable, not only hot or cold.	(Y. Li et al., 2024; S. Wang et al., 2025)
Thermal Preference Vote	Identifies whether children prefer cooler, warmer or unchanged conditions.	(Huang et al., 2021; Lopes, Remoaldo, Ribeiro, Martín-Vide, & Ribeiro, 2024; Qi et al., 2022)

Thermal Acceptability Vote	Evaluates whether children accept the outdoor thermal condition.	(Fabbri, 2024; Qi et al., 2022; Marcel Schweiker et al., 2025)
Simplified verbal scales	Uses simple words such as cold, okay, warm, hot; useful for younger children.	(Kitaura et al., 2026; H. Luyao et al., 2025; Qi et al., 2022)
Pictorial questionnaires / visual scales	Uses drawings, images or visual supports to help children understand thermal questions.	(Fabbri, 2024; Luparelli et al., 2025; Mishra, Wargocki, & Caporale, 2025)
Emoji / smiley-face scales	Uses facial icons to express comfort, discomfort or emotional response. Mostly recommended for child-centred questionnaires.	(Fabbri, 2024; Luparelli et al., 2025; Mishra et al., 2025)
Colour-based scales	Uses colours to help children express comfort, heat or environmental preference. More common in child perception research than in strict OTC field studies.	(Fabbri, 2024; Zapata-Lancaster & Smith, 2026)
Child-adapted questionnaires	Collects children's sensation, comfort, preference, activity, clothing and perception of shade or greenery.	(Abu-Qulbain & Taleb, 2025; Gu et al., 2022; H. Luyao et al., 2025; Qi et al., 2022)
Open-ended questions	Allows children to explain why a place feels hot, cool, pleasant or uncomfortable.	(Fabbri, 2024; Mishra et al., 2025; Sanz-Mas et al., 2025)
Caregiver questionnaires	Used especially with preschool children when direct child responses are limited.	(Qi et al., 2022)
Teacher questionnaires / interviews	Used to understand children's thermal behaviour, schoolyard use and adult interpretations of children's comfort.	(Sanz-Mas et al., 2025; Xin Yuan & Yuji Ryu, 2022)

Direct behavioural observation	Observes shade-seeking, resting, drinking water, movement, play intensity and clothing adjustment.	(T. Guo et al., 2026; Qi et al., 2022; Nils Wallenberg et al., 2023)
Adaptive-behaviour recording	Records children's responses to heat or cold, such as seeking shade, drinking water or reducing activity.	(T. Guo et al., 2026; Qi et al., 2022)
Behaviour mapping	Maps where children play, avoid, rest or gather in relation to sun, shade and surface materials.	(Sanz-Mas et al., 2025; Nils Wallenberg et al., 2023)
Children's interviews	Explores children's lived experience of heat, shade, comfort and outdoor play.	(Fabbri, 2024; Sanz-Mas et al., 2025; Zapata-Lancaster & Smith, 2026)
Focus groups	Allows group discussion about outdoor comfort, schoolyard use and heat perception.	(Fabbri, 2024; Sanz-Mas et al., 2025)
Drawing activities	Lets children represent comfortable or uncomfortable places visually. Mostly used in child-centred environmental perception research.	(Fabbri, 2024; Mishra et al., 2025)
Participatory mapping	Children mark hot, cool, shaded, pleasant or avoided areas.	(Fabbri, 2024; Sanz-Mas et al., 2025)
Sensory walks / walking interviews	Captures children's thermal perception while moving through outdoor spaces.	(Fabbri, 2024; Zapata-Lancaster & Smith, 2026)
Photovoice	Children use photos to express perceptions of heat, shade, comfort and schoolyard experience.	(Sanz-Mas et al., 2025)
Photo-based comparison	Uses photographs of different outdoor settings to support perception or preference questions.	(Fabbri, 2024)

Preference ranking of spaces	Children rank places according to comfort, attractiveness, shade or play value.	(Abu-Qulbain & Taleb, 2025; Sanz-Mas et al., 2025)
Perceived environmental quality questions	Assesses children's perception of shade, vegetation, wind, water, surface materials, safety and attractiveness.	(Antoniadis et al., 2020; Sanz-Mas et al., 2025)
Facial-expression assessment	Uses non-verbal emotional responses to detect discomfort, useful when children cannot clearly verbalise thermal stress.	(Z. Li, Zhou, Hong, & Qiu, 2024b)
Physiological feedback linked to subjective perception	Combines children's votes with skin temperature, heart rate or wearable sensors.	(Z. Li et al., 2024b; Xin Yuan & Yuji Ryu, 2022)
Mixed-method assessment	Combines questionnaires, microclimate data, observation, interviews, visual tools and sometimes physiological data.	(Abu-Qulbain & Taleb, 2025; Sanz-Mas et al., 2025)

2.3. Emerging innovations

Recent children's OTC research is moving from static, point-based assessment towards dynamic and integrated monitoring. This shift is important because children's thermal exposure changes continuously through movement, play intensity, route choice, shade-seeking, drinking

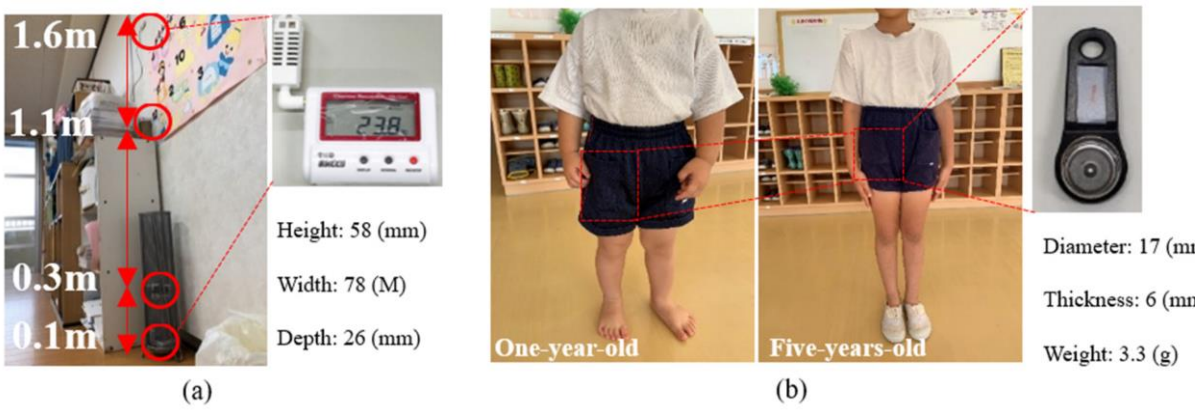


Figure 4. 2*: Fixed sensors at child height (a) and wearable sensor placement (b). Source: Adapted from (Xin Yuan & Yuji Ryu, 2022).*

water, resting and short-term adaptation across different microclimates. Emerging methods therefore include wearable sensors, mobile microclimatic monitoring, GPS tracking, accelerometers, heart-rate monitoring, skin or ear temperature measurement, facial-expression recognition, real-time physiological tracking, machine-learning prediction models, GIS-based thermal mapping and simulation-based optimisation (Li et al., 2024; Sanz-Mas et al., 2025; Wang et al., 2025; Luyao et al., 2025). As shown in Figure 4.2, recent OTC studies increasingly use fixed sensors at child height and wearable devices to capture children's personal thermal exposure more accurately.

For architecture and urbanism, these innovations are valuable because they connect thermal exposure with children's actual spatial behaviour. They help identify not only where heat stress occurs, but also how children move, which spaces they avoid, where they rest, and whether the built environment offers accessible adaptive opportunities such as shade, vegetation, water and thermally safe play surfaces. However, these tools also raise methodological challenges related to calibration, sensor placement, synchronisation, data processing, privacy and ethics. More importantly, high-resolution data do not explain perception by themselves. Therefore, recent research supports methodological integration rather than technological substitution: combining simulation, field measurement, physiological monitoring, behavioural observation and child-responsive subjective tools within one evaluative framework.

This integrated approach prepares the transition to spatial configuration analysis, where children's OTC can be examined through both measurable environmental performance and lived spatial experience.

3. Methodological approaches to children's Spatial Configuration

3.1. Quantitative assessment

Quantitative assessment of children's spatial configuration focuses on the measurable relationship between urban form, movement potential, visibility, accessibility and children's use of space. Unlike general child-friendly city indicators, which often measure the presence of facilities, configurational methods examine how spatial structure itself enables or restricts children's mobility, play and independent access. Recent studies increasingly use GIS-based accessibility analysis, Space Syntax, network analysis, VGA, isovist analysis, walkability modelling, route-directness measures, behavioural mapping, GPS tracking and scenario-based spatial simulations to evaluate how children encounter streets, schoolyards, playgrounds and

neighbourhood spaces. Table 4.2 summarises the main quantitative tools and methods used to assess children's spatial configuration.

These tools are valuable because they translate spatial configuration into measurable design evidence. As stated in chapter III, Space Syntax, for example, can assess integration, choice, connectivity, and depth, helping to identify whether children's destinations are spatially accessible or hidden within fragmented networks. Other studies combined Space Syntax with objectively measured built-environment features to examine children's active school travel, showing the relevance of configurational analysis for child mobility research (Ozbil, Yesiltepe, Argin, & Rybarczyk, 2021). However, quantitative configurational tools also have limitations. They can identify spatial potential, but they do not automatically explain children's lived experience of fear, attraction, exclusion or play value. A street may be spatially integrated but perceived as unsafe; a playground may be visually connected but socially unwelcoming; and a route may be short but unusable because of traffic, poor crossings or lack of adult permission. Therefore, quantitative assessment is strongest when used to reveal spatial affordances and constraints, rather than as a complete measure of child-friendliness.

Table 4. 2: *Quantitative assessment tools and methods for children's spatial configuration. Source: Author, 2026.*

Type	Tool/method	Definition	Role in children's spatial configuration assessment	References
Software/tool	DepthmapX	Open-source software for Space Syntax, VGA and spatial network analysis.	Used to calculate configurational measures such as VI, TC, connectivity, depth and visibility.	(Istiani, Alkadri, van Nes, & Susanto, 2023; Turner, 2004, 2007)
	GIS software	Geographic Information System platforms such as ArcGIS or QGIS used for spatial data mapping and network analysis.	Measures access to schools, parks, playgrounds, services and child-related destinations through distance, buffers or network routes.	(Torun, Akın, Bingol, Defeyter, & Severcan, 2024)

	GPS devices / GPS tracking apps	Location-recording devices or mobile applications that capture movement trajectories.	Records children's actual routes, walking paths, pauses and home–school mobility patterns.	(Larroya et al., 2023)
	Video recording tools	Cameras or fixed video systems used to record behaviour and movement over time.	Supports later coding of children's movement, social interaction, play behaviour and spatial occupation.	(R. Zhang et al., 2025)
	Space Syntax plug-ins/ Rhino–Grasshopper workflows	Parametric or computational workflows that can model spatial networks, visibility, accessibility and design alternatives.	Useful for testing design scenarios, route accessibility, visibility and spatial optimisation.	(Luo & Lin, 2023)
Method	Space Syntax analysis	A configurational method that studies how spatial layout influences movement, visibility and social use.	Evaluates whether children's destinations are spatially integrated, segregated, visible or difficult to reach.	(Luo & Lin, 2023)
	Segment/ angular analysis	A Space Syntax method that analyses route direction, angular change and movement potential.	Helps evaluate route directness and complexity in children's school or neighbourhood journeys.	(Soltani et al., 2022)
	VGA	A method that measures visual connectivity and visibility across a space.	Assesses whether playgrounds, schoolyards or public spaces are visually connected, supervised or fragmented.	(Istiani et al., 2023)

Isovist analysis	A method that measures the visible field from a particular point.	Useful for studying supervision, visual safety, hidden areas and spatial legibility from a child's perspective.	(Istiani et al., 2023)
GIS accessibility analysis	A spatial method that calculates access through distance, buffers, catchments or network routes.	Evaluates whether children can reach parks, schools, playgrounds and services within safe and walkable distances.	(Larroya et al., 2023; Torun et al., 2024)
Time sampling/ spot observation	An observational method where behaviours are recorded at fixed time intervals.	Captures temporal rhythms of use, peak activity periods and changes in spatial occupation.	(R. Zhang et al., 2025)
Tracking/ movement-path observation	A method for documenting actual movement paths through observation, GPS or mapped trajectories.	Identifies children's route choices, pauses, detours and movement patterns.	(Larroya et al., 2023)
Route-choice analysis	Compares actual routes with shortest, safest or most spatially integrated routes.	Reveals whether children follow efficient paths or avoid routes because of safety, traffic, visibility or social constraints.	(Michail & Torun, 2024)
Scenario-based spatial simulation	Tests alternative design layouts before implementation.	Evaluates how new paths, entrances, crossings, play nodes or visibility changes may affect children's movement and accessibility.	(Luo & Lin, 2023; R. Zhang et al., 2025)

	Machine-learning/ deep-learning spatial analysis	Uses computational models to detect patterns between spatial features and behaviour or emotional response.	Emerging method for linking spatial typologies, behaviour maps and children's emotional/spatial responses.	(R. Zhang et al., 2025)

3.2 Qualitative assessment

Qualitative assessment addresses the main weakness of quantitative spatial analysis: children's spatial experience cannot be reduced to distance, visibility or network connectivity. Children do not use urban space only according to geometric efficiency; they also respond to perceived safety, social permission, sensory comfort, play value, curiosity, fear, memory and attachment. Recent studies confirm that children's everyday spatial choices are strongly influenced by the perceived quality of streets, parks, neighbourhood spaces and opportunities for social interaction, not only by physical proximity or accessibility (Michail & Torun, 2024; Rodela, Lundmark, & Norss, 2025; Torun et al., 2024; Veitch, Flowers, Ball, Deforche, & Timperio, 2020).

Recent child-centred urban studies therefore use walking interviews, child-led walks, participatory mapping, mental mapping, drawings, focus groups, photo-elicitation, photovoice, observation, spatial ethnography and caregiver or teacher interviews to reveal how children perceive streets, schoolyards and public spaces. Table 4.3 summarises the main qualitative tools and methods used to assess children's spatial configuration. For example, Veitch et al. (2020) used walk-along interviews to explore children's views of park features, Torun (2024) used participatory map-based focus groups and qualitative GIS with children aged 9–12, while Michail et al. (2024) examined children's actual walking routes to identify street attributes influencing route preference. Photovoice and image-based methods have also been used to capture youth perceptions of public spaces and street-design preferences (Jurkevičienė & Budrytė, 2025; Stark et al., 2025). Rieh (2020) demonstrates the value of sketch-based methods for understanding how children construct a sense of place and how specific spatial qualities become memorable (Rieh, 2020).

The value of qualitative assessment lies in its ability to expose the gap between configured space and experienced space. A route that appears accessible in GIS may be rejected by children

because it feels unsafe; a highly visible space may still be avoided if it lacks shade, seating, play diversity or social comfort. Conversely, children may appropriate informal or marginal spaces that are not recognised as formal play areas but are meaningful in their everyday routines. Qualitative methods therefore make visible the social, perceptual and emotional dimensions of spatial configuration that quantitative tools alone cannot capture.

Table 4. 3*: Qualitative assessment tools and methods for children's spatial configuration. Source: Author, 2026.*

Type	Tool / method	Definition and role	References
Tool/ material	Paper maps/ base maps	Used during workshops or interviews to let children locate safe, unsafe, preferred or avoided places.	(Rodela et al., 2025)
	Behavioural mapping	A systematic observation method that records where children play, pause, gather, avoid or move.	(R. Zhang et al., 2025)
	Photographs/photo cards/ child-produced photos	Support discussion of spatial quality, safety, attraction and public-space experience.	(Jurkevičienė & Budrytė, 2025; Stark et al., 2025)
	Drawing sheets/ sketch templates	Help children express routes, landmarks, feared places and desired improvements visually.	(Jurkevičienė & Budrytė, 2025; Rieh, 2020)
Tool/ software	Audio/video recording and qualitative coding software	Records interviews, focus groups, walks or spatial behaviour; supports thematic coding in NVivo, MAXQDA or Atlas.ti.	(Jurkevičienė & Budrytė, 2025; Veitch et al., 2020)
Method	Participatory mapping/ map-based focus groups	Children collectively mark and discuss meaningful, unsafe, attractive or avoided places.	(Rodela et al., 2025; Torun et al., 2024)
	Walking interviews / child-led walks	Children describe spatial experience while moving through real routes or places.	(Michail & Torun, 2024; Veitch et al., 2020)

Mental mapping/ children's drawings	Reveals children's cognitive maps, landmarks, boundaries, fears and preferred spaces.	(Torun et al., 2024)
Photo-elicitation/ photovoice	Uses photographs to make children active interpreters of their public-space experience.	(Jurkevičienė & Budrytė, 2025; Rodela et al., 2025; Stark et al., 2025)
Semi-structured interviews/ focus groups	Explores children's perceptions of safety, accessibility, play value, independence and spatial barriers.	(Michail & Torun, 2024)
Photographing/ videotaping/ spatial ethnography	Documents children's spatial practices, micro-behaviours, social interaction and appropriation of space.	(Jurkevičienė & Budrytė, 2025; Veitch et al., 2020)
Caregiver/ teacher interviews	Adds adult perspectives on supervision, permission, safety and restrictions on children's mobility.	(Michail & Torun, 2024; Veitch et al., 2020)

3.3 Emerging innovation

Recent research on children's spatial configuration is moving beyond static maps and conventional observation towards data-rich and predictive spatial assessment. Emerging approaches include GPS-based mobility tracking, mobile activity-space analysis, child-centred GIS, AI-supported street-view analysis, computer vision, machine-learning prediction models, digital twins, VR-based navigation experiments and integrated Space Syntax–behavioural datasets . These methods are important because they allow researchers to examine children's spatial experience as a dynamic process shaped by movement, route choice, visibility, perceived safety and access to meaningful destinations.

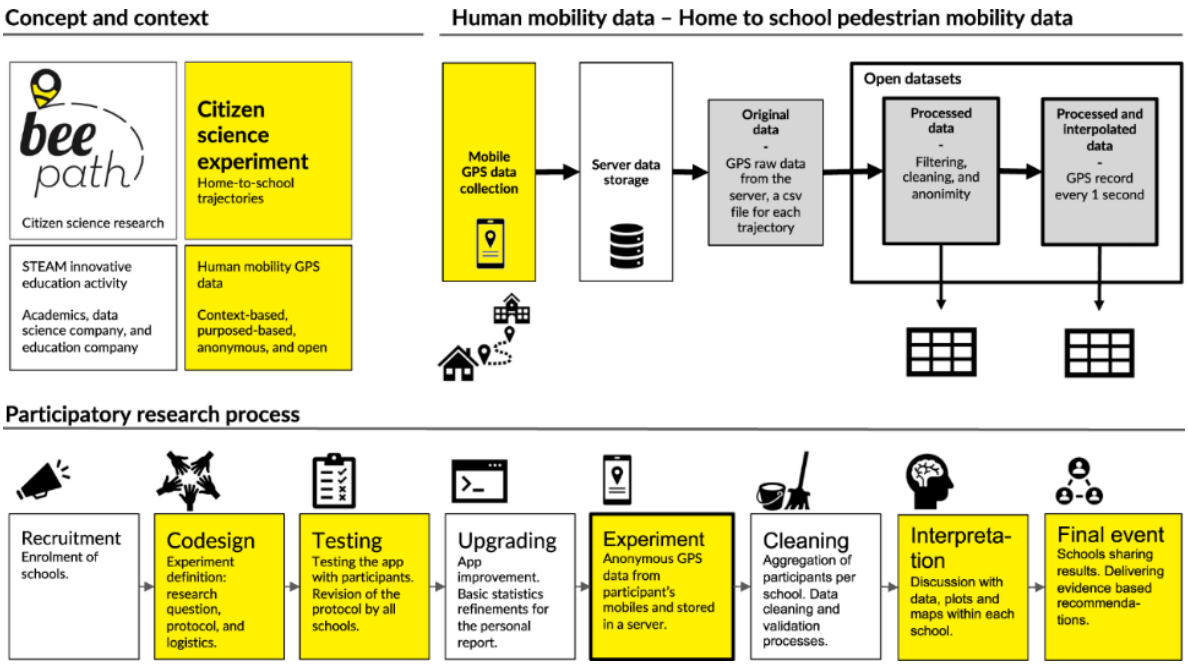


Figure 4. 3: *Beepath citizen-science initiative. Source Adapted from (Larroya et al., 2023).*

For architecture and urbanism, these innovations are valuable because they connect spatial configuration with children's actual mobility and perception. GPS tracking and activity-space analysis can reveal the routes children really use, where they stop, and which areas are avoided or repeatedly visited (See Figure 4.3). Machine-learning studies have also begun to predict children's active transportation from built-environment, population and housing variables, showing how spatial data can support child-sensitive mobility planning (HubkaRao, Nettel-Aguirre, Cloutier, & Hagel, 2025). Street-view imagery and deep learning are another emerging direction, as recent child-friendly walkability research uses eye-level street images to assess urban streets from a more child-centred perspective (W. Jia & He, 2026; Tu, Miao, & Jin, 2026). At the same time, these innovations should not be treated as neutral technical solutions. Digital tools can identify spatial patterns, but they may miss children's emotional, social and cultural interpretations of space. A route may appear efficient in GPS data but still be stressful; a street may score highly in a deep-learning model but remain inaccessible because of parental restrictions, traffic fear or gendered use. Therefore, the most robust direction is methodological integration: combining configurational analysis, GIS, GPS data, behavioural observation, participatory mapping and children's own narratives. This allows spatial configuration to be assessed not only as a measurable network, but as a lived and negotiated environment.

4 The relation between Spatial Configuration and multisensory Environmental conditions

4.1 Empirical evidence on Spatial Configuration and OTC

Recent studies generally agree that spatial configuration and OTC are closely related, rather than acting as separate influences on the use of outdoor space. Research using Space Syntax, thermal simulation, and field measurement shows that visibility, integration, enclosure, and accessibility can affect airflow, shading, solar exposure, and patterns of occupation. In this respect, studies of gardens, urban spaces, and dwellings suggest that more integrated and visually connected areas often correspond with more favourable thermal conditions, whereas segregated spaces may remain less used even when their microclimate is acceptable (Du, Bokel, & van den Dobbelsteen, 2019; Shuang Liu, Zhao, Xu, & Ahmadian, 2021).

These studies differ in scale and method. Some examine outdoor public spaces through Space Syntax, CFD (Computational Fluid Dynamics), and thermal indices such as PET or UTCI. In contrast, others focus on buildings or street geometry and their influence on local thermal variation. Reviews of the field likewise show that urban form, network integration, street orientation, and vegetation can all modify thermal exposure, although the strength of these effects varies by climate and context (Aghamolaei et al., 2023).

Their main limitation is that they are often based on adult users and are usually confined to particular climates or site types. In relation to CUL, however, this body of work is important because it shows that children's use of urban space is likely to depend not only on layout, but also on how that layout shapes local environmental conditions.

4.2 Spatial Configuration and other sensory Environmental conditions

Recent studies suggest that spatial configuration should not be examined separately from thermal and other sensory conditions. A 2025 study in Hong Kong combined DepthmapX, XGBoost and on-site verification to relate visibility and connectivity measures to local OTC; however, it was not child-specific. A campus study that combined Space Syntax, behavioural mapping and thermal questionnaires reached a similar conclusion, but again focused on a general user group rather than children (C.-H. Chen, Lai, Chen, & Guo, 2025). A second group of studies combines thermal assessment with acoustic, visual or aesthetic variables. In Hong Kong, Lau and Choi examined thermal perception, along with perceived acoustic and aesthetic quality, using on-site meteorological measurements and questionnaires; this study was not child-specific. In Fuzhou, a park-based study used measurements, questionnaires, and sensory walking to analyse combined thermal–acoustic effects, again with general users rather than children. In Chongqing, another study combined acoustic, light and thermal parameters through field measurements and questionnaires, but it likewise did not focus on children. A recent

systematic review confirms that multisensory studies are increasing, but also shows that this literature is still dominated by adult or mixed-user samples (Hong, Du, Zhai, & Matzarakis, 2025; Lau & Choi, 2021; F. Zeng et al., 2024).

By contrast, studies that are clearly child-specific tend to focus on thermal conditions alone. For example, Hu Luyao et al. (2025) examined children's OTC in Guilin using meteorological measurements, UTCI and children's thermal perception surveys, while Wang et al. (2022) studied children's activity spaces in Chongqing through field measurements and questionnaires. These studies are directly relevant to children, but they do not combine thermal assessment with spatial configuration, acoustic quality, air quality or visual quality in one integrated framework (H. Luyao et al., 2025; Lei Wang, Han, He, & Jung, 2022). Taken together, these studies broadly agree that outdoor experience is shaped by multiple interacting factors and that single-variable assessment is often insufficient. They differ mainly in what they combine and how they measure it: some use spatial analysis and modelling, while others rely on field surveys, sensory walks or questionnaires. Their main limitation is that integrated studies are usually context-specific and rarely child-focused. In relation to CUL, this is important because it shows that children's everyday use of urban space is likely to depend on the combined effects of layout, thermal exposure, soundscape and visual quality, yet direct evidence on these interactions for children remains limited.

Conclusion

This chapter reviewed the main methodological approaches used to assess CUL, with particular attention to the role of OTC and spatial configuration as two complementary dimensions that can enhance CUL. The review showed that CUL assessment has increasingly moved towards indicator-based frameworks, child-friendly city tools and multidimensional evaluation models. These approaches are useful for identifying broad urban deficits, but they remain limited when they are used alone, as they often privilege availability over usability and do not fully capture children's lived spatial and thermal experience. The chapter also showed that previous studies on children's OTC have developed through quantitative measurements, thermal indices, simulation tools, subjective assessment instruments and emerging technologies such as wearable sensors and mobile monitoring. Similarly, research on children's spatial configuration has advanced through Space Syntax, GIS-based accessibility analysis, behavioural mapping, participatory tools, GPS tracking and other digital methods. However, these methodological traditions have often been applied separately. OTC studies tend to focus on thermal exposure

and comfort conditions, while spatial configuration studies tend to focus on accessibility, visibility and movement potential. This separation limits the understanding of how children actually use outdoor places, since their behaviour is shaped by both environmental comfort and spatial structure. The main finding of this chapter is therefore that no single method is sufficient to assess CUL in a comprehensive way. A robust approach requires the combination of spatial, thermal, behavioural and child-centred tools in order to understand not only what outdoor places provide, but also how they are configured, how they feel, and how children perceive and use them. This methodological synthesis justifies the selection of an integrated mixed-method approach, which will be operationalised later in Chapter VI.

As the final chapter of the theoretical part of the thesis, Chapter IV establishes the methodological basis for the empirical investigation. The next chapter begins the practical part of the research by presenting the study area and selected case studies in El Khroub. It introduces their urban, climatic, morphological and functional characteristics, and explains their relevance for examining how OTC and spatial configuration contribute to the enhancement of CUL.

CHAPTER V: INVESTIGATION

"A city is more than a place in space — it is a drama in time."

— Patrick Geddes, Cities in Evolution (1915)

Introduction

When undertaking an empirical investigation of children's outdoor use, the interpretation of results depends on a clear understanding of the territorial, urban, climatic, and spatial conditions in which the selected sites are located. For this reason, the present chapter establishes the contextual and analytical framework of the study area. Its objective is to situate El Khroub within the wider metropolitan context of Constantine, to identify the urban and environmental characteristics that may influence CUL, and to justify the selection of the case studies and observation spots used in the empirical analysis.

The chapter is organised as a progressive movement from the wider context to the specific units of investigation. It first presents Constantine as the territorial and metropolitan frame of reference, before focusing on El Khroub as the main study area. It then examines the historical development, urban climate, and morphological and configurational structure of El Khroub centre. The second part of the chapter classifies the main outdoor places in El Khroub centre according to criteria related to CUL. This classification supports the selection of three contrasting case studies: the Square, Martyr Plaza, and Snoberland. The chapter then presents these sites and explains why they provide a relevant comparative basis for examining how spatial configuration and OTC influence children's use of outdoor spaces.

Finally, the chapter explains the selection of observation and measurement spots within each case study. These spots were chosen to capture contrasting micro-spatial and environmental situations. The overall logic of the chapter is summarised in Figure 5.1, which illustrates the transition from the wider territorial context to the classification of outdoor places, the selection of case studies, and the identification of observation spots.

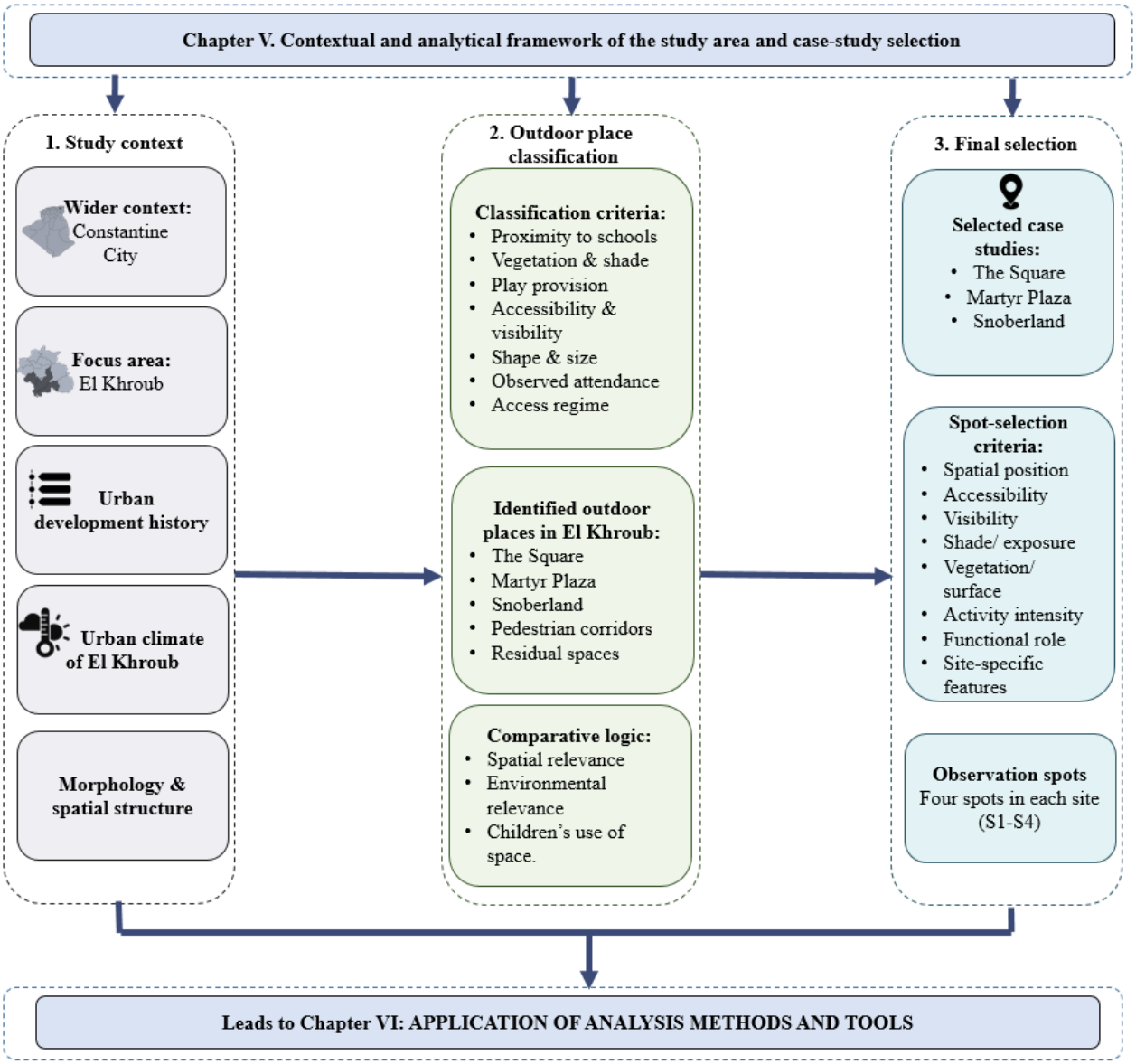


Figure 5. 1: *Structure of Chapter V. Source: Author, 2026.*

1. Presentation of the city of Constantine

Constantine, also known as the "*City of Bridges*" or Bled el Haoua, as described by El Bekri in his book Description of North Africa (1965), is one of the world's oldest cities. With over 2,500 years of history, it possesses a rich cultural heritage shaped by the successive passage of multiple civilizations on its rocky terrain. Its topography is particularly heterogeneous, with steep and narrow rocky formations, earning it the reputation of a natural fortress. Geographically, Constantine is located in eastern Algeria, between latitude 36.23° and longitude 7.35°, approximately 437 km from Algiers. It represents one of the most important crossroads in eastern Algeria, covering an area of 2,297.2 km² and hosting a population of

938,475 according to the 2008 census, currently estimated at around 1.5 million inhabitants. Bounded by the wilayas of Skikda to the north, Oum El Bouaghi to the south, Guelma to the east, and Mila to the west, Constantine is well-connected by national highways (Figure 5.2), including the N20 to Guelma, N10 to Tébessa, N3 to Batna (which crosses Constantine from south to north linking it to Skikda and Annaba), N5 to the west connecting it to Algiers, and N27 towards Jijel and Mila, as well as N79. Additionally, a network of regional and communal roads, such as C.W. 133, 51, and 101, serves the surrounding areas. Administratively**,** the city is divided into six daïras, comprising a total of twelve communes (Fantazi, 2021). Within this metropolitan structure, El Khroub occupies a strategic position as one of Constantine's main satellite cities. Its location to the south-east of the metropolis and its connection to major transport corridors justify the transition from the wider context of Constantine to the specific study area of El Khroub.

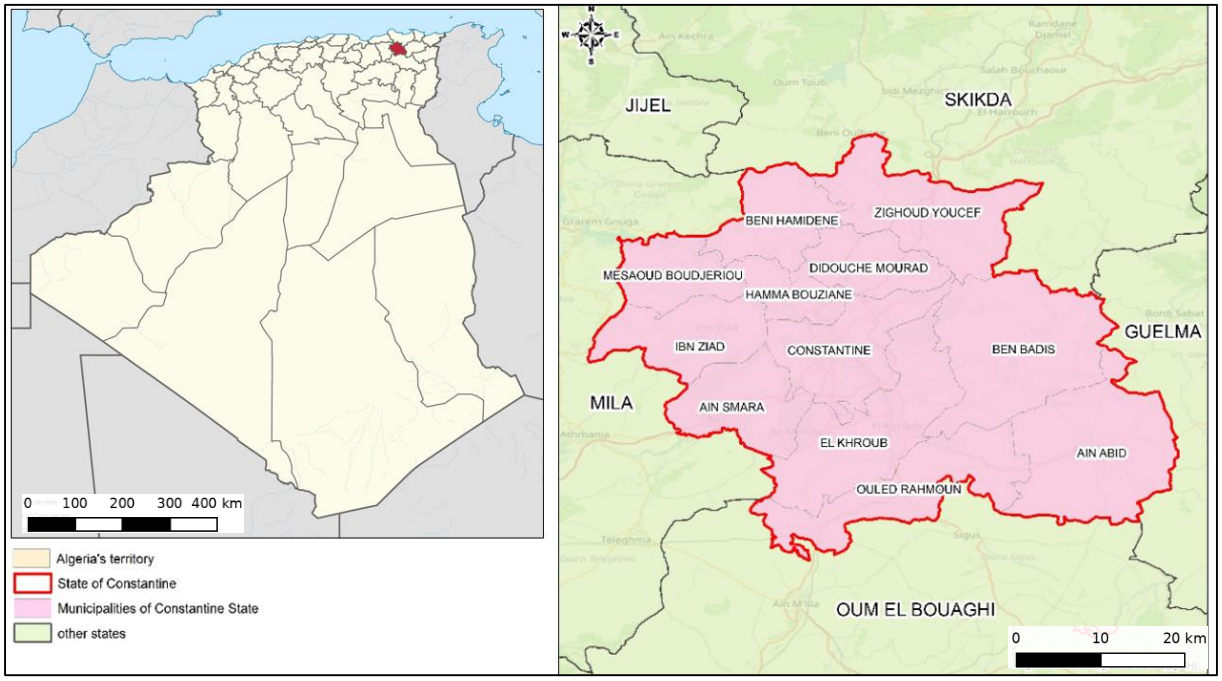


Figure 5. 2*: Map of the administrative location of the city of Constantine. Source: Adapted from (Benchenna, Achene, & Houria, 2022).*

2. Location of El Khroub

El Khroub is a major city in eastern Algeria, with a population of approximately 179,033 inhabitants, and functions as the primary satellite city of the metropolitan area of Constantine (2008 census). Located to the south of the Constantine metropolis, El Khroub occupies a strategically significant position due to its favourable conditions for human settlement, including its advantageous topography and its role as a key transit node linking the southern

regions of Algeria with the eastern border areas. The urban agglomeration of El Khroub is structured around its colonial core. This central area is defined by the Master Plan for Development and Urban Planning (PDAU), within boundaries marked by Oued Hamimime to the north, the Tomb of Massinissa to the east and north-east, the railway line to the west, Wilaya Road 175 to the north-west, and Salah Deradji to the south (Rérat, 2006). Over time, urban growth extended beyond this core towards peripheral sectors such as Massinissa, Ain Nahass, Oued Hamimime, Salah Deradji and other recent residential extensions. These areas are therefore considered part of the wider urban expansion of El Khroub, but they differ from the historic centre in their urban fabric, housing forms, spatial logic and public-space structure. It occupies an important geographical position, serving as a gateway between the high plains and the Tell Atlas, and acting as a connector between the Tell region and the desert. Its location along National Road 03 provides direct access northwards to Constantine, 16 km away, and southwards towards other parts of the province. Additionally, it is connected via National Road 20 to Guelma and National Road 10 to Oum El Bouaghi. These transport links have established El Khroub as a regional and functional centre, which has undergone significant demographic growth due to internal migration and maintains extensive interactions with surrounding areas. The study area is located in northeastern Algeria, within Constantine Province, in the southeastern sector of the city of Constantine, covering an area of 244.65 km² and situated approximately 16 km from the city centre (Figure 5.3) (Lifa, 2024).

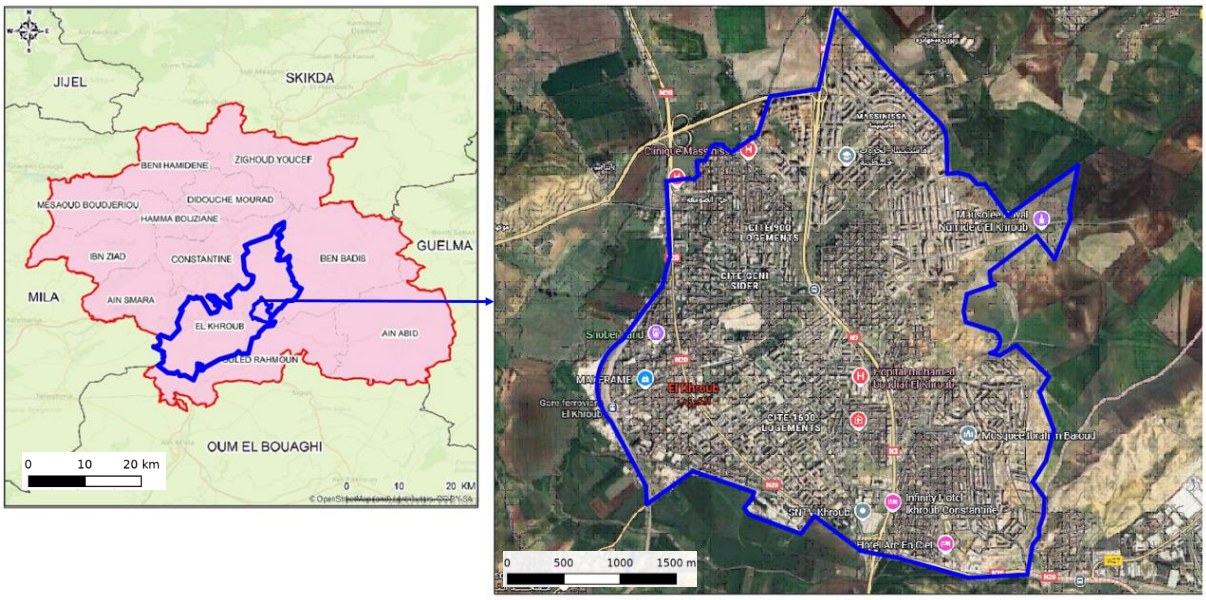


Figure 5. 3: *Aerial view depicting the location of the city of El Khroub. Source: Author, 2026.*

2.1. History of urban development in El Khroub

The urban growth of El Khroub constitutes a complex and multidimensional process with important implications for both residents' quality of life and the surrounding environment. Over time, this growth has been accompanied by a major demographic increase, extensive land consumption, and significant pressure on infrastructure, services, and natural resources. The urbanised area of the city expanded from 28.25 hectares in 1977 to 583.90 hectares in 1998, reaching 1,200 hectares in 2008 and 2,000 hectares by 2020. Over the same period, the population increased from 14,962 inhabitants in 1977 to 65,344 in 1998, then to 89,251 in 2008, and 183,921 in 2020. These transformations illustrate the scale and intensity of El Khroub's urban development and provide the basis for understanding its successive phases of expansion.

The urban development of El Khroub can be divided into six major phases:

2.1.1. Phase 1: The initial stage (pre-1962)

The first stage of El Khroub's urban expansion dates back to the colonial period, before Algeria's independence in 1962 (see Figure 5.4). At that time, the settlement remained predominantly rural, consisting mainly of agricultural land and scattered dwellings. During the colonial period, the urban core was organised according to a grid layout, with straight streets and rectangular plots. This spatial structure was designed primarily to serve the needs of the colonial population and was associated with marked social and spatial inequalities. The built fabric included individual housing for French settlers as well as semi-collective housing for the local population, reflecting a differentiated pattern of occupation within the urban core. This initial phase therefore, laid the foundations of El Khroub's later urban structure while also expressing the unequal socio-spatial order of the colonial period.



Figure 5. 4: *Town hall of the city of El Khroub during the colonial era. Source: Adapted from (Rosso, 2008).*

2.1.2. Phase 2: The second stage (1962–1977)

The second phase of El Khroub's urban expansion began following Algeria's independence in 1962. This period witnessed the first substantial growth of the urban centre, characterised by the construction of large housing estates and the emergence of informal settlements, driven by rural-to-urban migration as the city became a major attractor for surrounding rural populations. Urbanisation during this phase was relatively modest in terms of vertical expansion, with buildings largely concentrated along the main national road passing through the city. The urbanised area grew from 18.21 hectares before 1962 to 28.25 hectares by 1977, while the population increased from 8,742 in 1962 to 14,962 in 1977. Despite this growth, El Khroub retained a predominantly rural character during this period, reflecting the theory of spatial dependence, wherein colonial structures continued to influence urban development (Khenchouche & Khenchouche, 2020).

2.1.3. Phase 3: The third stage (1977–1987)

During this stage, the city underwent rapid expansion through numerous urban development projects, including the construction of new neighbourhoods, industrial and commercial zones, and improvements to the road and public transport network. This growth extended primarily eastwards, covering an area of 268 hectares. However, this expansion also reduced agricultural and natural land, thereby affecting the local environment and living conditions. From an interpretive perspective, this process may be understood as a form of urban sprawl, that is, the

outward expansion of urban areas into previously non-urban land (Ewing, Pendall, & Chen, 2002). By contrast, urban densification has been discussed in the literature as a more compact and potentially more sustainable alternative to extensive spatial growth (Batty, 2013).

2.1.4. Phase 4: The fourth stage (1987–1998) – Slowing of spatial growth

During this period, urban construction slowed moderately compared with the previous phase, reflecting a stage of urban consolidation rather than rapid outward expansion. Projects initiated before 1987 were continued, including the completion of 116 dwellings within a larger complex of 950 units, as well as 284 houses in a new urban housing area comprising 1,600 units. Additional developments were also undertaken, including the construction of 312 houses and 250 houses in two neighbourhoods within the El-Wafa subdivision, making use of vacant land within the city. These areas, located beyond the current National Road No. 3, were identified in the Land Use Plan as a new urban entity known as Massinissa. During this phase, the population increased significantly, rising from 47,461 inhabitants in 1987 to 65,344 in 1998. By the end of this period, and particularly by 2000, the urbanised area had reached 668.90 hectares.

2.1.5. Phase 5: The fifth stage (1998–2010)

After 1998, a project comprising 250 participatory housing units was launched and subsequently completed in order to address the housing needs of El Khroub. This period was marked by a clear acceleration in the development of residential subdivisions, particularly in the Massinissa sector. Building on the urban footprint established at the end of the previous phase, the urbanised area increased from around 668.90 hectares in the early 2000s to 1,004 hectares by 2010, representing an additional 335.1 hectares. Population growth during this period was more moderate than in the preceding decade. In 2008, the city's population was estimated at 86,100 inhabitants, with a growth rate of 2.81% and a net migration rate of 1.09%. It is also important to note that much of this urban expansion took place on land with limited agricultural potential.

2.1.6. Phase 6: The sixth stage (2010–2022) – Urbanisation on high-potential agricultural land

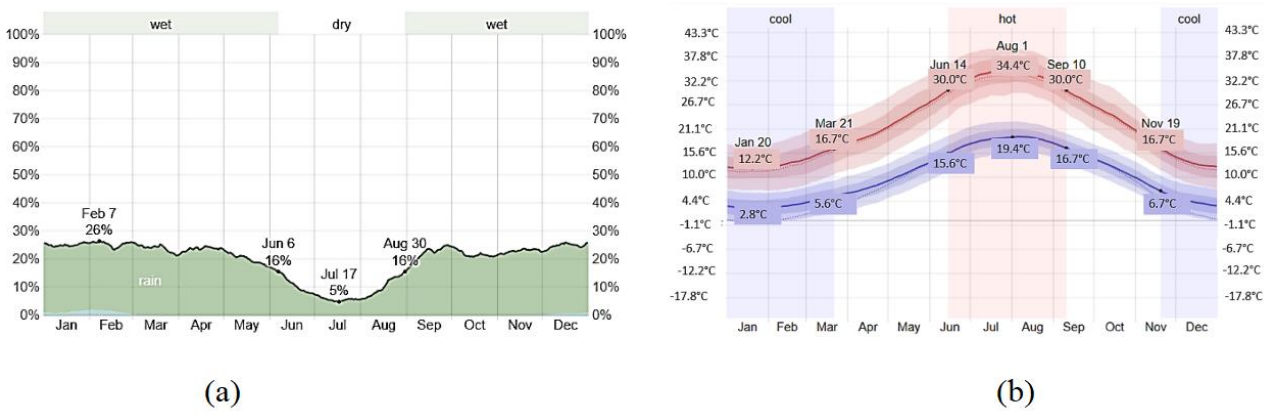
During the most recent period, El Khroub underwent substantial change with the launch of the Ain Nahass programme, which comprised 3,000 housing units constructed on highly fertile agricultural land. This programme was intended to accommodate approximately 10,752

inhabitants. This development strategy marked a significant departure from previous policies, which had prioritised the preservation of cultivable land. Agricultural land, often regarded as a non-renewable resource because of its limited capacity for regeneration, was thus converted into residential areas in order to meet urgent housing needs. The transformation of fertile land into urban zones has sparked debate about contemporary planning choices and their long-term sustainability. Land-use decisions now face the challenge of balancing immediate housing demand with the need to preserve natural resources for future generations.

3. Urban climate of El Khroub

El Khroub is located at an elevation of approximately 700 metres, which contributes to moderating its temperatures. According to the Köppen–Geiger classification, the wider Constantine–El Khroub region has a hot-summer Mediterranean climate (Csa), with a transition towards semi-arid conditions due to its dry summers, strong solar exposure and relatively low summer humidity (Beck et al., 2023). The analysis of the principal climatic indicators relevant to children's outdoor use in El Khroub therefore includes Ta, RH, solar exposure, AV, precipitation and extreme heat.

- RH follows a marked seasonal pattern. It is highest in winter, reaching about 75% in January and December, and lowest in summer, falling to approximately 43% in July and 46% in August. This indicates that summer discomfort in El Khroub is not primarily caused by humid heat, but by the combination of high air temperature, strong solar exposure, and dry atmospheric conditions. Precipitation is concentrated mainly in the cooler months. The wettest months are April (65 mm), March (64 mm), and May (62 mm), while July is the driest month with only 10 mm of rainfall. This dry summer period reinforces the importance of vegetation quality, irrigation, shaded routes, and surface material choice in the selected outdoor places (Figure 5.5a).
- The annual temperature cycle shows a strong seasonal contrast. January is the coldest month, with an average temperature of 6.2 °C, a minimum of 1.7 °C, and a maximum of 11.6 °C. July is the hottest month, with an average temperature of 25.9 °C, a minimum of 18.4 °C, and a maximum of 33.8 °C (Figure 5.5b).



(a) (b)

Figure 5. 5*: Temperature and precipitation averages for 9 years (2017–2026) in El Khroub: (a) Annual precipitation averages; (b) Monthly averages of temperature.*

- Solar exposure is particularly relevant for the analysis of OTC. El Khroub records its highest sunshine duration in July, with approximately 12.6 hours of sunshine per day, while January records the lowest value, with about 5.6 hours per day. In terms of short-wave solar energy, the brightest period extends from May to August, with July reaching approximately 7.8 kWh/m²/day, whereas December records the lowest value at around 2.4 kWh/m²/day. These values justify the need to examine children's outdoor use in relation to shaded and exposed areas, especially in paved or weakly vegetated space (Figure 5.6).

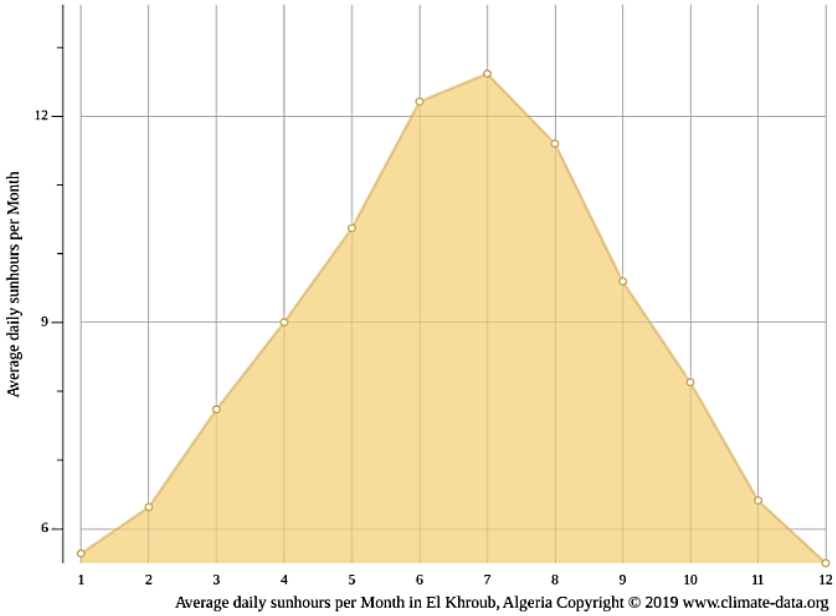


Figure 5. 6: *Average daily short-wave solar energy in El Khroub. Source: Adapted from WeatherSpark / MERRA-2 data, 2026.*

- El Khroub experiences moderate seasonal variation in AV, with the windiest period extending from November to April (Figure 5.7). The highest average AV occur in winter, reaching around 8.6 mph, approximately 3.8 m/s, in December. Whilst the calmest month is September, with about 6.8 mph, approximately 3.0 m/s. Dominant wind directions vary seasonally: winds are most frequently from the north between April and October, from the west between October and April, and briefly from the south in October.

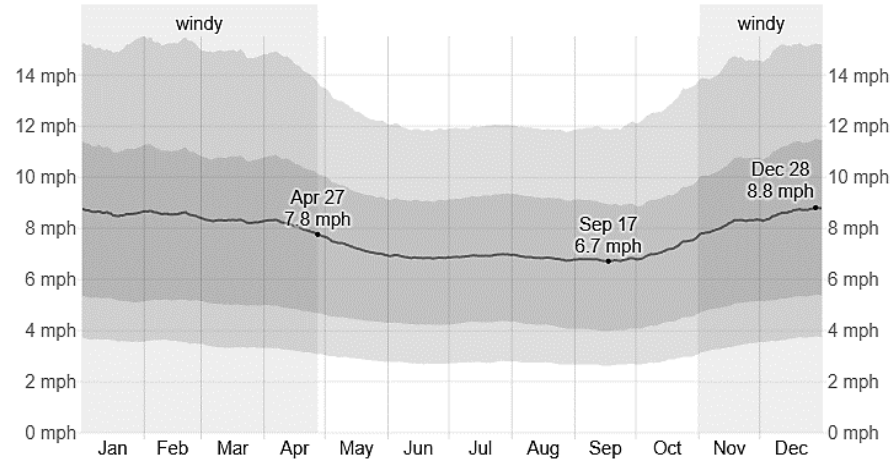


Figure 5. 7: *The average of mean hourly AV (dark grey line). Source: https://weatherspark.com/s/53047/1/Average-Summer-Weather-in-El-Khroub-Algeria#Figures-WindSpeed.*

4. **Morphological and configurational structure of El Khroub centre**

El Khroub centre presents a relatively legible morphology inherited largely from the colonial period. Its historic core is structured by an orthogonal grid, regular plots and a principal axial route around which civic functions and public spaces are concentrated. This early planning structure is illustrated in the 1962 master plan, where the central urban fabric appears as the main organised nucleus around which routes, facilities and later extensions were structured (Figure 5.8). This central core functions as the city's primary generative nucleus. During the colonial period, two intersecting axes framed the main public garden and Square, creating a structured relationship between movement, visibility and collective urban life. Around this core, key civic and communal facilities were located, including the Chiad Mosque, the Lossif Mebarka health centre, the central post office, the school, the former church and the courthouse (BADER, 2001).

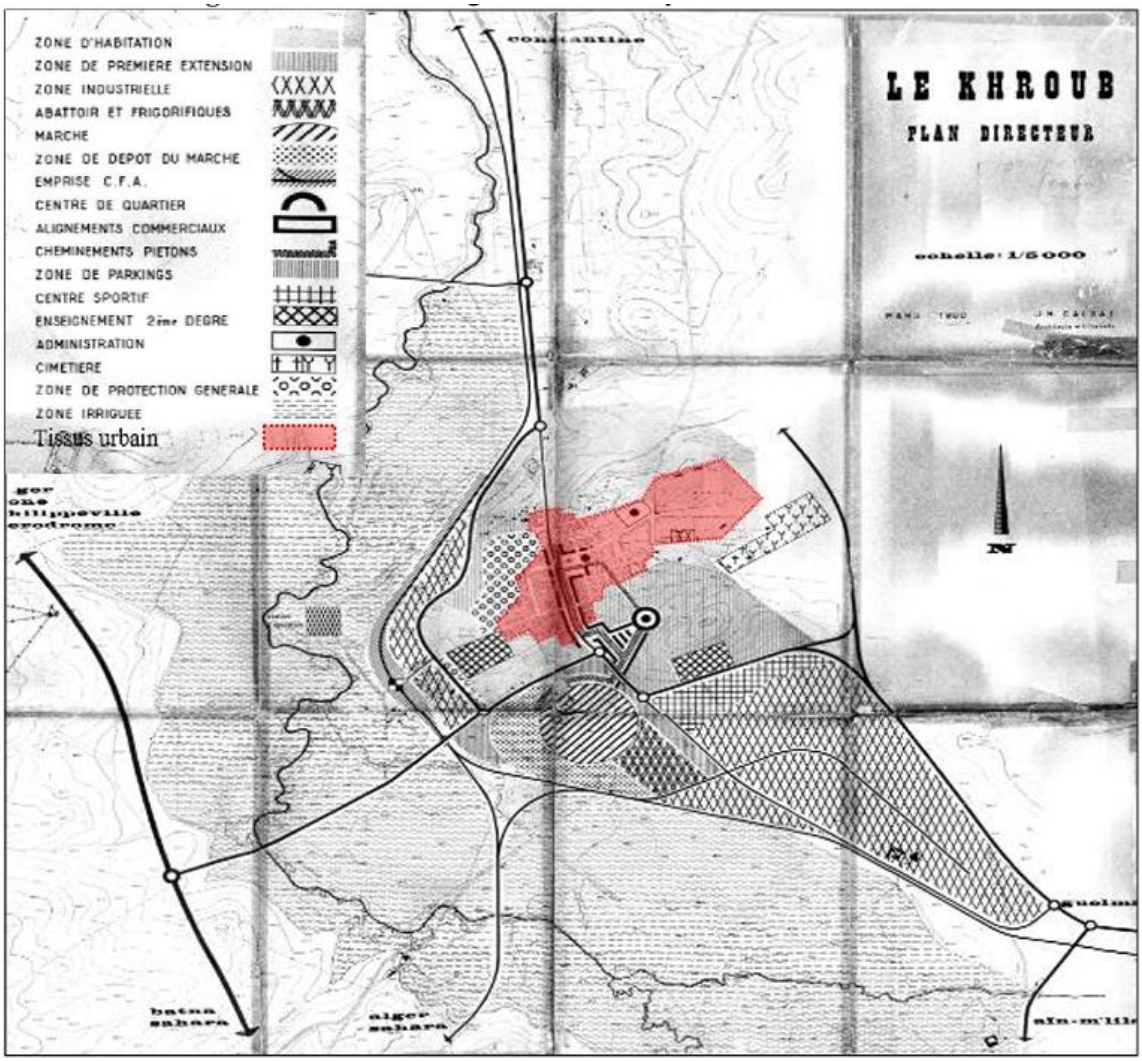


Figure 5. 8*: Organisational structure of the central core of El Khroub. Source: EL Khroub APC archive (year 1962).*

5. Criteria for classifying outdoor places

The classification of outdoor places in this research is used as an analytical step for identifying the spaces most relevant to CUL. Since the thesis examines how OTC and spatial configuration contribute to the enhancement of CUL, the selected criteria must reflect not only the physical form of outdoor places, but also their capacity to support children's presence, movement, and play. Recent child-friendly urban research confirms that children's access to outdoor environments depends on a combination of spatial, environmental and social conditions (Ding et al., 2024; Moura, Rosa, & Barros, 2024; WHO, 2026). Therefore, the criteria used in this study were selected because they allow outdoor places in El Khroub to be assessed in relation to children's actual and potential use. These criteria are summarised in Table 5.1, which presents their relevance to CUL and the indicators used for classification and selection.

5.1. Proximity to schools

Proximity to schools was retained as a key criterion because schools structure children's daily movements and increase the probability of their presence in nearby outdoor spaces. Outdoor places located close to primary schools, middle schools or nurseries are more likely to be encountered during routine journeys, after-school periods and family-accompanied movements. However, proximity is not sufficient in itself. A nearby public space may remain underused if the route is unsafe, exposed to traffic, poorly shaded or socially unsuitable. For this reason, school proximity is treated here as an indicator of potential child catchment, not as automatic evidence of child-friendly quality. Recent research on school travel and children's independent mobility confirms that access to school-related routes is closely associated with physical activity, autonomy and everyday outdoor exposure (Duffy et al., 2024; Kerai et al., 2024).

5.2. Vegetation cover and shaded conditions

Vegetation cover was selected because it directly affects both environmental comfort and the attractiveness of outdoor places for children. In hot or semi-arid contexts, trees, shaded areas and planted surfaces can reduce exposure to solar radiation and improve OTC, making outdoor spaces more usable during warm periods. Recent studies on children's OTC show that plant configuration, shading and low-radiation materials are essential for improving children's thermal conditions in activity spaces (Lehnert et al., 2024). Nevertheless, vegetation should not be considered only as a percentage of green surface. Its spatial distribution is equally important: trees located along movement paths, play zones and resting areas are more relevant for children than isolated green patches with little functional use. Therefore, vegetation cover is assessed in relation to shade, microclimatic moderation and its connection to children's activity areas.

5.3. Play provision

Play provision was included because play is one of the most direct expressions of CUL. Outdoor places that provide dedicated play equipment, flexible surfaces or informal play opportunities are more likely to support children's physical, social and imaginative activity. However, the presence of play equipment alone does not guarantee child-friendly performance. Recent child-friendly urban design research emphasises that meaningful play environments require safe walking routes, creative and challenging play opportunities, family-friendly surroundings and green settings (Pia & Bezboruah, 2025). In this study, play provision is therefore evaluated critically: the aim is not only to identify whether formal equipment exists, but also to examine whether the space allows children to move, interact, explore and remain outdoors comfortably.

5.4. Spatial location, accessibility and visibility

Spatial location was selected because the position of an outdoor place within the urban structure influences its accessibility, visibility and degree of integration into everyday movement networks. A centrally located space may attract more users and benefit from natural surveillance, while an edge or poorly connected space may be less visible, less accessible and less used by children. This criterion is particularly important because CUL is not determined only by the presence of public spaces, but by how these spaces are spatially connected to homes, schools, streets and pedestrian routes. Recent studies on children's independent mobility and child-friendly planning emphasise the need to understand how built-environment indicators make routes safe, attractive and usable for children (Khanian, Łaszkiewicz, Kronenberg, Baró, & Khmara, 2026). In this research, spatial location is therefore assessed through centrality, edge condition, relation to main pedestrian routes and visibility within the surrounding urban fabric.

5.5. Shape and size

Shape and size were retained as morphological criteria because they influence legibility, supervision, activity diversity and patterns of occupation. In this thesis, shape is not used as a purely formal category; it is considered in relation to children's ability to read, cross, appropriate and feel secure within the space. A regular and clearly bounded space may support orientation and visual control, while a more irregular space may offer varied perspectives and opportunities for exploration. Size is approached in the same way: a large outdoor place may support diverse activities and movement, but it can also feel exposed or difficult to supervise; a smaller space may feel more contained and socially legible, but may limit play diversity or become overcrowded.

5.6. Observed attendance

Observed attendance was included because the study aims to examine outdoor places that are not only planned or available, but actually used by children. A public space may appear suitable on maps or in planning documents, yet remain underused because of poor maintenance, weak attractiveness, thermal discomfort, safety concerns or social restrictions. Attendance therefore, acts as an empirical filter that helps distinguish potential child-friendly spaces from spaces that function as meaningful everyday environments. However, attendance is not interpreted as a simple measure of quality. High attendance may reflect attractiveness, centrality, or lack of alternatives, while low attendance may reveal exclusion, discomfort or poor accessibility. For this reason, observed child presence is used alongside other spatial and environmental criteria rather than as an isolated indicator.

5.7. Access regime

The access regime was retained because CUL depends not only on the physical qualities of a space, but also on whether children can practically enter and use it. Open public spaces, semi-public spaces, managed parks and fee-paying recreational areas do not offer the same degree of everyday accessibility. This distinction is important in the present study because some outdoor places are managed as leisure space with stronger supervision and a different mode of access. Recent research on children's access to green space and independent mobility shows that formal availability does not always translate into real accessibility, particularly when social, economic, safety or management conditions limit children's use (Hällqvist, 2024).

Table 5. 1: *Criteria used for classifying and selecting outdoor places in El Khroub. Source: Author, 2026.*

Criterion	Influence on CUL	Indicator used
Proximity to schools	Indicates potential child catchment and likelihood of routine use.	Number of nearby schools; approximate walking distance.
Vegetation cover and shade	Influences OTC, shade, microclimatic moderation and duration of stay.	Percentage of vegetation; presence of trees and shaded zones.
Play provision	Indicates the capacity of the space to support recreational, social and physical activity.	Percentage of dedicated play area; presence or absence of equipment.
Spatial location, accessibility and visibility	Affects movement potential, natural surveillance, spatial integration and everyday accessibility.	Central, adjacent, edge position; relation to main pedestrian routes and visible access points.
Shape and size	Influences legibility, enclosure, supervision, activity diversity and spatial appropriation.	Regular / irregular form; degree of openness or enclosure; total area in m².
Observed attendance	Confirms whether the space is actually used by children.	High / moderate / low child presence during preliminary observation.

Access regime	Determines practical and social accessibility.	Open public / semi-public / managed / fee-paying.

6. Classification of El Khroub's outdoor places

The classification was limited to El Khroub centre, rather than to the whole commune. This delimitation was necessary because the research focuses on children's everyday outdoor use within the historic and central urban fabric, where the selected case studies are located. Peripheral sectors such as Massinissa, Ain Nahass and other recent extensions were excluded because they belong to different urban fabrics, with different housing forms, spatial logics and public-space structures. Previous work confirms that El Khroub centre contains the city's most historically established outdoor places. Sahli (2008) notes that the old square dates from the 1920s and is located in the historic centre, directly adjoining the public garden (Sahli, 2008). Chaabna (2022) also identifies streets, boulevards, places and placettes as important supports of sociability in El Khroub's city centre (Chaabna, 2022). At the wider city scale, Benkouachi et al. identified only five parks, gardens and squares, which confirms the limited supply of formal green and public spaces in El Khroub and supports a focused central-area inventory (Benkouachi & Alatou, 2017). The inventory therefore, identified the main formal and semi-formal outdoor places relevant to children's potential use in El Khroub centre: the Square, Martyr Plaza, Snoberland Park, pedestrian corridors, and smaller residual or transitional open spaces, as shown in Figure 5.9. However, these spaces were not treated as equivalent. Residual and transitional spaces were excluded because they lacked sufficient spatial definition, regular child attendance, or comparable conditions for behavioural observation and microclimatic measurement.



Figure 5. 9: *Main outdoor places identified in El Khroub centre are shown in yellow. Source: Author, 2026.*

7. Choice of case studies

The three case studies were not selected as equivalents, but as a deliberate typological gradient of public-space governance: from the openly accessible place of the Square, through the formally designed municipal plaza of Martyr Plaza, to the enclosed, fee-paying recreational park of Snoberland. This gradient allows the thesis to examine CUL not only as design questions but also as questions of access regime and governance.

Within this gradient, the final selection retained the Square, Martyr Plaza and Snoberland as they correspond to three distinct typologies previously defined in Chapter I: an urban square, a civic plaza, and a park/green space with integrated play areas. As shown in Table 5.2, the three sites share a central location and regular children's presence, but differ in size, play provision, vegetation cover, access regime and observed patterns of use. This makes them suitable for a

comparative analysis of how spatial configuration and OTC influence CUL under similar urban and climatic conditions.

Table 5. 2: *Comparative characteristics and selection rationale of the case-study sites. Source: Author, 2024.*

Outdoor place	Urban location	Area / type	Play provision	Vegetation	Observed child-use profile	Selection rationale
The Square	Central core; close to four primary schools, four lower secondary schools, and one high school.	10,002 m². Urban square.	Limited play equipment around the central kiosk, approx. 0.8% of total area.	3,505 m², 35%.	Highly frequented; mainly supervised neighbourhood use.	Represents an everyday central square with high attendance but weak formal play provision.
Martyr Plaza	Central core; close to one primary school and one nursery school.	6,390 m². post-independence civic plaza.	Only two foosball tables.	2,449 m², 38%.	Moderately frequented; mainly walking, cycling and short stays.	Represents an open civic space where children's use is movement-oriented rather than play-based.
Snoberland	Central area; close to three primary schools and two lower secondary schools.	28,365 m². Park and green space with integrated play areas.	Dedicated play areas, approx. 15% of total area.	11,714 m², 41%.	Highly frequented; family-oriented recreational use.	Represents the most play-oriented and recreationally equipped case.

7.1. The Square

The Square is one of the oldest outdoor places in El Khroub, dating back to the 1920s. It is located in the historic centre, and covers an area of approximately 10,002 m². Historically,

it functioned as a central public place framed by trees and organised in relation to the main street. It was formerly equipped with benches under ash trees and animated by a music kiosk, demolished in 1980, which hosted public talks, celebrations and festive events (Rosso, 2008). Its orthogonal layout, central position and relationship with surrounding civic elements made it an important place of convergence within the original village core. The historical photograph in Figure 5.11 illustrates its former role as a structured public space associated with collective life and urban sociability. From a contemporary perspective, the Square remains relevant to this study because of its centrality, its proximity to several primary schools and secondary schools, and its regular use by children, particularly during after-school periods. Its vegetation coverage, estimated at around 35%, contributes to shaded conditions and may improve OTC during warm periods. However, formal play provision remains very limited, occupying only about 0.8% of the total area. This contrast between high child attendance and weak dedicated play provision makes the Square a useful case for examining how children appropriate an everyday urban square beyond formal playground design. Its location and immediate urban context are shown in Figure 5.10.

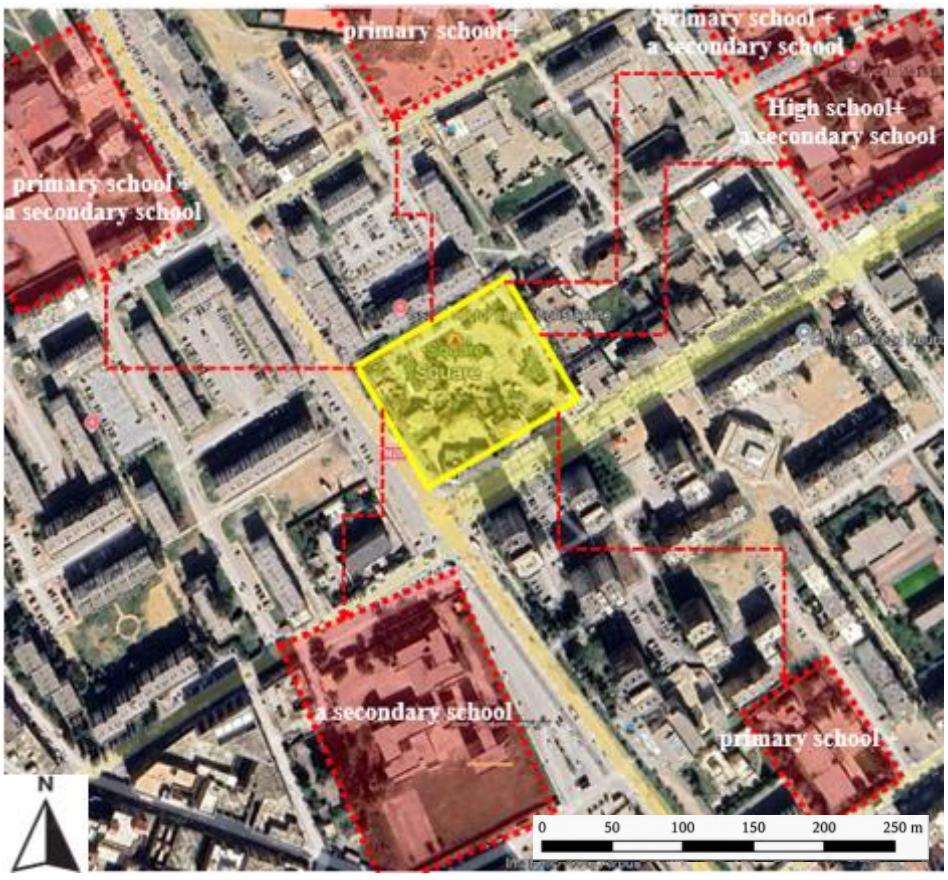


Figure 5. 10: *Location and immediate urban context of the Square. Source: Author, 2026.*



Figure 5. 11: *Historical photograph of the former El Khroub Square. Source: Adapted from (Chaabna, 2022).*

7.2. Martyr Plaza

Martyr Plaza is a post-independence civic space named in memory of those who died during the War of Independence. Following 1962, it became part of El Khroub's expanding public-space structure and gradually acquired several urban functions, including commemoration, passage, gathering and local social interaction. Its central location and proximity to educational facilities make it relevant for observing children's routine presence, especially during school-related movements and short stays.

Unlike the Square and Snoberland, Martyr Plaza does not contain a designated play area. Children's use is therefore more movement-oriented, involving walking, cycling, waiting and brief social interaction rather than structured play. Although it is smaller than the Square, with an area of approximately 6,390 m², it has relatively high vegetation coverage, estimated at around 38%. Its urban furniture and open layout support temporary occupation, but its civic and mineral character, together with the absence of formal play equipment, may limit longer recreational use by children. For this reason, Martyr Plaza provides a contrasting case through which to examine how a civic plaza without dedicated play provision can still participate in CUL through accessibility, visibility, shade and everyday movement patterns. Its location and immediate urban context are shown in Figure 5.12.



Figure 5. 12: *Location and immediate urban context of Martyr Plaza. Source: Author, 2026.*

7.3. Snoberland

Snoberland is a contemporary leisure space located within the old urban centre of El Khroub, developed on the site of a former abandoned green area known locally as *La Pépinière*. Its transformation into an amusement and recreational park represents an important intervention in the revitalisation of the historic core. Since its development, Snoberland has become a major family-oriented recreational destination, attracting users from El Khroub and neighbouring cities such as Constantine, Tébessa, Biskra, Oum El Bouaghi and Mila (Khenchouche & Khenchouche, 2020). From an environmental and spatial perspective, Snoberland differs clearly from the other two case studies. It is the largest site, covering approximately 28,365 m², and has the highest vegetation coverage, estimated at around 41%. It also provides the strongest formal play provision, with dedicated play areas occupying about 15% of the total surface. These characteristics make it particularly relevant for examining the relationship between play provision, spatial configuration, OTC and children's attendance. However, Snoberland also differs in its access regime: as a managed and fee-paying recreational park, it does not offer the same level of everyday public accessibility as the Square or Martyr Plaza. This distinction is important because CUL is shaped not only by spatial and thermal conditions, but also by supervision, management and practical access. Its location and immediate urban context are shown in Figure 5.13.

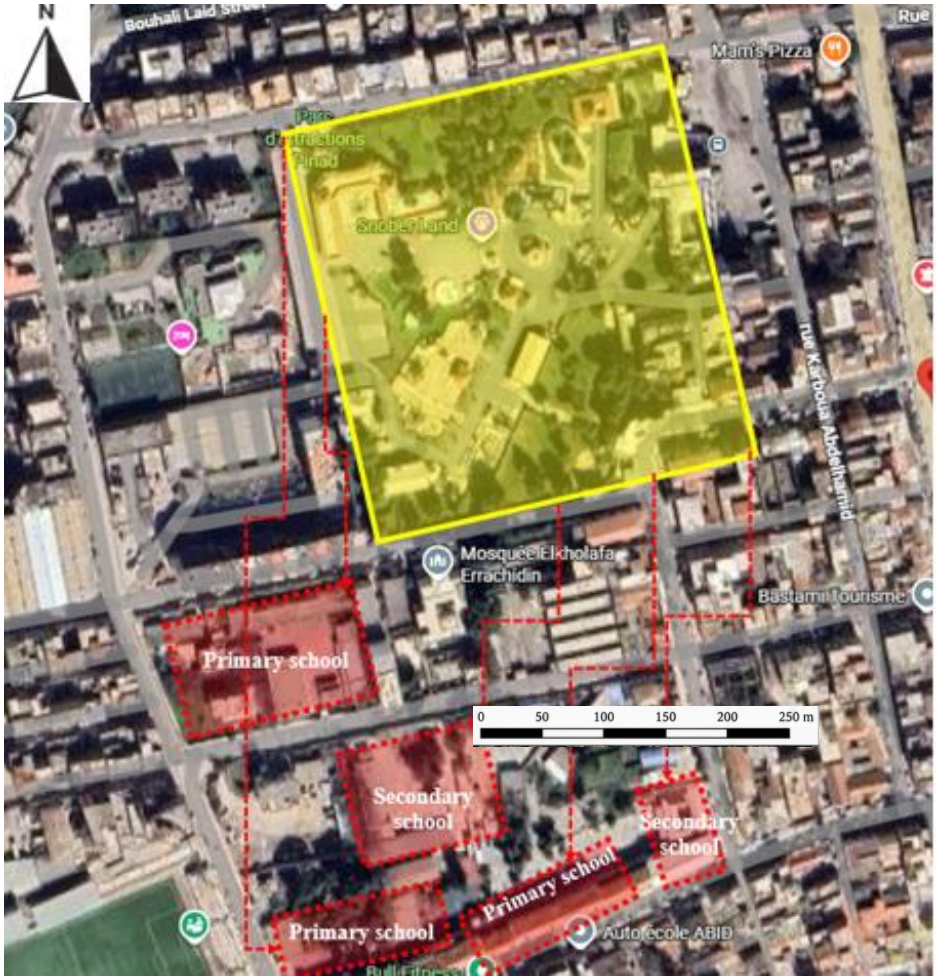


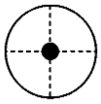
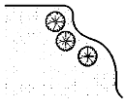
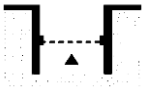
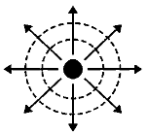
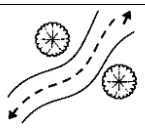
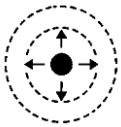
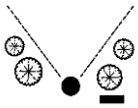
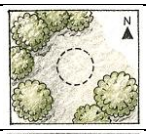
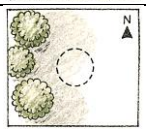
Figure 5. 13**:** *Location and immediate urban context of Snoberland. Source: Author, 2026.*

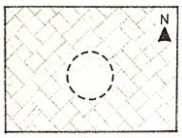
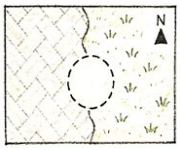
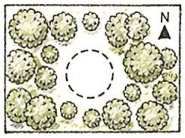
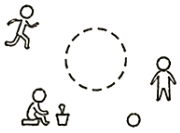
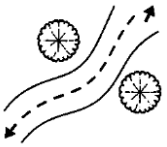
8. Criteria and selection of spots

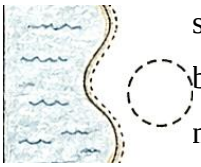
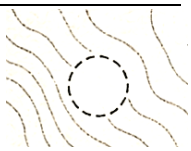
8.1. Criteria for selecting spots

The selection of observation and measurement spots was designed to translate the study's theoretical framework into an operational field strategy. Within each case study, four spots (S1-S4) were selected according to a common set of criteria represented in Table 5.3. The aim was to identify representative micro-spatial situations where spatial configuration and OTC were likely to influence CUL. In Snoberland, additional attention was given to topography and proximity to water because these features may affect local thermal conditions. The use of four spots in each site was therefore a deliberate methodological choice intended to ensure comparability across the three case studies while remaining sensitive to the specific internal structure of each space.

Table 5. 3: *Criteria used for selecting spots within the case studies. Source: Author, 2026.*

Criterion	Indicator used for spot selection		Importance for CUL	References
Spatial position	Central position		Captures differences between spaces of convergence, edge conditions and access points, which may influence children's visibility, movement, appropriation and sense of spatial control.	(Çamaş, Erçek, Dumitrescu, & Kaya, 2025; Ding et al., 2024; WHO, 2026)
	Peripheral edge			
	Entrance or threshold			
Accessibility and relation to paths	Highly accessible		Children's presence is strongly influenced by how easily they can reach and cross a space through everyday routes.	(Çamaş et al., 2025; Duffy et al., 2024; Moura et al., 2024; Soltani et al., 2022)
	Circulation route			
	Less accessible zone			
Visibility and surveillance	Highly visible		Visibility supports perceived safety, adult supervision and children's confidence in using outdoor spaces.	(Ding et al., 2024; Moura et al., 2024; WHO, 2026)
	Less visible			
Shade and solar exposure	Shaded		Shade directly affects OTC and determines whether children can remain outdoors during hot periods.	(H. Luyao et al., 2025; Qi et al., 2022; Xie et al., 2025)
	Partially shaded			
	Exposed			
Vegetation and surface character	Vegetated surface			(Teshnehdel, Gatto, Li, &

	Mineral or paved surface		Vegetation, paved surfaces and mixed surfaces influence heat exposure, comfort, attractiveness and duration of stay.	Brown, 2022; Xie et al., 2025)
	Mixed surface			
	Dense vegetation			
Activity intensity	High child presence		Spots should include both highly used and less used areas to avoid analysing only the most attractive locations.	(Bishop et al., 2024; Han et al., 2022; Joshi et al., 2026)
	Moderate child presence			
	Low child presence			
Functional role	Play area		Different activities may be linked to different spatial and thermal conditions.	(Bishop et al., 2024; Çamaş et al., 2025; Han et al., 2022)
	Seating zone			
	Gathering node			
	Circulation route			

Site-specific environmental feature	Water surface proximity		Some local features may create specific microclimatic or behavioural conditions that must be captured.	(Liang et al., 2024; Teshnehdel et al., 2022; X. Wang et al., 2025)
	Topographic variation			

8.2. Preliminary field verification of the spots

Following the definition of the spot-selection criteria, a preliminary field verification was carried out across the three selected outdoor places. In the present chapter, this phase is mentioned only in relation to the validation of the observation and measurement spots, while its broader methodological role as a pilot investigation is developed in Chapter VI. This field verification made it possible to confirm whether the proposed spots reflected the spatial and environmental contrasts required by the research framework, including central and peripheral positions, shaded and exposed areas, vegetated and mineral surfaces, circulation routes, gathering nodes, play areas, and different levels of children's presence. It therefore helped ensure that the four selected spots in each case study were observable, accessible, representative of the internal diversity of each site, and suitable for repeated fieldwork.

8.3. Selection of spots within the case studies

8.3.1. The Square

In the Square, the four spots were selected to reflect the main contrasts defined in Table 5.3: spatial position, accessibility, visibility, shade, surface character, activity intensity and functional role. These four spots capture the main micro-spatial and environmental variations within the Square without unnecessary repetition (Figure 5.14).

- **S1** was selected as a partially shaded area, allowing comparison with more exposed parts of the Square.
- **S2** was retained as the central reference point because it corresponds to the most accessible and socially active part of the site, where pedestrian convergence and children's interaction are most likely to occur.

- **S3** represents a more exposed and less visible zone, making it useful for assessing how solar exposure and reduced visual control may affect children's presence.
- **S4** was located near a building entrance, in a partially shaded edge condition, in order to examine the relationship between threshold spaces, shade and peripheral use.

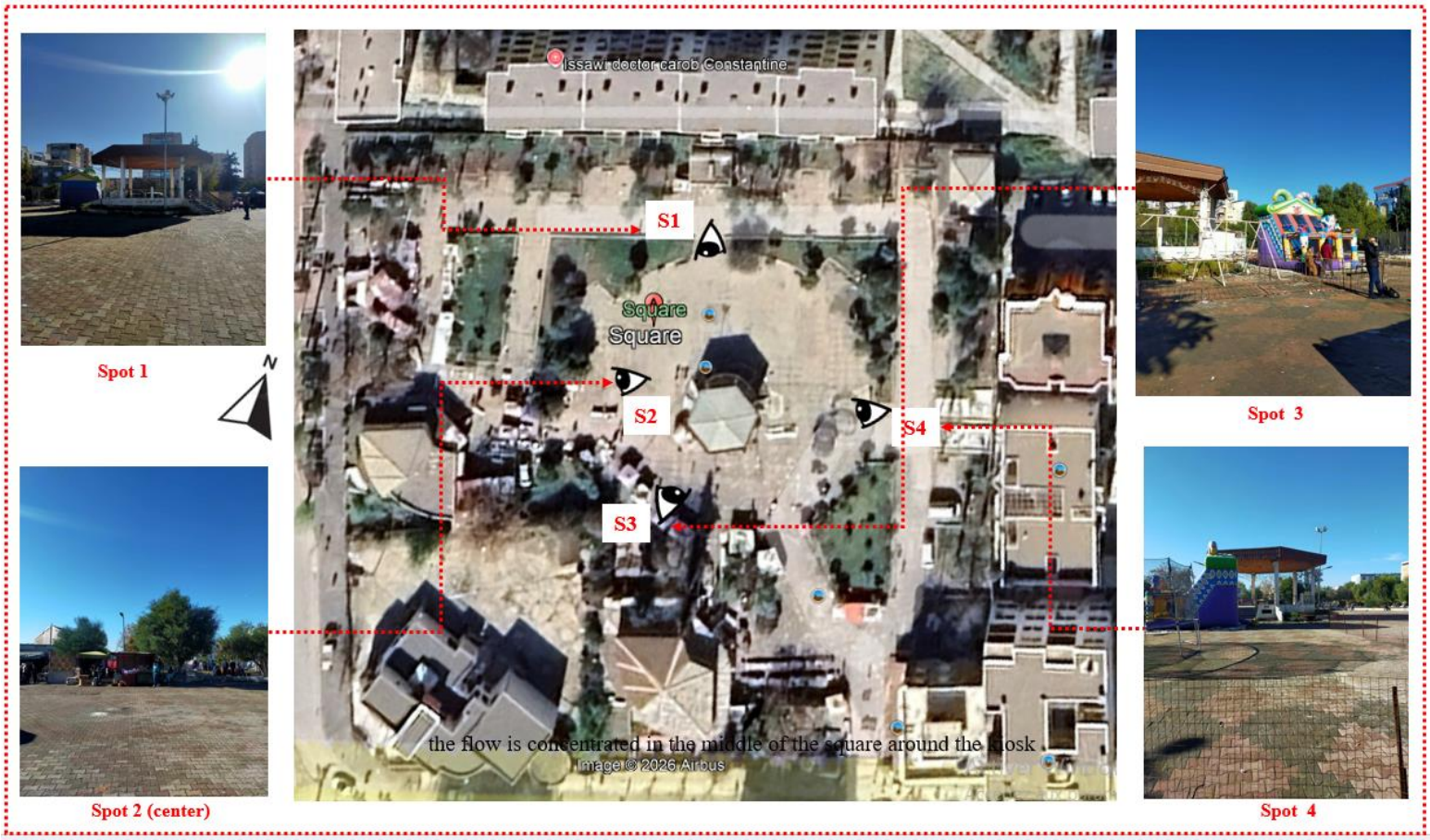


Figure 5. 14: *The location of the four selected spots (S1-S4) in the Square. Source: Author, 2024.*

8.3.2. Martyr Plaza

In Martyr Plaza, the same criteria were applied within a smaller and more compact civic space. The four spots compare central and edge positions, shaded and exposed conditions, movement routes and resting areas within Martyr Plaza (Figure 5.15).

- **S1** was located near an entrance and along a circulation path, in a partially shaded condition, making it relevant for analysing movement-related use.
- **S2** was selected as the central and most visible reference point, where movement convergence and short social interaction are most likely to occur.

- **S3** was selected as an exposed edge condition near an entrance and seating zones, allowing the study to assess how openness, solar exposure and resting facilities influence children's occupation.
- **S4** was positioned near the shaded pergola areas, providing a contrasting condition where shade and seating may encourage longer stays.

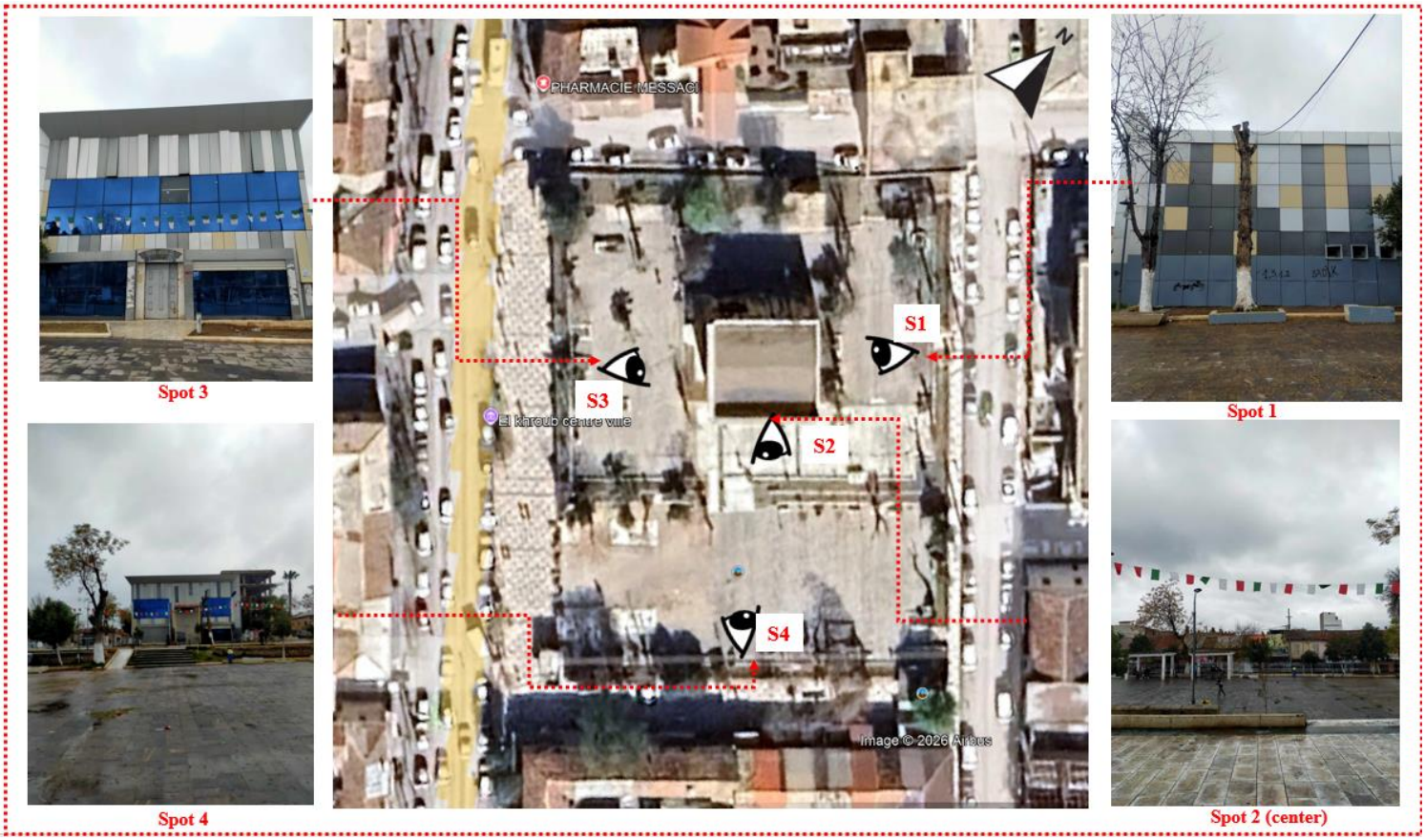


Figure 5. 15: *The location of the four selected spots (S1-S4) in Martyr Plaza. Source: Author, 2024.*

8.3.3. Snoberland

In Snoberland, the spot-selection criteria were adapted to a larger and more environmentally diverse recreational setting. In addition to spatial position, accessibility, visibility, shade, vegetation, surface character and activity intensity, site-specific features such as water proximity and topographic variation were also considered.

- **S1** and **S3** were located near water features to capture possible cooling effects and child attraction.
- **S2** was positioned within the principal gathering and play zone because it combines functional intensity, accessibility and high child presence.

- **S4** was selected within a densely vegetated area to assess the effects of shade, evapotranspiration and relative enclosure.

This selection allowed comparison between water-influenced and non-water areas, shaded and exposed conditions, vegetated and mineral surfaces, and active and quieter zones (Figure 5.16).

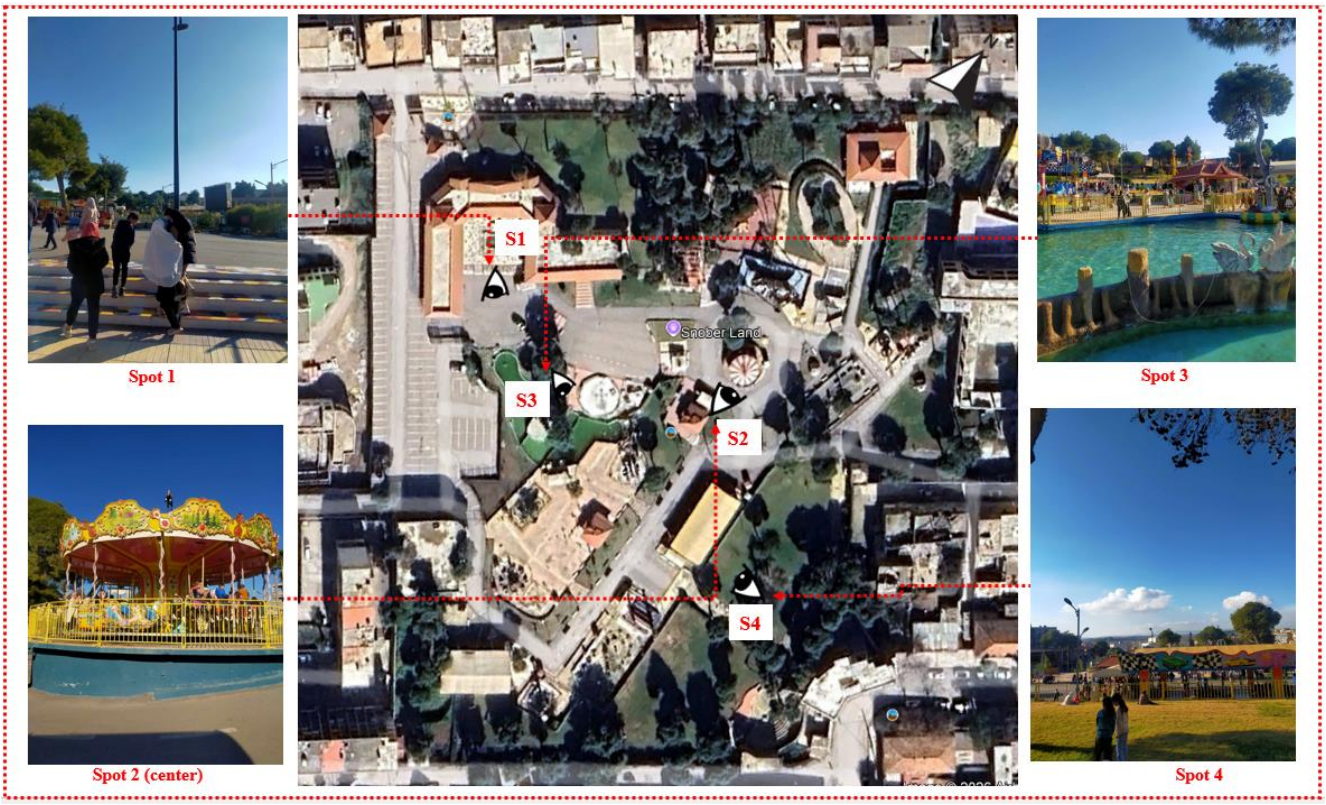


Figure 5. 16: *The location of the four selected spots (S1-S4) in Snoberland. Source: Author, 2024.*

Conclusion

This chapter established the contextual and analytical foundation for the empirical investigation of children's outdoor use in El Khroub. By situating El Khroub within the wider territorial framework of Constantine, it clarified the metropolitan position of the study area and its role as a major satellite city connected to regional transport corridors. The chapter also showed that El Khroub's present urban structure results from successive phases of development, beginning with the colonial core and continuing through post-independence expansion, housing growth and recent urbanisation towards peripheral sectors. The analysis of El Khroub's urban climate highlighted the relevance of semi-arid conditions for the study of OTC. Seasonal temperature variation, low summer humidity, strong solar exposure, limited summer rainfall and changing wind conditions all confirm that children's outdoor use cannot be interpreted without

considering shade, vegetation, surface materials and exposure to microclimatic stress. In parallel, the reading of El Khroub centre's morphology and spatial structure showed the importance of the historic core, its orthogonal layout, civic functions and public-space network in shaping accessibility, visibility and potential patterns of use.

The chapter further demonstrated that outdoor places in El Khroub centre differ significantly in terms of proximity to schools, vegetation and shade, play provision, accessibility and visibility, shape and size, observed attendance and access regime. This classification justified the selection of three contrasting case studies: the Square, Martyr Plaza and Snoberland. These sites offer a relevant comparative basis because they represent different types of outdoor places, an urban square, a civic plaza and a managed recreational park.

Finally, the chapter translated this contextual reading into an operational field strategy through the selection of four observation and measurement spots within each case study. These spots were chosen to capture contrasting spatial and environmental conditions, including central and peripheral positions, shaded and exposed areas, vegetated and mineral surfaces, movement routes, play areas, and, in the case of Snoberland, water proximity and topographic variation. This selection ensures that the empirical investigation can compare not only different sites, but also different micro-spatial situations within each site.

Overall, the chapter has moved from territorial context to empirical units of analysis, establishing a coherent basis for examining how spatial configuration and OTC may influence CUL in El Khroub. The next chapter, *Application of Analysis Methods and Tools*, builds on this foundation by presenting the methodological procedures used to assess the selected case studies. Its objective is to operationalise the research framework through behavioural observation, microclimatic measurements, OTC assessment, child-centred tools, spatial configuration analysis and data integration across the selected sites and observation spots.

CHAPTER VI: APPLICATION OF ANALYSIS METHODS AND TOOLS

"*Space is not a neutral container. It is an active force shaping human behaviour*."

— Bill Hillier, Space is the Machine (1996)

Introduction

Following Chapter V, which established the study area, selected the three case-study sites and justified the selected spots, the present chapter explains how the empirical investigation was operationalised. While the selection of methods is informed by the previous methodological approaches reviewed in Chapter IV, this chapter focuses on the specific hybrid mixed-method protocol applied for the fieldwork in the Square, Martyr Plaza and Snoberland.

The adopted hybrid method combines quantitative and qualitative tools to examine how OTC and spatial configuration jointly influence CUL across the three case studies. The quantitative method includes microclimatic measurements, UTCI simulation, Space Syntax analysis, spatial–thermal overlay, and statistical analysis. The qualitative method includes questionnaires and participatory drawings, while behavioural mapping functions as a mixed observational tool that links children's spatial behaviour with thermal and configurational conditions.

The chapter first presents the preliminary investigation and protocol validation, which allowed the research tools and fieldwork organisation to be tested before the main investigation. It then introduces the conceptual methodological framework of the study, followed by the operational nine steps used. Finally, the chapter addresses the ethical considerations related to research involving children and caregivers.

1. Preliminary investigation and protocol validation

Prior to the main empirical investigation, a preliminary investigation was conducted across the three selected outdoor places. In rigorous empirical research, pilot studies constitute a fundamental methodological prerequisite (Van Teijlingen & Hundley, 2010). They are essential for validating data collection protocols, confirming the logistical feasibility of the study design (Lancaster, Dodd, & Williamson, 2004), and ensuring that qualitative instruments are appropriate for the target demographic before full-scale deployment (Malmqvist, Hellberg, Möllås, Rose, & Shevlin, 2019).

The preliminary investigation was undertaken in mid-July 2024 across the three case-study outdoor places.

- The preliminary visit to the Square was conducted on 15 July 2024 from 2.00 pm to 4.00 pm, followed by Martyr Plaza on the same day from 4.30 pm to 6.30 pm, while Snoberland was investigated on 16 July 2024 from 3.00 pm to 5.00 pm.
- These exploratory sessions made it possible to define the four observation spots in each outdoor place (as detailed in Chapter V), verify the practical organisation of the fieldwork, and pilot-test the questionnaire. The adapted instrument was pilot-tested with five users; minor wording adjustments were made before the main fieldwork.

2. Conceptual methodological framework of the Investigation

Following the preliminary investigation and protocol validation, the empirical methodology was organised into a conceptual framework that structures the overall steps of the investigation. As shown in Figure 6.1, the framework illustrates how the research moves from the selected case studies and target users towards data collection, analysis, results, recommendations and conclusion.

The purpose of this framework is to show how the different methods are connected within a single analytical process designed to examine how OTC and spatial configuration jointly shape CUL.

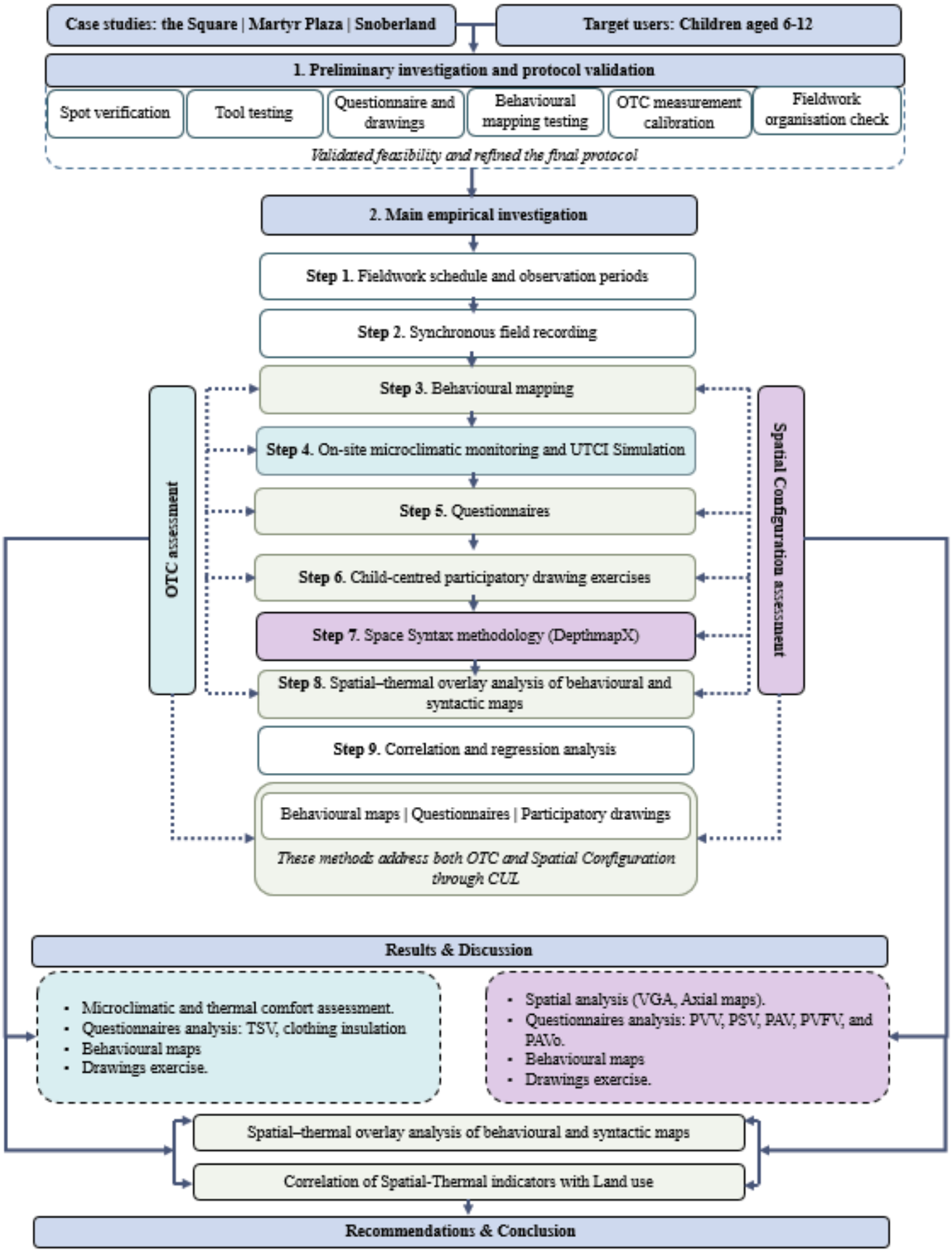


Figure 6. 1: *Conceptual framework of the thesis. Source: Author, 2026.*

2.1. Step 1: Fieldwork schedule and observation periods

The main investigation began by defining the temporal framework of the fieldwork. This step was necessary to ensure that children's outdoor use could be observed under contrasting seasonal conditions and at different times of the day. For this reason, data collection was organised during a typical summer week from 20 to 25 July 2024 and a typical winter week from 22 to 31 December 2024.

Within these two reference weeks, observations and measurements were recorded at one-hour intervals from 9.00 am to 9.00 pm. The starting time of 9.00 am was selected because the fieldwork was conducted during school holidays, when children's outdoor presence was expected to begin later than during regular school periods. An earlier starting hour would therefore have been less effective for capturing behavioural patterns of children's activity and presence. However, the daily observation hours were adjusted slightly according to the actual rhythm of use in each site, particularly in Snoberland, where children's attendance was concentrated later in the day. In each season, the empirical investigation was conducted over two selected days per site. The complete fieldwork schedule is summarised in Table 6.1.

Table 6. 1*: Fieldwork schedule and observation periods. Source: Author, 2024.*

Study area	Typical summer week	Typical winter week	Summer hours	Winter hours	Measured interval
The Square	July 20-21st, 2024	December 22-23rd,2024	9.00 am to 9.00 pm	9.00 am to 9.00 pm	1 hour
Snoberland	July 22-23rd,2024	December 30-31st,2024	3.00 pm to 9:00 pm	11.00 am to 9.00 pm	1 hour
Martyr Plaza	July 24-25th,2024	December 26-27th,2024	9.00 am to 9.00 pm	9.00 am to 9.00 pm	1 hour

2.3 Step 2: Synchronous field recording

To ensure methodological consistency during fieldwork, an outdoor activity and microclimate recording table was designed for each site visit (see Appendix E, p. A-5). This table was used to record behavioural and microclimatic data simultaneously at one-hour intervals, following the predefined morning, afternoon, and evening periods. It included fields for Ta, RH, and AV across the four observation spots (S1–S4), together with children's presence according to gender and companionship status. A section was also included for visual sequences, allowing photographic records to be linked to the corresponding observation hour. The full visual sequences are presented separately in Appendix B (see Appendix B, p. A-2).

2.4 Step 3: Behavioural mapping

The observational component of the methodology was operationalised through behavioural mapping, which was used to capture how children occupied, moved through, and appropriated the three outdoor places. This method allowed children's activities to be recorded spatially on scaled base maps, making it possible to analyse patterns of use in relation to specific zones within each site. At each site, four observation spots were defined to cover the main activity areas, circulation spaces and edge conditions. During each hourly observation cycle, the entire site was scanned for approximately 20 minutes, and all visible children across the four spots were recorded on the corresponding base plan within the same scan window. The four spots therefore functioned as internal spatial reference zones for coding and comparison, while the observation unit remained the *site-wide timed scan*.

Directly asking children their age was avoided, as this would have disrupted the non-intrusive nature of the behavioural-mapping protocol. Age groups were therefore estimated using visual proxies, a common approach in observational child–environment research (Cosco, Moore, & Islam, 2010; Whitzman, Worthington, & Mizrachi, 2010). The mapping protocol used a dual-coding system based on symbols and colours (Figure 6.2). Geometric symbols distinguished between *static activities*, such as sitting, eating and standing, and *dynamic activities*, such as playing, running and cycling. Additional symbols were used to record *companionship status*, differentiating between children observed independently and those accompanied by caregivers. In addition to activity type, the mapping distinguished children who *occupied* a spot through stationary or play activity from those merely *passing* through. Both categories were also coded by companionship status, indicating whether children were accompanied by a caregiver or unaccompanied. For passing children, triangles represented accompanied children and circles represented unaccompanied children. This distinction was methodologically important because TC already models *through-movement* potential. Including transient passers-by in occupation

counts would have conflated the dependent variable with the spatial property predicted by TC, creating circularity in the correlation analysis. Passing children were therefore excluded from the spatial–thermal occupation counts, ensuring that values correlated with VI and TC represented actual occupation rather than transit flow.

Gender was visually estimated for group-level comparison between girls and boys, while the behavioural maps recorded occupied activity zones, including central, peripheral, shaded, exposed, play-oriented and circulation-related areas. This made it possible to identify occupation density, activity typologies and spatial clustering across the selected sites. As demonstrated in youth-focused urban studies, behavioural mapping is particularly valuable for translating transient and spontaneous forms of play into analysable spatial data (Little, 2020). The resulting maps were later triangulated with questionnaire data in order to compare observed behaviour with children's reported perceptions and preferences.

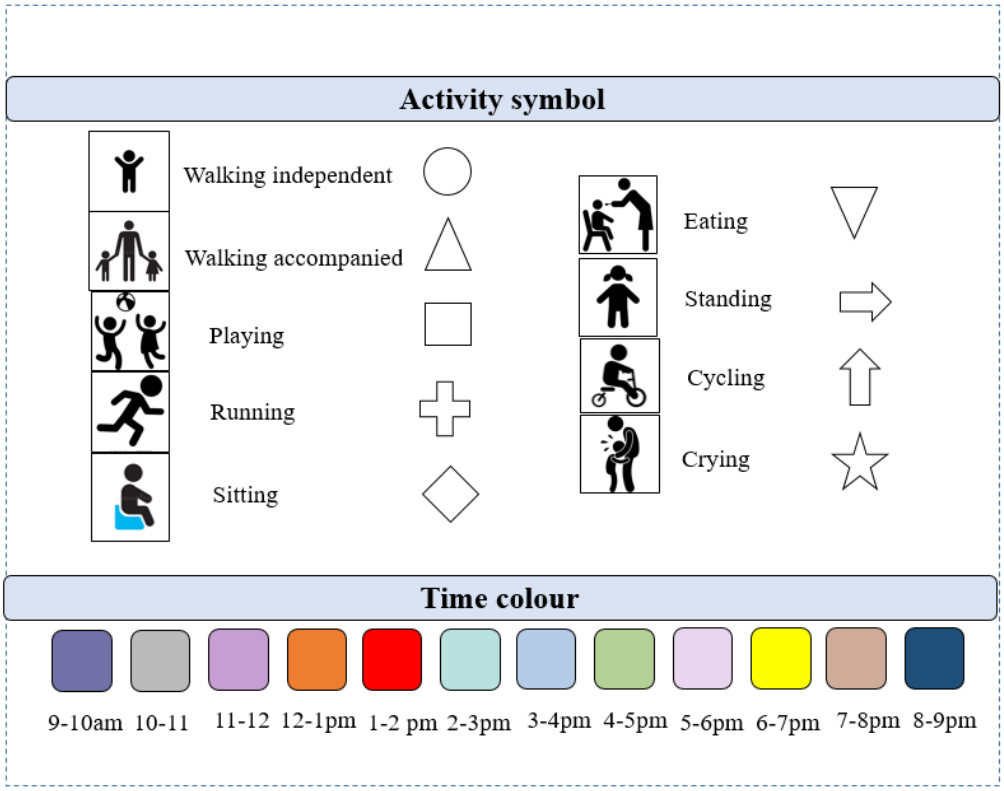


Figure 6. 2: *Symbol and colour coding for hourly behavioural observations. Source: Author, 2024.*

2.5 Step 4: On-site microclimatic monitoring and UTCI Simulation

On-site microclimatic data were measured at the four designated spots (S1–S4) using a calibrated Lutron LM-8000 multifunction meter (see Figure 6.3). Ta, RH, and AV were measured at a height of 1.2 metres to reflect children's biometeorological exposure rather than standard adult conditions (Table 6.2). This height corresponds to the approximate stature of the

target population, children aged 6–12 years, with an average age of 9 years. The instrument was selected for its portability, rapid response time, and ability to record the principal thermal variables required for systematic hourly field measurement, with each parameter recorded after a stabilisation period of approximately 3 seconds per measurement. The daily OTC data collection records, organised by season, selected investigation days, case-study site, and observation spot, are presented in Appendix C (see Appendix C, p. A-3).

Table 6. 2: *Technical characteristics of the Lutron LM-8000. Source: Author, 2026.*

Instrumentation	Parameter	Unit	Range	Accuracy	Instrument sampling interval	Measurement height
LUTRON LM-8000	Ta	°C	0 to 50 °C / Type K: -100 to 1300 °C	Ta: ±1.2 °C; Type K: ±(1% rdg + 1 °C)	3 s	1.2 m
	RH	%	10 to 95% RH	<70% RH: ±4% RH; ≥70% RH: ±(4% rdg + 1.2% RH)	3 s	1.2 m
	AV	m/s	0.4 to 30.0 m/s	≤20 m/s: ±3% F.S.; >20 m/s: ±4% F.S.	3 s	1.2 m

Children's clothing insulation was not assigned using a generic default value. Instead, each child reported their clothing configuration during the survey, and these responses were converted into clo values using the reference tables of Al-Rashidi et al. (2012) and Havenith (2007). This provided session- and season-specific clothing inputs. However, although the clo values were child-specific, UTCI itself remains based on a reference adult walking at 4 km/h with a metabolic rate of 135 W/m² (Al-Rashidi, Al-Mutawa, & Havenith, 2012; Havenith, 2007). The measured OTC parameters, namely Ta, RH, and AV, were then integrated into a Rhinoceros 3D–Grasshopper workflow using Ladybug Tools. These on-site measurements were combined with the three-dimensional geometry of each case-study site to generate spatial distributions of UTCI.

Tmrt was not measured directly in the field. Instead, it was estimated within the Ladybug Tools workflow from solar radiation models, surrounding surface conditions, and the site-specific geometry imported into Rhinoceros 3D. The modelled outputs were cross-checked against daytime peak Ta values for plausibility before integration into the UTCI calculations, consistent with comparable recent work in semi-arid contexts (Gál, 2020; Middel, Häb, Brazel, Martin, & Guhathakurta, 2014; Peng & Huang, 2022). The analysis, therefore, relied on the measured

microclimatic parameters and the simulated UTCI outputs to interpret spatial and temporal variations in OTC. These outputs were subsequently compared with children's behavioural patterns to examine how thermal conditions influenced CUL.

Although UTCI was originally developed for adults and does not include child-specific physiological coefficients, its use in this study is justified by three considerations. First, UTCI remains the most comparatively benchmarked outdoor thermal index in recent international studies of children's outdoor environments (Antoniadis et al., 2020; J. Vanos et al., 2023), which allows the present results to be compared directly with that emerging literature. Second, UTCI integrates the four environmental drivers (Ta, RH, Tmrt, AV) at the scale of bodily exposure rather than at the air-mass scale, which is the relevant scale for evaluating outdoor occupation by children. Third, comparative studies in semi-arid and Mediterranean contexts report UTCI to remain valid across the range of conditions observed during the fieldwork in El Khroub (Lai, Chen, & Liu, 2020; Nouri & Matzarakis, 2021).



Figure 6. 3*: Lutron LM-8000 multifunction meter. Source: Author, 2024.*

2.6 Step 5: Questionnaires

A structured survey was administered on-site to children aged 6–12, who were the primary users of the sites, and to their accompanying caregivers. This age group was selected because it broadly corresponds to middle childhood, during which children become more capable of expressing spatial preferences, describing comfort and discomfort. As mentioned in Chapter I, it also corresponds to Jean Piaget's '*Concrete Operational Stage'*, during which logical

reasoning and spatial classification become more developed (Çanakçıoğlu, 2015). No fixed number of questionnaire participants was predetermined before fieldwork. Instead, participants were recruited on-site based on their presence during the observation periods at each site and season. The survey therefore, followed a non-probabilistic, presence-based sampling logic, involving children and caregivers who were available and willing to participate during the fieldwork.

As a result, the number of respondents varied between sites and seasons. These variations were not treated as a flaw in the sampling procedure, but as an empirical reflection of differences in attendance, rhythms of use and patterns of occupation across the three outdoor places. Consequently, the questionnaire findings were interpreted comparatively and contextually, rather than as statistically standardised results based on equal-sized samples.

To ensure methodological validity and cognitive accessibility, the child-focused questionnaire was refined with input from an educational psychologist specialised in children's cognitive and developmental needs. The questionnaire required approximately 15 minutes per child, while the caregiver questionnaire took around 10 to 15 minutes. The instrument was then organised into four analytical sections (see Appendix A, p. A-1):

- *Collection of basic participant information*, including the child's name, age, gender and school level.
- *Space Usage and Preferences***:** This section captured the temporal and motivational context of the visits, including visit frequency, duration, and the primary reasons for occupying the space.
- *TSV***:** Children's subjective thermal experience was assessed using a simplified three-category thermal sensation vote: hot, neutral and cold. This format was chosen to make the question easier to understand and more suitable for children during the field survey. The TSV item was recorded alongside the clothing vote, allowing children's perceived thermal sensation to be interpreted in relation to their reported clothing insulation.
- *Safety and Entertainment***:** This segment evaluated the psychosocial dimension of urban liveability, measuring perceived safety, experiences of vulnerability or harassment, and overall recreational satisfaction.
- *Spatial Design Perceptions***:** This section translated spatial configuration concepts into child-friendly questions. Questions assessed spatial TC (how easily they access

favourite spots), VI (overall navigability and movement), and visibility (the ease of locating peers or finding concealed areas for play).

2.7 Step 6: Child-centred participatory drawing exercises

The drawing exercise was included because children's spatial preferences and environmental meanings are not always easily expressed through verbal questionnaires (Figure 6.4). Visual representation can reveal how children imagine, remember and evaluate outdoor places, especially in relation to comfort, attraction, safety and desired improvements. This methodological choice is supported by Rieh (2020), who shows that children's sketches can help identify the spatial qualities through which they construct a sense of place (Rieh, 2020).

Children were given materials and asked to draw the outdoor place as they preferred it to be or as they imagined it should look. This qualitative method provided non-verbal insights into the



Figure 6. 4: *Children's participatory drawing exercises carried out during field observation sessions in outdoor spaces. Source: Author, 2024.*

physical elements, natural features, and play facilities that children associate with an ideal and liveable urban environment.

Each drawing session lasted about 15 minutes per child, as children were allowed to work at their own pace without time limits, in line with drawing-based research methods (Berti & Cigala, 2022). The duration of questionnaires and drawings instrument is summarised in Table 6.3.

Table 6. 3: *Subjective assessment protocol: Duration per Instrument. Source: Author, 2026.*

Instrument	Target	Duration per participant
Structured questionnaire	Children	~15 minutes
	Caregivers	~10–15 minutes
Participatory drawing exercise	Children	~15 minutes

2.8 Step 7: Spatial Configuration analysis via Space Syntax

In the seventh step, the static configurational properties of the outdoor places were analysed in DepthmapX using Space Syntax methodology. The grid resolution was set at 0.5 metres. This fine-scale resolution was selected to reflect children's shorter step length and more detailed spatial perception, rather than relying on broader adult-oriented spatial models (Conroy Dalton et al., 2022). Two complementary syntactic metrics were computed to evaluate these open public spaces:

- VI at radius 3 (VI R3) on the VGA grid and TC at radius 400 m (TC R400) on the axial map. These measures were selected because they represent two distinct but complementary dimensions of pedestrian movement. VI captures *to-movement*, indicating the potential of a location to attract presence and occupation, while TC captures *through-movement*, indicating the likelihood of a route being used for circulation and passage (Hillier, 2007; Hillier et al., 1996). VI R3 was used to assess the locally perceivable visual field within which users orient themselves in bounded outdoor places. This local radius is particularly relevant for children, whose spatial attention and environmental understanding are more immediate and visually grounded than those of adults (Lynch, 1977; Rissotto & Tonucci, 2002). It therefore provides an

appropriate indicator for analysing children's potential gathering, pause and stationary activities.

- TC R400 was used to assess movement potential at the neighbourhood scale. The 400 m radius corresponds approximately to a five-minute walking distance and aligns with the documented autonomous mobility range of children aged 6–12 (Hillman, 1990; Shaw et al., 2015). It therefore captures the scale at which children's independent outdoor movement, exploration and route choice are most likely to occur.

A supplementary methodological application was conducted in Seoul, South Korea, during a research training period in autumn 2025. The spatial-configuration component of the protocol, Space Syntax analysis (VGA and Axial map), behavioural mapping, and questionnaires including children's subjective thermal-sensation items, was applied to four outdoor spaces under humid continental conditions, with each site investigated over three days between 12.00 pm and 6.00 pm. This supplementary application served as a methodological replication, confirming that the configurational component of the framework remains operationalisable beyond the semi-arid Algerian context. The detailed protocol and results are provided in Appendix D (p. A-4).

2.9 Step 8: Spatial–thermal overlay analysis of behavioural and syntactic maps

This step consists of analytical synthesis consisted of a spatial–thermal overlay analysis combining behavioural maps, syntactic maps and UTCI values. Behavioural maps representing peak and off-peak activity periods were overlaid with the corresponding VGA and Axial maps for each case study. In addition, the UTCI values simulated at the spots (S1–S4) were added to each map in order to provide a direct thermal reference for the interpretation of children's use. This procedure made it possible to examine whether syntactically favourable spots, expressed through higher levels of VI and TC, consistently attracted children, while more segregated spots remained less occupied, or whether their spatial potential was realised mainly during thermally acceptable UTCI conditions and constrained during thermally stressful conditions. This step therefore directly addressed the hypothesis that *static spatial parameters influence CUL most clearly, when dynamic spatiotemporal parameters are thermally favourable*.

2.10 Step 9: Correlation and regression analysis

Following the spatial–thermal overlay analysis, a statistical stage was conducted to examine the strength and direction of the relationships between behavioural, spatial and thermal variables. Pearson's correlation analysis was applied to assess the association between children's use of

outdoor space and the principal spatial–thermal indicators, namely VI, TC, UTCI, and Ta. Behavioural indicators included children's land use, occupation density and activity intensity. The analysis was structured around a crossed correlation design in which two methodologically distinct groups of predictors were tested against the same behavioural outcome: dynamic spatiotemporal factors (Ta, UTCI), which vary across hours and spots, and static spatial factors (VI, TC), which vary across spots but remain constant in time. This crossing made it possible to test whether children's use increased in syntactically favourable areas, decreased under thermally stressful conditions, or reflected the combined influence of spatial configuration and OTC. The structure of this crossed design is illustrated in Figure 6.5.

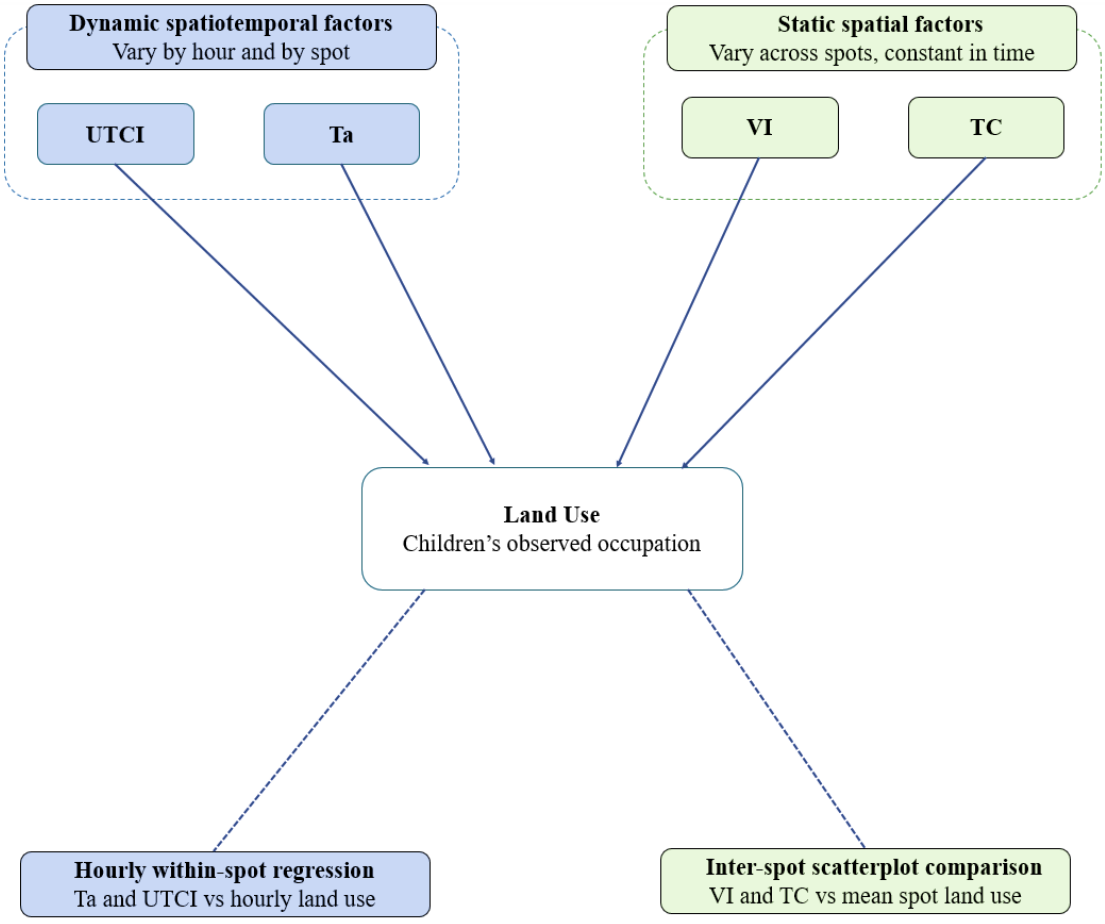


Figure 6. 5: *Crossed correlation design of dynamic spatiotemporal factors (Ta, UTCI) and static spatial factors (VI, TC) with children's land use. Source: Author, 2026.*

Because the two groups of predictors differ in their temporal structure, they were operationalised through two different analytical procedures. Dynamic factors (Ta, UTCI) were tested through within-spot hourly regression, where each spot supplied the full hourly time series. Static factors (VI, TC) were tested through inter-spot scatterplot comparison, using the mean observed land use for each of the four spots. This methodological distinction is critical:

it ensures that each predictor is analysed at the temporal resolution at which it actually varies, rather than imposed on a common but inappropriate time grid.

Regression analysis was then used to explore the predictive contribution of selected spatial and thermal variables to children's occupation patterns. Because the configurational analysis compares four spots per site, the corresponding R^2 values are not used to infer population-level significance, but to identify the direction and relative strength of association across spots within each site. Statistical significance (p-values) is reported only for the within-spot thermal regressions, where each spot supplies the full hourly time series. The configurational scatterplots should therefore be read as descriptive rather than inferential. This approach is consistent with small-sample configurational studies, where statistical modelling is used to support spatial interpretation rather than replace it (Hillier & Vaughan, 2007). The general form of the model can be expressed as:

$$Y = \beta_0 + \beta_1 x + \in$$

where Y represents the behavioural outcome variable, such as child presence, occupation density, or activity frequency; β_0 is the intercept; β_1 is the regression coefficient associated with the predictor x; and ϵ is the error term. Depending on the analytical objective, *x* represented a spatial or thermal predictor, such as VI, TC, UTCI or Ta. Where several predictors were examined, the results were interpreted cautiously because of the small number of observation points. The explanatory power of the regression models was assessed using the coefficient of determination:

$$R^2 = 1 - \frac{\sum(Y_i - \hat{Y}_i)^2}{\sum(Y_i - \ddot{Y}_i)^2}$$

where Y_i denotes the observed values, $\hat{Y}_i$ the predicted values, and $\ddot{Y}$ the mean of the observed values. Higher R^2 values indicated that a greater proportion of variation in children's behaviour is explained by the predictor included in the model. In interpretative terms, this made it possible to distinguish between spaces where children's use was mainly associated with configurational advantages and spaces where use was reduced despite favourable spatial properties because of thermal stress.

3 Ethical considerations

Research involving children requires careful ethical consideration, particularly in public outdoor places. In this study, participation was voluntary, and informed consent was obtained

from caregivers before data collection. Child assent was also sought through age-appropriate explanations, recognising children as active participants while respecting the protective role of caregivers. Confidentiality and anonymity were ensured throughout the research process. No identifying personal information was retained, and all data were anonymised after collection. Visual materials, including photographs and observational records, were handled carefully to minimise the risk of individual identification. All research data were stored securely, with restricted access, and used only for academic and scientific purposes related to this thesis.

Conclusion

This chapter has presented the operational methodology adopted to investigate how OTC and spatial configuration jointly influence CUL in the three selected outdoor places of El Khroub. It translated the theoretical framework of the thesis into a hybrid mixed-method protocol. The chapter first clarified the role of the preliminary investigation as a protocol-validation phase. This step made it possible to test the feasibility of the fieldwork, refine the research tools, and confirm the practical organisation of data collection before the main investigation. The chapter then presented the conceptual methodological framework and the nine operational steps used to collect, analyse, and integrate the empirical data. These steps included the definition of observation periods, synchronous field recording, behavioural mapping, microclimatic measurement, UTCI simulation, questionnaires, participatory drawings, Space Syntax analysis, spatial–thermal overlay and correlation/regression analysis. The main contribution of this chapter is the establishment of a coherent methodological basis for analysing CUL through both measurable and experiential dimensions. Quantitative tools provided data on thermal conditions, spatial configuration and statistical relationships, while child-centred and observational tools helped capture children's use, perception and spatial appropriation. Together, these methods make it possible to examine not only where children are present, but also how thermal stress, visibility, accessibility and perceived comfort influence their patterns of occupation. The next chapter presents the first results and the discussion stage of the empirical investigation. It focuses on *Outdoor Thermal Comfort and Children's Urban Liveability,* analysing the measured and simulated thermal conditions across the three case studies and examining how these conditions relate to children's behaviour, perceptions, and use of outdoor space.

CHAPTER VII: RESULTS AND DISCUSSION: OUTDOOR THERMAL COMFORT AND CHILDREN'S URBAN LIVEABILITY

"*Thermal comfort is not a luxury — it is a prerequisite for human presence in outdoor space*."

— Baruch Givoni, Climate Considerations in Building and Urban Design (1998)

Introduction

This chapter presents the results and discussion on the influence of OTC on CUL in the selected outdoor places. It is organised into four complementary parts (Figure 7.1): (1) A descriptive reading of the sites through their child-centred quality, behavioural observations, microclimatic conditions, and questionnaire results. (2) An empirical reading of children's temporal patterns of presence and activity in relation to seasonal and hourly thermal variation. (3) A comparative reading of measured and perceived thermal conditions across the three sites, including the relationship between microclimatic conditions, thermal sensation, and children's presence. (4) A synthetic discussion that brings these findings together before considering their implications. This progression is intended to explain *when*, and under *what thermal conditions*, children occupy the spaces under study.

The chapter tests the hypothesis that OTC, as a dynamic environmental factor varying across both space and time, influences when outdoor spaces become more or less liveable for children. While spatial configuration provides a relatively stable spatial framework of use, OTC changes throughout the day, between seasons, and across observation spots. For this reason, the chapter focuses on the temporal conditions under which children's outdoor presence and activity are enabled, reduced, or transformed.

By combining behavioural observations, microclimatic measurements, and user perceptions, the chapter provides an empirical account of the thermal dimension of CUL in a semi-arid context. It also establishes the basis for the broader integrative discussion and the GUD recommendations developed in the final stage of the thesis.

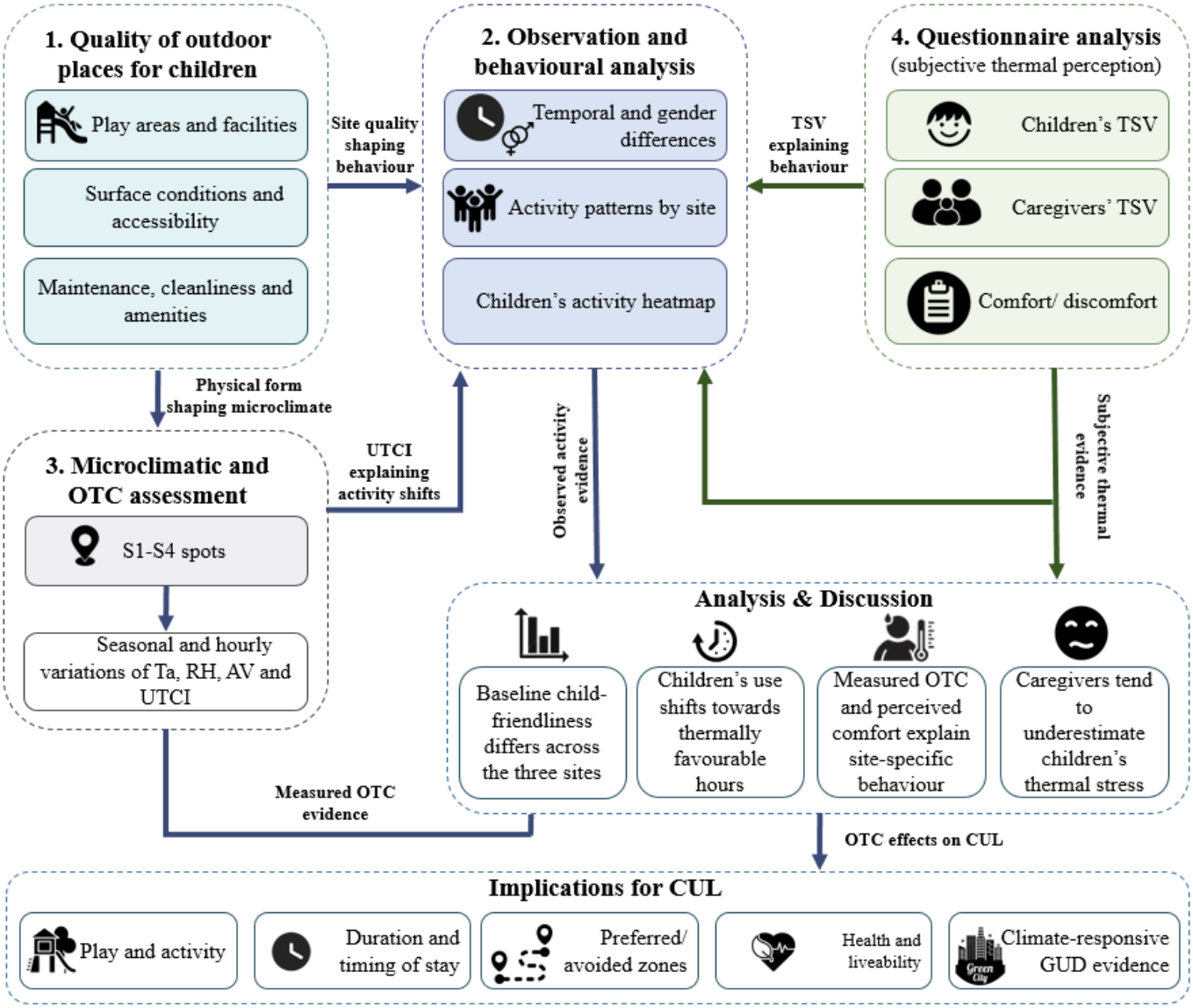


Figure 7. 1: *Structure of Chapter VII. Source: Author, 2026.*

1. Quality of outdoor places for children

This section evaluates the quality of the three selected sites in El Khroub from a child-centred perspective. Children experience urban environments differently from adults, primarily regarding mobility, play behaviour, and thermal sensitivity. The physical characteristics of the sites are examined through key dimensions: play opportunities, surface conditions, and maintenance. The empirical data derive from field visits conducted on selected days within typical summer and winter weeks, capturing seasonal and diurnal variations in children's spatial preferences.

1.1. Play areas, facilities, and built structures

The provision and condition of recreational infrastructure vary across the three sites, reflecting different municipal management approaches.

1.1.1. The Square

In the case of the Square, the recreational infrastructure is degraded and relies primarily on temporary equipment. Permanent structures, such as trampolines, show physical wear, including broken springs and rusted frames (Figure 7.2a). Temporary installations, such as inflatable slides, are deployed according to seasonal rhythms, appearing after 5.00 pm in summer and from 11.00 am in winter. While this operational flexibility adapts to thermal conditions, it indicates an informal approach to spatial management. Furthermore, informal vendors frequently occupy pedestrian pathways, limiting the area available for children's play (Figure 7.2b).



Figure 7. 2*: (a) Damaged and poorly maintained play structures within the Square; (b) Presence of informal trade activities occupying the Square. Source: Author, 2024.*

1.1.2 Snoberland

In marked contrast to the infrastructural deficits observed at the Square, Snoberland provides an extensive recreational infrastructure. The 28,365 m² site contains approximately 50 play structures, including conventional playgrounds, mechanised attractions, and water-based features (Figure 7.3). These facilities are organised into discrete zones catering to different age groups and physical capabilities. This provision supports extended, multi-activity play sessions. These observations align with recent research showing that diverse, accessible and age-responsive recreational infrastructures support longer and more active outdoor play by increasing children's opportunities for varied physical, social and exploratory activities (E.-Y. Lee et al., 2021; Pereira, Vila-Nova, Veiga, Lopes, & Cordovil, 2024).



Figure 7. 3: *Representative play equipment at Snoberland, illustrating the diversity and quality of recreational infrastructure. Source: Author, 2024.*

1.1.3 Martyr Plaza

In contrast to the structured provision at Snoberland, formal recreational facilities in Martyr Plaza are limited to two foosball tables, which are frequently chained for security (Figure 7.4). To adapt to this lack of designated infrastructure, children use the open hardscape for self-directed mobility, including cycling, skateboarding, and informal football. This behaviour exemplifies affordance-based play, where users adapt unprogrammed spaces for recreation. While the expansive area supports older children, the absence of structured equipment provides fewer affordances for younger children who generally require formal activity settings.



Figure 7. 4*: Lack of designated play infrastructure in Martyr Plaza, highlighting the spatial marginalisation of children's recreational needs. Source: Author, 2024.*

1.2. Surface conditions and accessibility

1.2.1. The Square

The surface conditions in the Square present physical barriers to play. The paving is broken, featuring large cracks, missing sections, and vegetation growing through gaps. These irregularities introduce tripping hazards that impede dynamic, running-based play or wheeled activities. The degraded hardscape signals a lack of maintenance, which can negatively influence caregivers' willingness to visit the site.

1.2.2. Snoberland

In contrast, Snoberland features a maintained surface mosaic of paving, asphalt, and grass. This material zoning guides spatial appropriation, helping users identify appropriate areas for high-speed wheeled play versus relaxed activities. Continuous hard surfaces facilitate motor coordination, while grassed zones provide softer landings for informal sports. Additionally, the

integration of permeable, vegetated surfaces enhances latent heat flux, moderating local temperatures and improving the microclimate.

1.2.3. Martyr Plaza

A consistent pavement provides a secure ground plane for children at Martyr Plaza. The absence of surface degradation minimises tripping hazards, accommodating affordance-based play such as informal cycling and skateboarding. For caregivers, the uniform ground condition communicates a safe environment, increasing their willingness to permit autonomous play.

1.3. Conditions, maintenance, and cleanliness

1.3.1. The Square

The Square functions primarily as a transitional thoroughfare rather than a destination. The physical condition of the site is poor; surfaces are unclean, litter is present, and public waste receptacles are absent. The lack of basic urban furniture, such as benches, limits dwell time and social interaction. Additionally, the illicit parking of vehicles within the space reduces pedestrian safety.

1.3.2. Snoberland

Snoberland is articulated through stepped platforms and terraces that structure the site into functional zones. The park is consistently clean and equipped with diverse street furniture, including ornamental fountains, litter bins, and shaded seating. Lighting columns ensure adequate illumination during evening hours, extending the window for safe spatial appropriation.

1.3.3. Martyr Plaza

Martyr Plaza offers a provision of benches and public litter bins, framed by trees and planted areas. However, the maintenance of vegetative elements is inconsistent, diminishing their contribution to microclimatic regulation. The 6,390 m² site is insufficiently shaded, with only two pergolas offering covered seating, which limits comfort during periods of thermal stress.

Discussion

Overall, this section shows that the three sites do not offer the same baseline conditions of CUL, even before behavioural, thermal, or configurational factors are considered.

- *Snoberland* provides a supportive physical environment through diversified play equipment, better maintenance, and more comfortable amenities, but this advantage is qualified by its private and fee-paying character, which makes access more selective.
- *The Square*, by contrast, offers open public access but combines degraded infrastructure, weak maintenance, traffic exposure, and limited child-specific provision, thereby reducing both safety and attractiveness.
- *Martyr Plaza* occupies an intermediate position: its open layout and continuous surface support movement and informal use, yet the lack of formal play equipment and insufficient shade limit its suitability, especially for younger children.

Analytically, this means that CUL depends not only on the physical quality of the environment, but also on the social conditions of access and on whether design, maintenance, and amenities translate space into a genuinely usable setting for children.

2. Observation and Behavioural analysis

Behavioural mapping provided direct empirical evidence of actual space utilisation, facilitating the visualisation of spatial preferences and activity concentrations.

2.1. Temporal and gender differences

2.1.1. Summer observations

The summer observations show clear temporal differences in children's presence across the three sites (Table 7.1). Across all sites, attendance remains relatively low during the afternoon hours and increases later in the evening. The three sites, however, display different summer profiles.

- In the Square, accompanied children are more visible during the morning and early afternoon, with girls particularly represented in these supervised visits.
- In Martyr Plaza, unaccompanied boys become more numerous in the evening, when the space functions more clearly as a gathering place.
- In Snoberland, children's presence is concentrated later in the day, with accompanied attendance peaking between 7.00 pm and 9.00 pm, reflecting its role as a family-oriented recreational destination.
- Gender differences are also evident in the dataset. In the Square and Snoberland, girls appear predominantly in accompanied groups, whereas in Martyr Plaza, boys constitute the majority of unaccompanied users.

Overall, the summer results suggest that children's use is shaped by the interaction between time of day, site function, accompaniment and gendered patterns of spatial permission. Girls appear more frequently in supervised or family-oriented visits, while boys are more visible in unaccompanied evening use, particularly in spaces that function as informal gathering places. This pattern is consistent with recent studies identifying gender, seasonality, parental regulation and site-specific social context as important correlates of children's outdoor play (Dodd et al., 2021; E.-Y. Lee et al., 2021; Pinto, Ferreira, & Pereira, 2024).

Table 7. 1: *Temporal and gendered patterns of accompanied and unaccompanied children during Summer. Source: Author, 2025.*

B: G:		The Square		Martyr Plaza		Snoberland	
Period	**Hours**						
Summer	9-10 am	G = 5, B=4	G =0, B=2	G = 0, B=3	G =0, B=3	/	/
	10-11 am	G =10, B=7	G =0, B=1	G = 2, B=0	G =0, B=5	/	/
	11-12 pm	G =8, B=2	G =0, B=0	G =1, B=3	G =0, B=8	/	/
	12-1 pm	G =5, B=3	G =0, B=1	G = 0, B=1	G = 0, B=3	/	/
	1-2 pm	G =2, B=0	G =1, B=1	G = 0, B=0	G =0, B=7	/	/
	2-3 pm	G = 0, B=1	G =0, B=1	G =0, B=1	G =0, B=0	/	/
	3-4 pm	G =0, B=2	G =0, B=5	G = 0, B=0	G = 0, B=0	G = 9, B=2	G =0, B=0
	4-5 pm	G =6, B=2	G =1, B=2	G = 0, B=0	G =2, B=0	G = 13, B=11	G = 0, B=0
	5-6 pm	G =12, B=5	G =0, B=15	G = 1, B=0	G = 3, B=15	G = 26, B=13	G =3, B=4
	6-7 pm	G = 14, B=16	G =3, B=18	G =6, B=8	G =3, B=16	G = 26, B=29	G =4, B=5
	7-8 pm	G =14, B=11	G =3, B=18	G =14, B=5	G =11, B=33	G = +45, B=+42	G =4, B=3
	8-9 pm	G =12, B=10	G = 3, B=4	G =10, B=2	G = 4, B=54	G =+80, B=+85	G =0, B=0

2.1.2. Winter observations

The winter observations reveal a different temporal pattern across the three sites (Table 7.2). Compared with summer, overall attendance is lower and is concentrated more narrowly around midday and the early afternoon. This suggests that winter use is more restricted and occurs mainly during the mildest hours of the day.

- In the Square, accompanied children are most present from late morning to early afternoon. While, unaccompanied children remain limited.
- Martyr Plaza shows the sharpest reduction in winter attendance, with both accompanied and unaccompanied children appearing only at limited intervals.
- By contrast, Snoberland continues to attract accompanied children, although its highest attendance shifts to the early afternoon. The absence of unaccompanied children in winter further reinforces its role as a supervised destination rather than an everyday autonomous play space.

Taken together, the winter results indicate that children's outdoor presence becomes more selective and compressed, with use concentrated around periods when family accompaniment, site attractiveness and everyday routines make outdoor visits more socially feasible. The strong decline in unaccompanied use, particularly in Martyr Plaza and Snoberland, suggests that winter conditions reinforce supervised and destination-based forms of children's public-space use rather than autonomous everyday play. This interpretation is consistent with recent studies showing that children's outdoor play varies by season, gender, parental regulation (Larouche et al., 2023; Z. Zhang et al., 2025).

Table 7. 2: *Temporal and gendered patterns of accompanied and unaccompanied children during Winter. Source: Author, 2025.*

B: G:		The Square		Martyr Plaza		Snoberland	
Period	**Hours**						
Winter	9-10 am	G =5, B=3	G =0, B=2	G = 0, B=0	G = 0, B=2	/	/
	10-11 am	G =14, B=21	G =0, B=2	G = 0, B=6	G =0, B=4	/	/
	11-12 pm	G =15, B=9	G =0, B=3	G =0, B=3	G =0, B=8	G = 36, B=37	G =0, B=0
	12-1 pm	G =5, B=6	G = 0, B=6	G = 0, B=0	G = 0, B=9	G = 52, B=56	G =0, B=0
	1-2 pm	G =15, B=12	G =0, B=3	G =0, B=3	G = 0, B=0	G =+81, B=+82	G = 0, B=0
	2-3 pm	G =34, B=23	G =5, B=1	G = 0, B=0	G =1, B=2	G =+120, B=+120	G =0, B=0
	3-4 pm	G =27, B=19	G =2, B=3	G = 0, B=1	G = 2, B=5	G= +170, B=+170	G = 0, B=0
	4-5 pm	G =21, B=14	G =2, B=1	G = 2, B=3	G =0, B=9	G =+155, B=+155	G = 1, B=1
	5-6 pm	G =2, B=2	G =0, B=3	G = 0, B=0	G =0, B=9	G =+70, B=+70	G = 0, B=0
	6-7 pm	G =0, B=0	G = 0, B=0	G =0, B=1	G = 0, B=0	G =+71, B=+65	G = 0, B=0

7-8 pm	G = 0, B=0	G = 0, B=0	G = 0, B=0	G = 0, B=0	G =23, B=36	G = 0, B=0
8-9 pm	G =0, B=0	G =0, B=0	G = 0, B=2	G = 0, B=0	G =11, B=12	G = 0, B=0

2.2. Activity patterns

2.2.1. The Square

Behavioural mapping in the Square shows clear hourly differences in children's activities.

- In summer (Figure 7.5), activity levels are highest in the late afternoon and early evening, particularly between 5.00 pm and 8.00 pm. The most frequent activities during this period are playing, running, cycling, and walking the site with caregivers (Figures 7.8a). By contrast, activity declines between 12.00 pm and 3.00 pm, while morning use remains moderate.
- In winter (Figure 7.6), the activity pattern is more restricted. Children taking a walk becomes the dominant activity, with the highest concentration observed between 3.00 pm and 4.00 pm. Running and cycling are less frequent than in summer, and overall activity levels are lower. Later in the evening, between 6.00 and 9.00 pm, there's an absolute absence of children (Figure 7.8b).
- To clarify these behavioural patterns spatially, Figure 7.7 synthesises the main child-presence hotspots and observed movement routes within the Square. The map shows how children's movement is distributed across the site.

Taken together, these results show that the Square supports a broader range of activities in summer than in winter, but that use in both seasons remains concentrated within specific hours of the day. In summer, activity is more strongly concentrated in the late afternoon and evening, whereas in winter it shifts towards the mildest afternoon period. This suggests that thermal conditions influence not only the number of children present but also the type and intensity of activity observed. This interpretation is consistent with previous studies showing that children's outdoor activity tends to decrease during periods of thermal discomfort and to concentrate within more favourable thermal conditions (Goodman, Paskins, & Mackett, 2012; Hu Luyao et al., 2025; Qi et al., 2022).

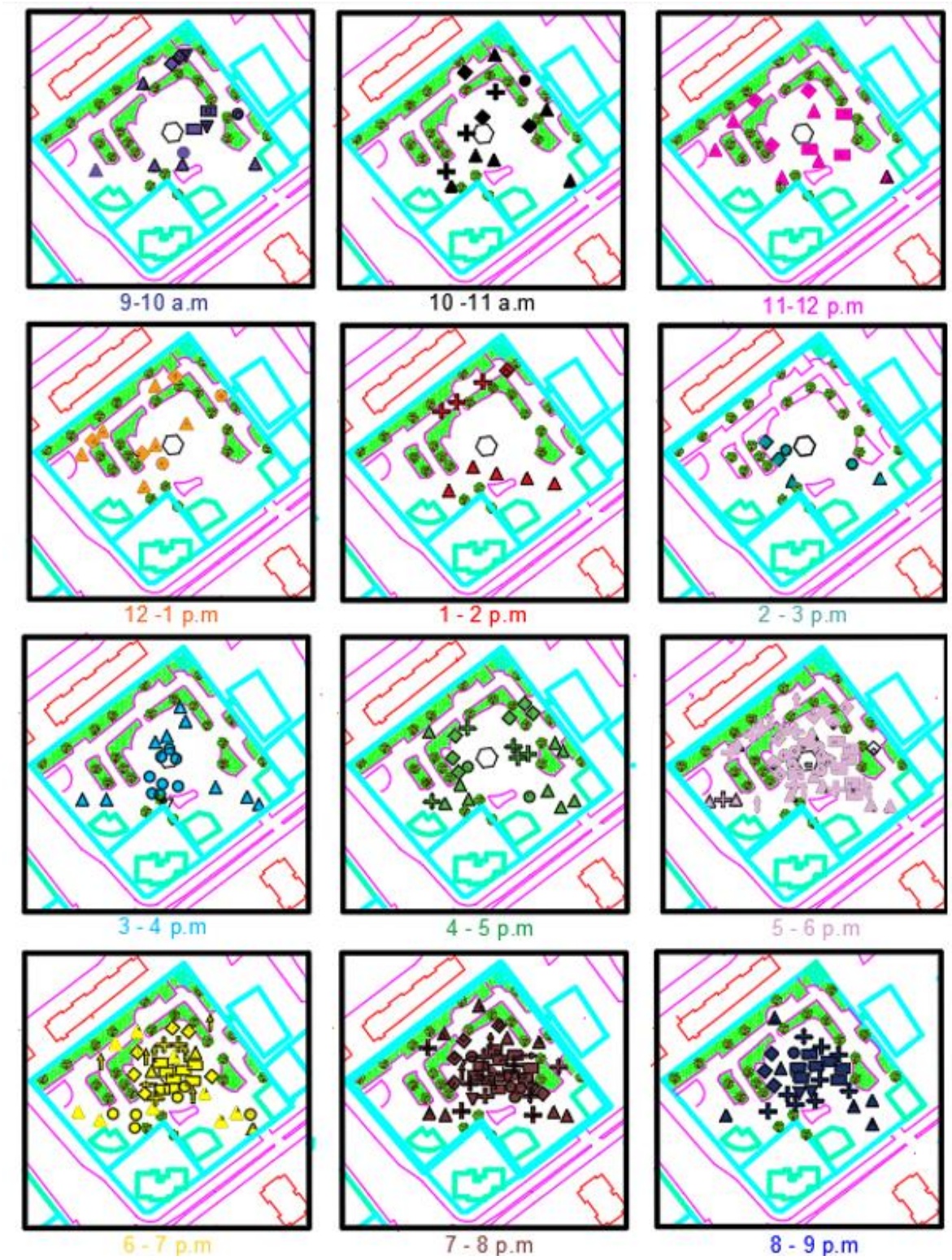


Figure 7. 5: *Average behavioural mapping showing temporal and spatial variation in activity levels across the Square during summer. Source: Author, 2025.*

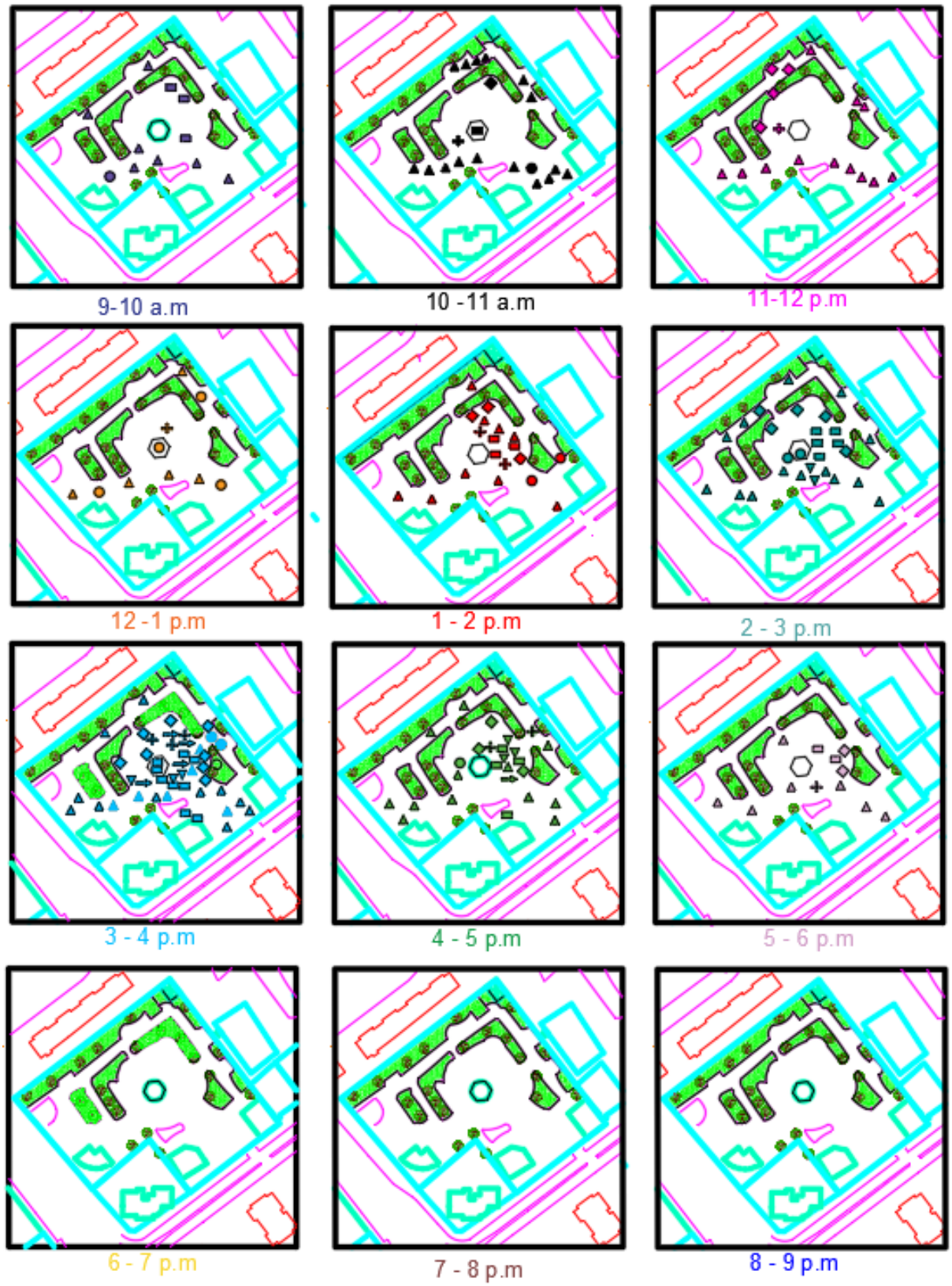


Figure 7. 6: *Average behavioural mapping showing temporal and spatial variation in activity levels across the Square during winter. Source: Author, 2025.*

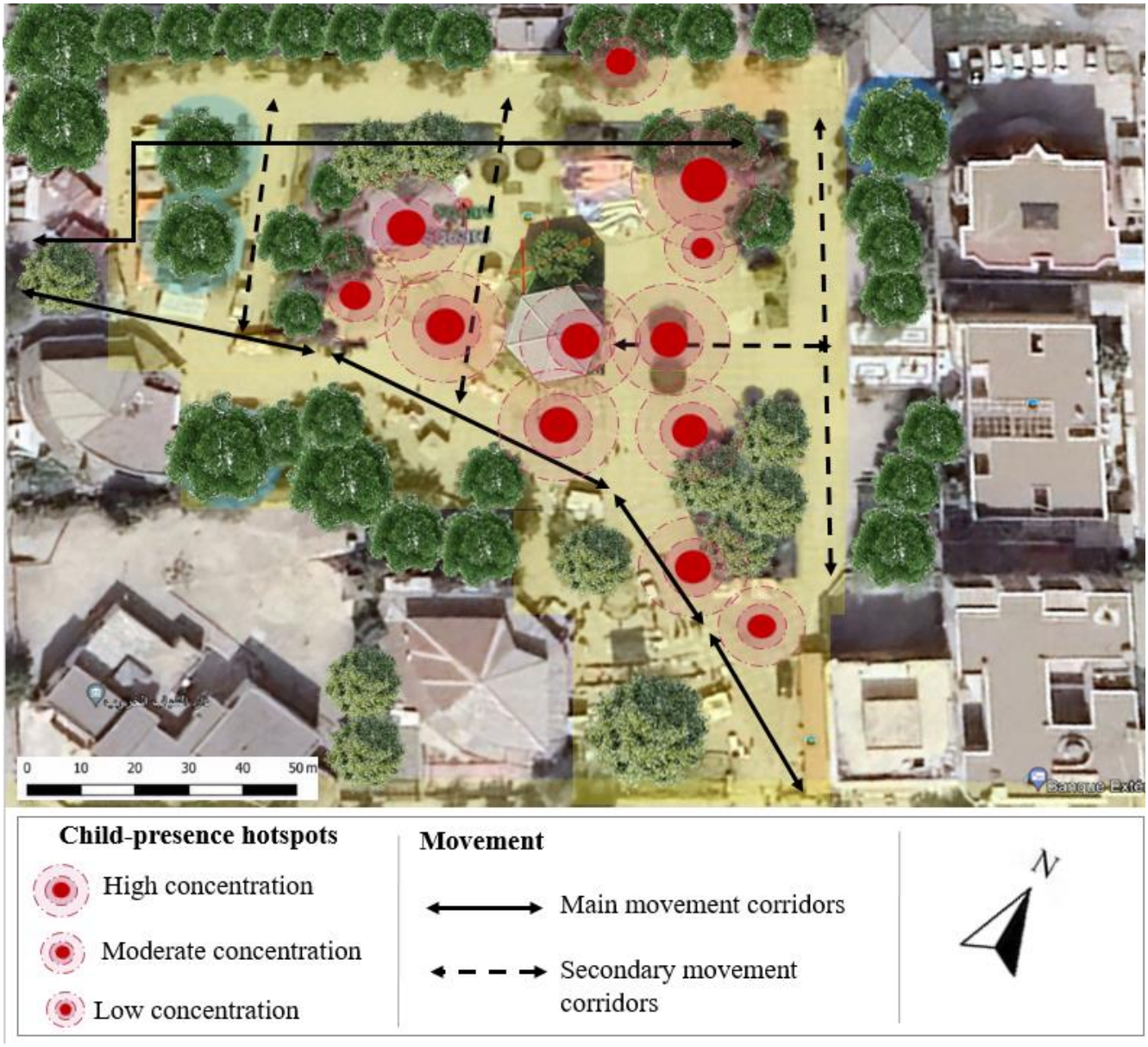
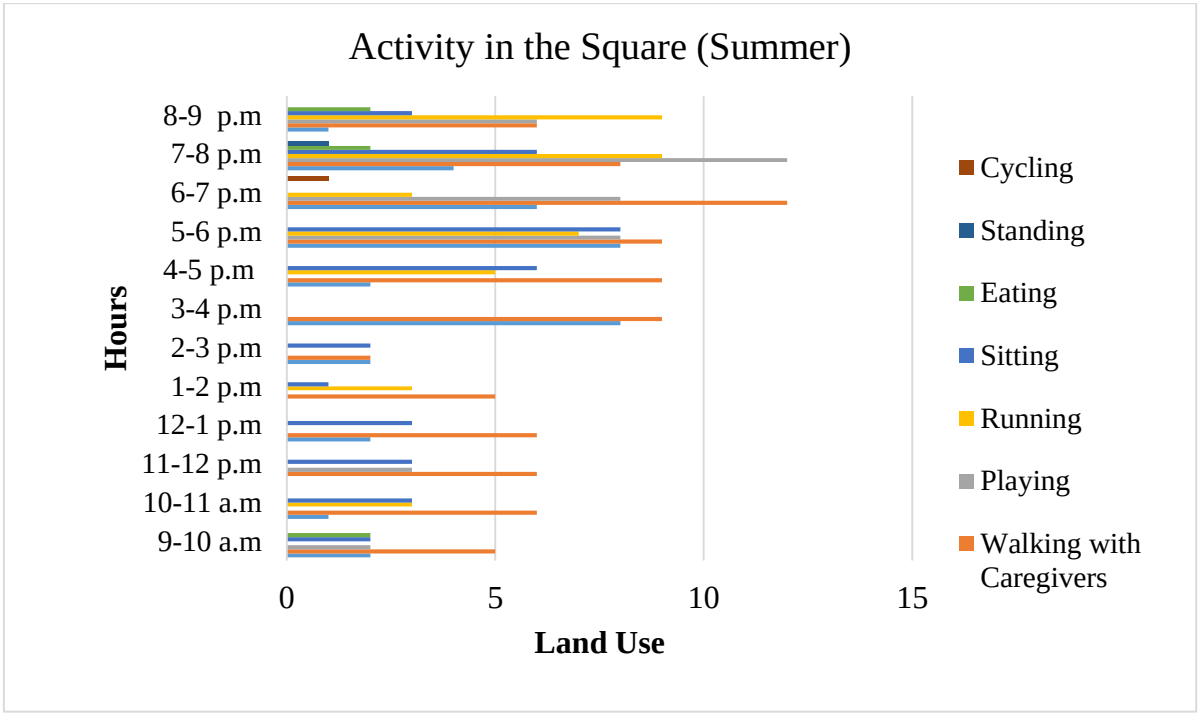
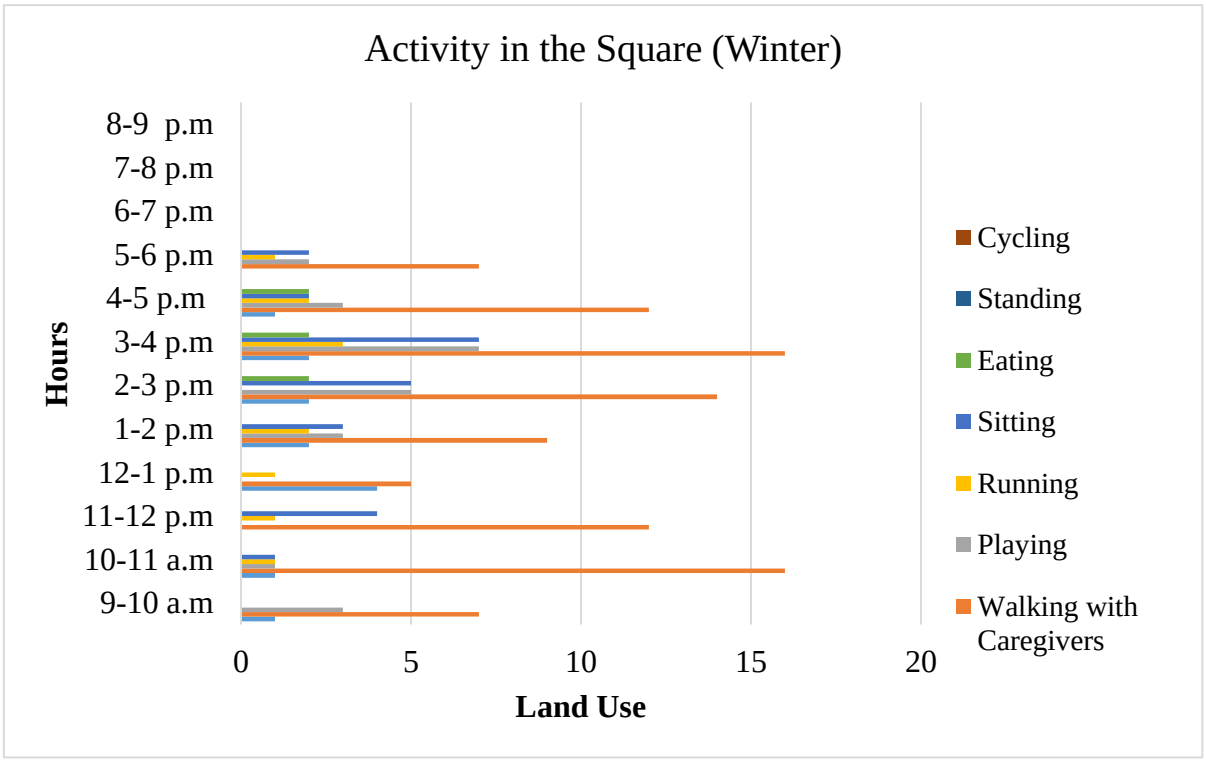


Figure 7. 7: *Behavioural concentration and observed movement map of children in the Square. Source: Author, 2026.*



(a)



(b)

Figure 7. 8: *(a) & (b) Children's outdoor activities by hour in the Square during Summer & Winter. Source: Author, 2025.*

2.2.2. Snoberland

Behavioural mapping in Snoberland shows a clear concentration of children's activities within specific hours in both summer and winter.

- In summer (Figure 7.9), activity is concentrated in the late afternoon and evening, with the highest levels observed between 6.00 pm and 7.00 pm. Playing is the dominant activity during this period, reaching around 75 children. Running, sitting, and walking with caregivers also increase in the evening (Figure 7.12a), while unaccompanied children appears mainly later in the day.
- In winter (Figure 7.10), activity remains concentrated within a narrower afternoon period, with the highest use observed between 3.00 pm and 4.00 pm. Although the park opens at 11.00 am in winter, use does not extend evenly across the day. Instead, children's presence remains focused on the afternoon, with accompanied visits clearly dominating. Compared with summer, the winter pattern is more compressed and less varied, although playing remains the principal activity (Figure 7.12b).

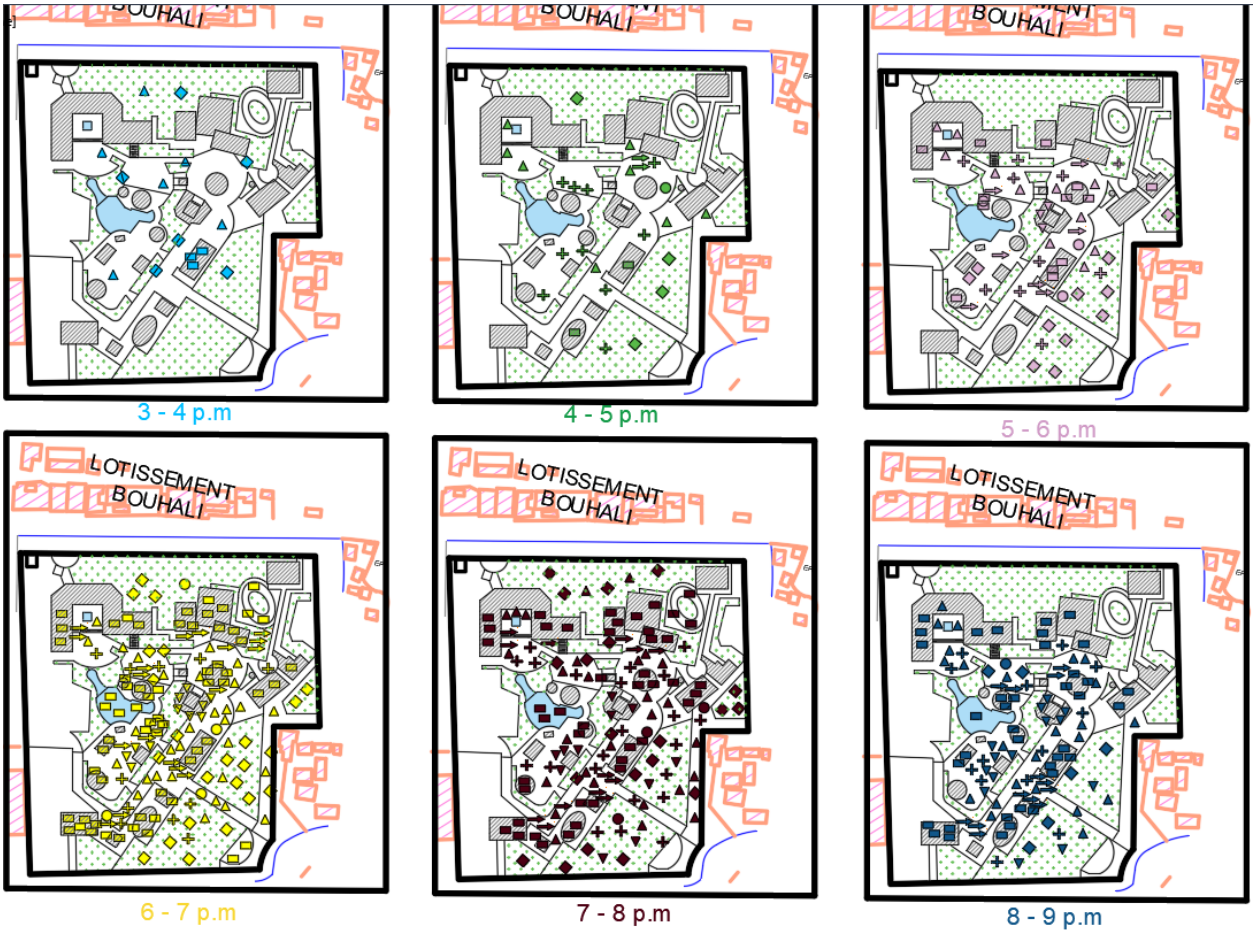


Figure 7. 9 : *Behavioural average mapping showing temporal and spatial variation in activity levels across Snoberland during summer. Source: Author, 2025.*

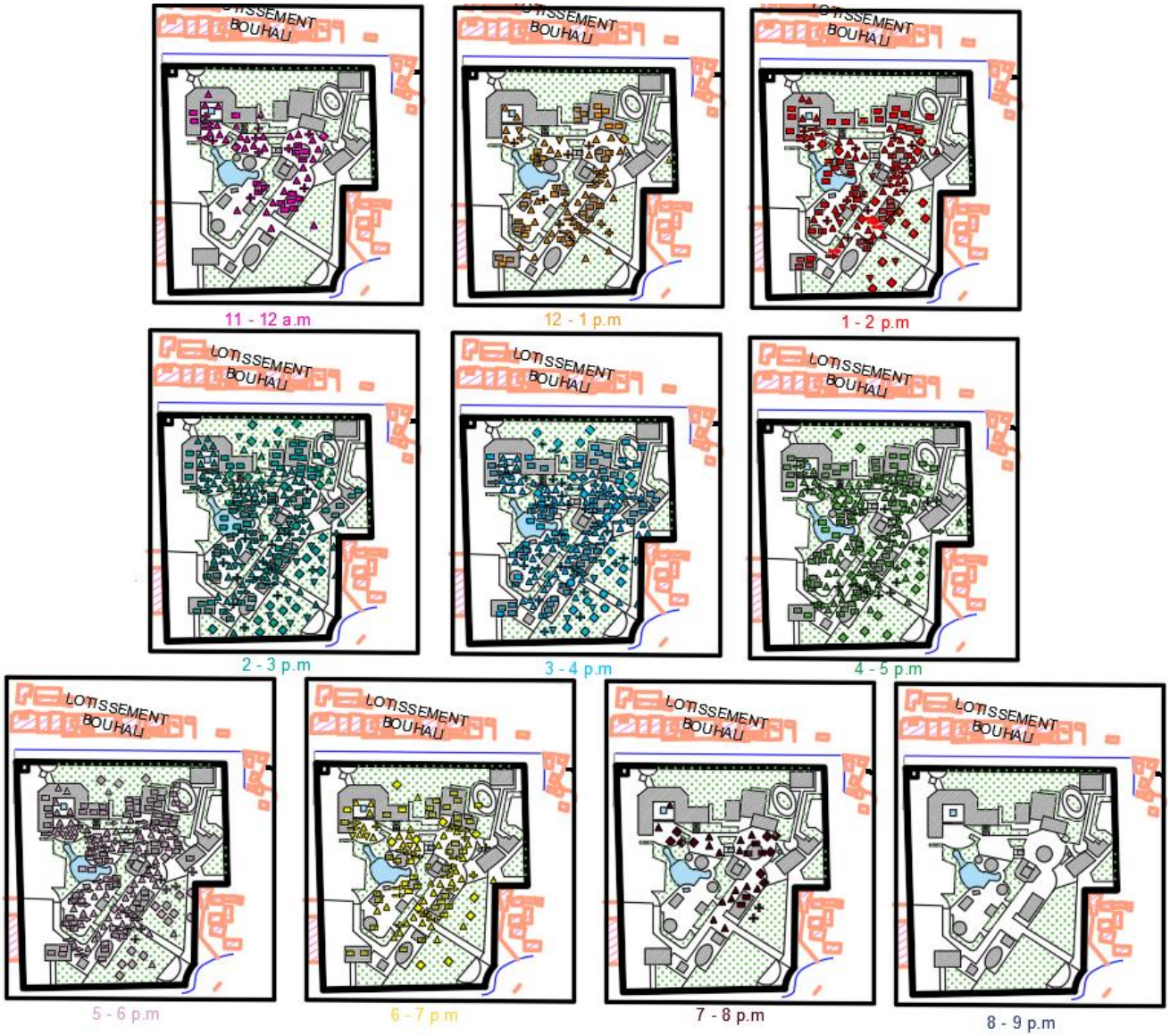


Figure 7. 10: *Behavioural average mapping showing temporal and spatial variation in activity levels across Snoberland during winter. Source: Author, 2025.*

- To clarify these behavioural patterns spatially, Figure 7.11 synthesises the main child-concentration and observed movement routes within Snoberland. The map highlights the concentration of children's presence around the park's most attractive play and stay areas, while also showing the main circulation paths linking these activity zones.

Taken together, these results show that Snoberland supports high levels of recreational use, but that this use remains strongly concentrated within the most favourable daily time windows. In summer, the highest activity occurs in the cooler evening period, whereas in winter it shifts to the milder afternoon hours. This suggests that, despite the park's rich recreational provision, children's activity is still shaped by seasonal thermal conditions. This interpretation is

consistent with previous research showing that thermal discomfort can reduce children's outdoor engagement (S. Gao, Oh, Lin, & Feng, 2024b; Z. Li, Zhou, Hong, & Qiu, 2024a).

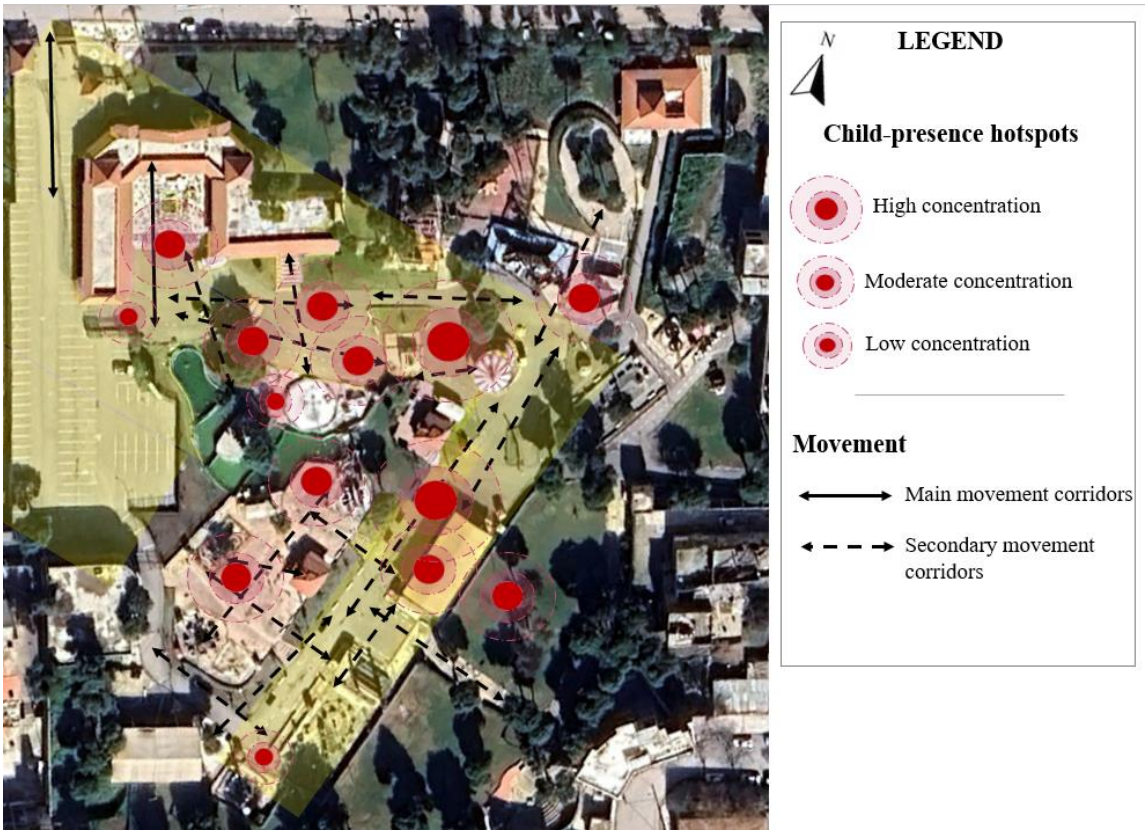
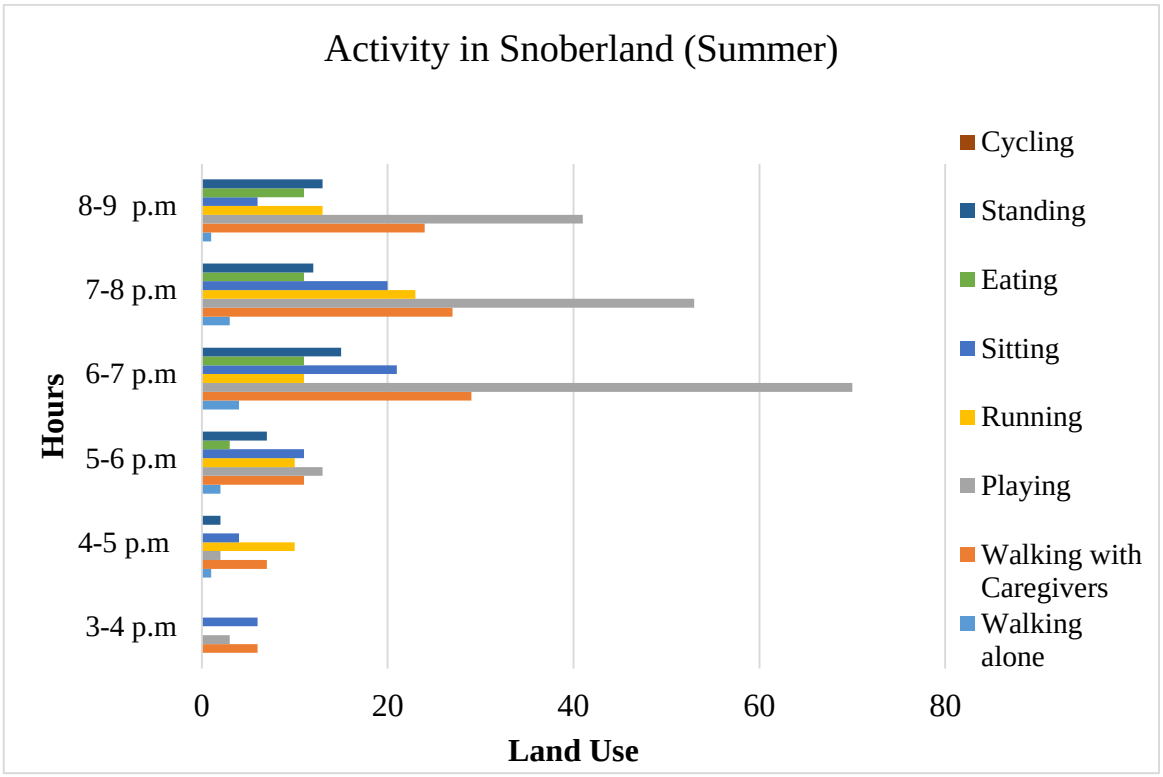
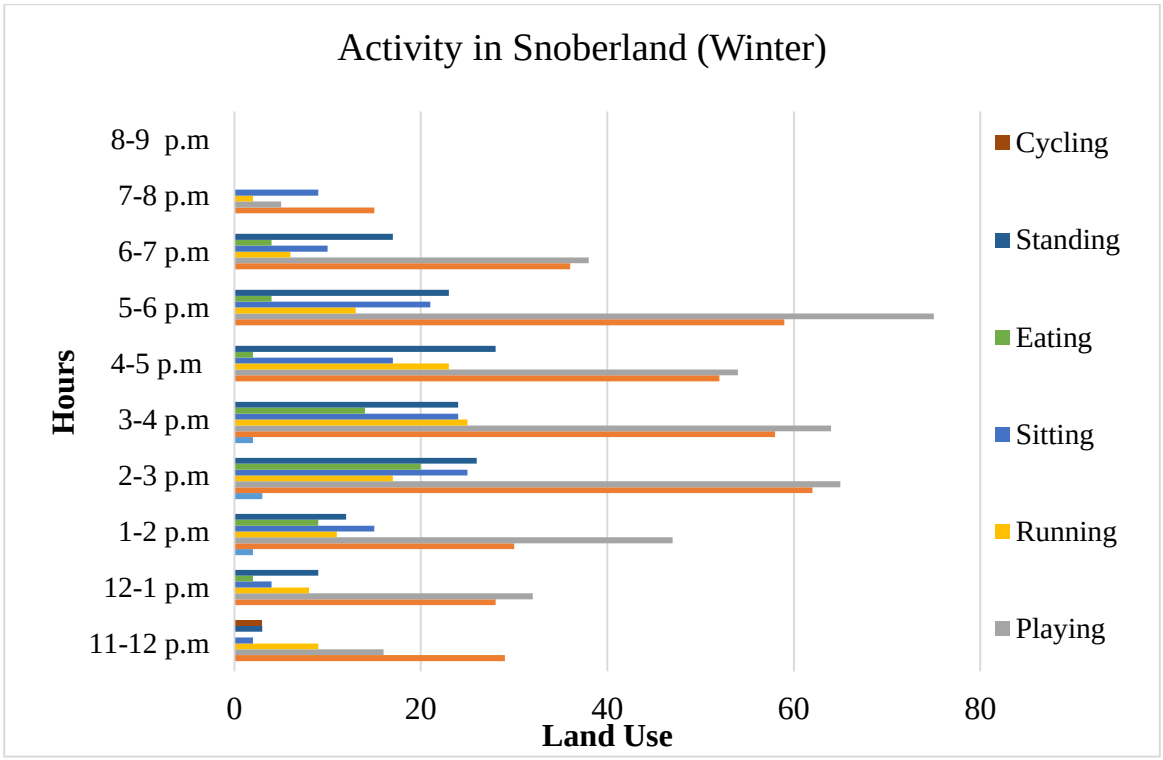


Figure 7. 11: *Behavioural concentration and observed movement map of children in Snoberland. Source: Author, 2026.*



(a)



(b)

***Figure 7. 12**:(a) & (b) Children's outdoor activities by hour in Snoberland during Summer & Winter. Source: Author, 2025.*

2.2.3. Martyr Plaza

Behavioural mapping in Martyr Plaza shows a distinct activity profile in both summer and winter, with movement-based activities dominating across the day.

- In summer (Figure 7.13), children were observed walking the plaza, with visible peaks between 12.00 pm and 1.00 pm and again between 6.00 pm and 7.00 pm. Cycling and walking with caregivers also increase later in the day, while static activities such as sitting, standing, and eating remain limited during the hottest midday hours (Figures 7.16b).

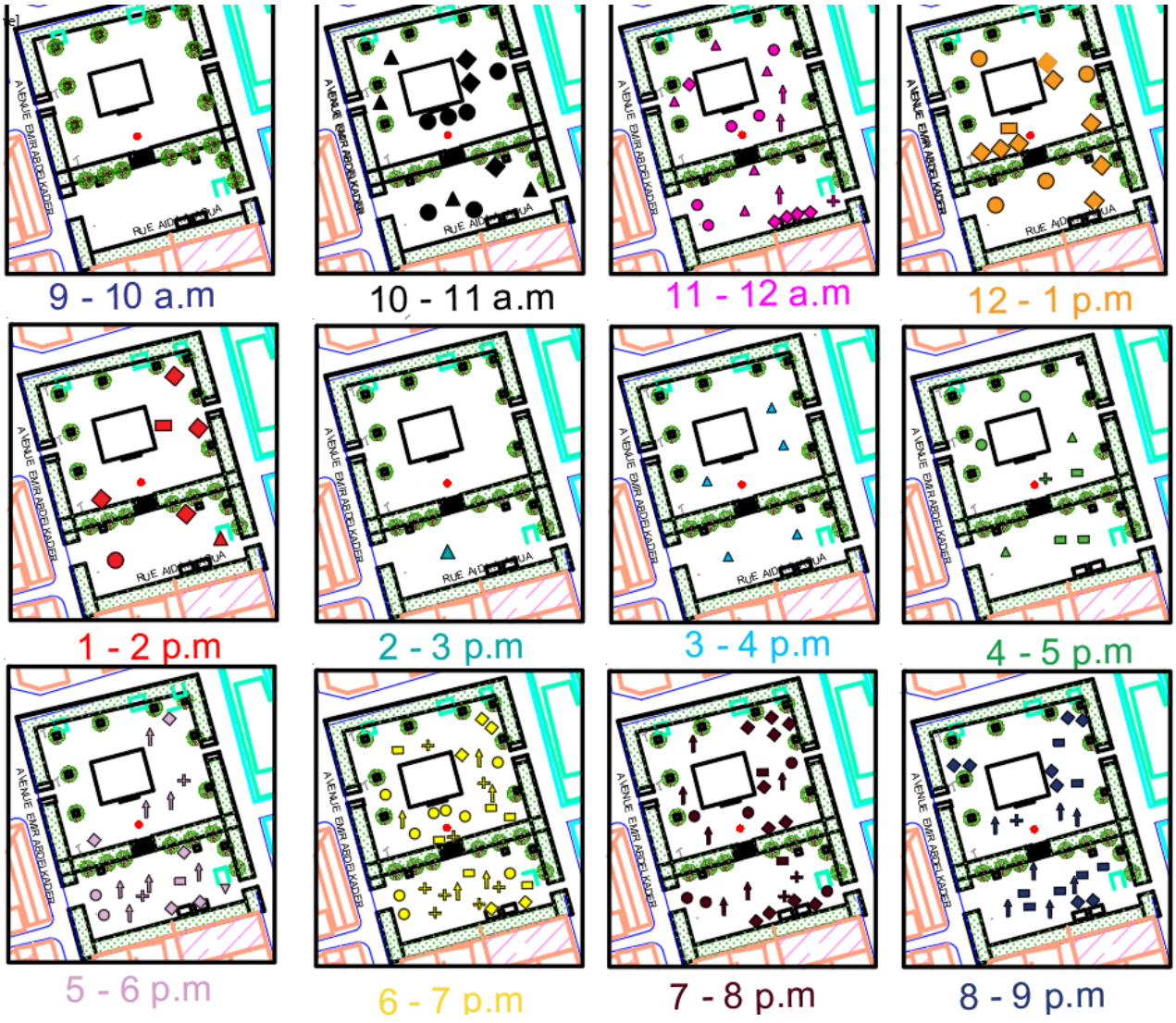


Figure 7. 13**:** *Average behavioural mapping showing temporal and spatial variation in activity levels across Martyr Plaza during Summer. Source: Author, 2025.*

- In winter (Figure 7.14), activity becomes more concentrated within the mildest part of the afternoon. Walking children reaches its highest level between 3.00 pm and 4.00 pm, followed by walking with caregivers between 4.00 pm and 5.00 pm. Compared with summer, overall activity is lower and more temporally restricted, with fewer static uses and a clearer concentration within a short afternoon window (Figures 7.16a).
- To clarify these behavioural patterns spatially, Figure 7.15 synthesises the main child-presence hotspots and observed movement routes within Martyr Plaza. The map highlights the predominance of circulation-based use.

Taken together, these results show that Martyr Plaza is used primarily as a space of movement and passage rather than as a place of prolonged stay due to the absence of play areas. Across both seasons, the most active periods coincide with the more thermally favourable hours of the day, while use declines during less comfortable conditions. This suggests that thermal conditions influence not only the intensity of use but also the balance between dynamic and static activities. This interpretation is consistent with previous research indicating that thermal discomfort tends to reduce lingering activities and to favour more mobile forms of outdoor use (M. Gao et al., 2024; Z. Li et al., 2024a).



Figure 7. 14*: Average behavioural mapping showing temporal and spatial variation in activity levels across Martyr Plaza during Winter. Source: Author, 2025.*

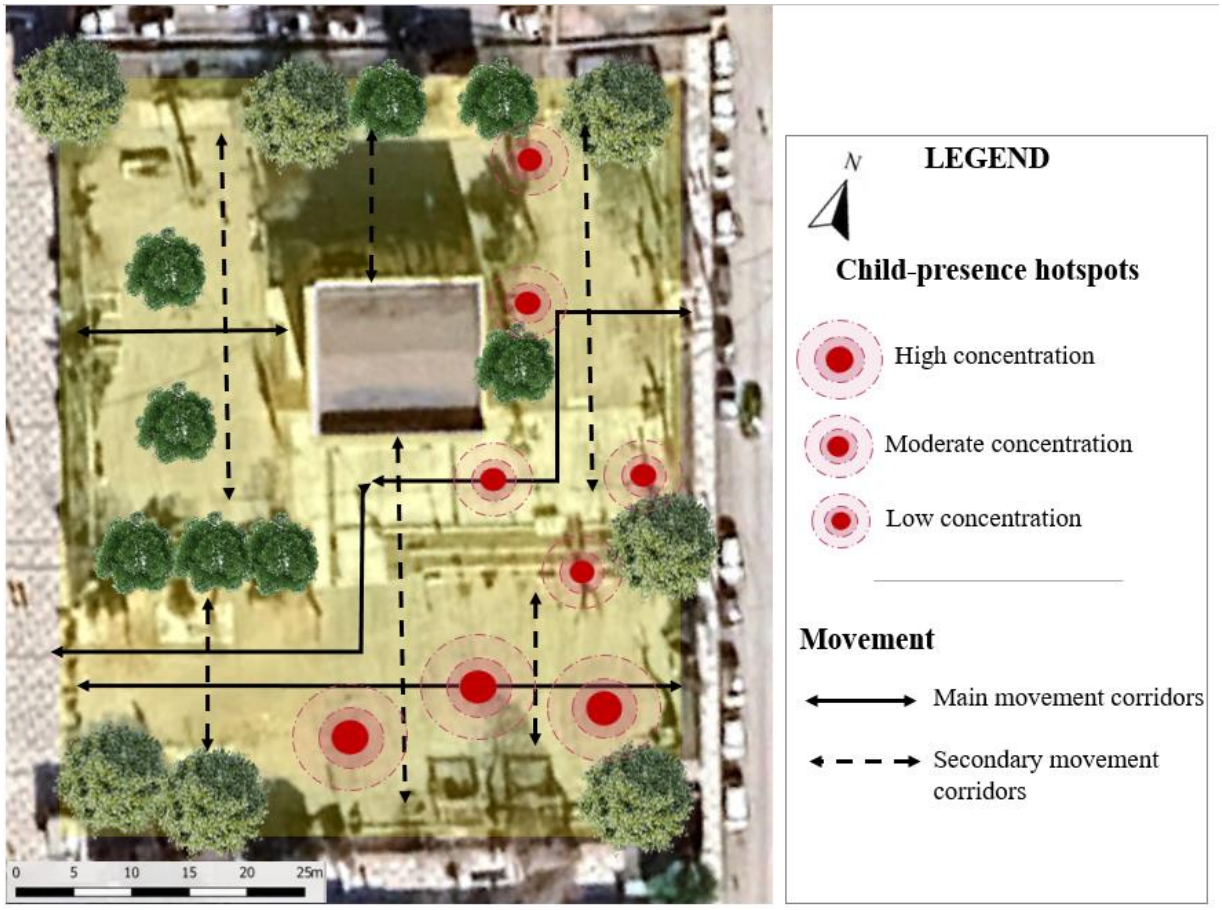
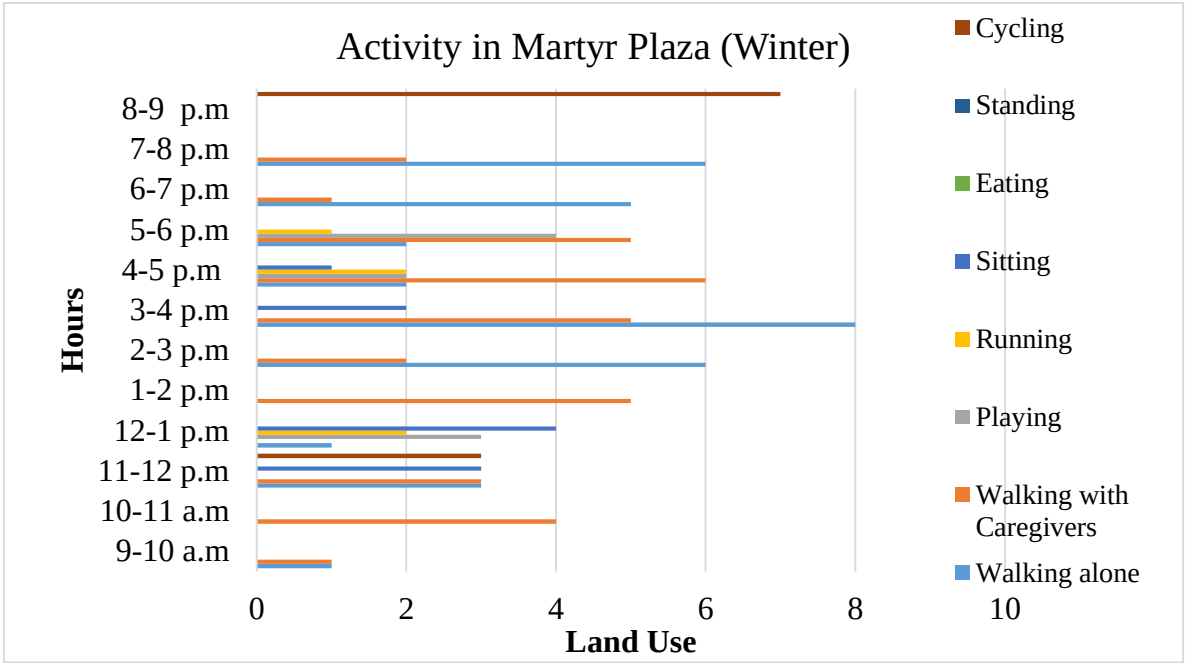
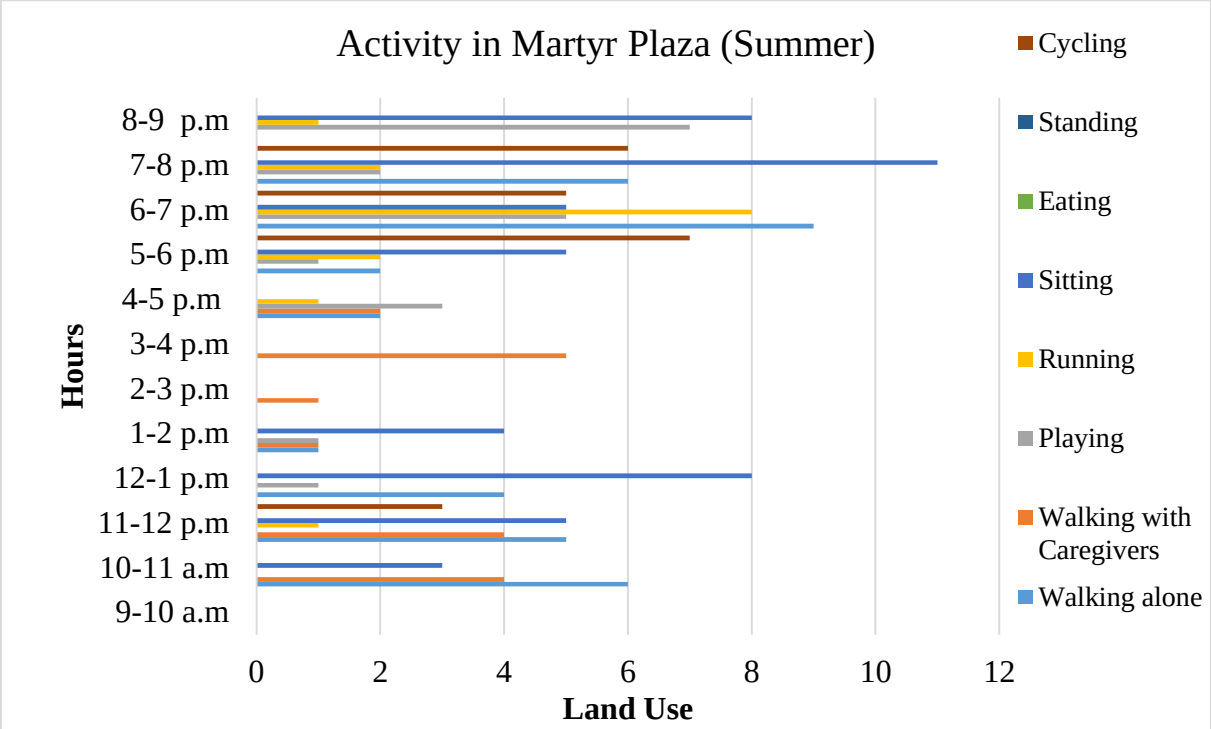


***Figure 7. 15**: Behavioural concentration and observed movement map of children in Martyr Plaza. Source: Author, 2026.*



(a)



(b)

Figure 7. 16: *(a) & (b) Children's outdoor activities by hour in Martyr Plaza during Summer & Winter. Source: Author, 2025.*

2.3. Children's activity heatmap

While the preceding figures present the behavioural patterns of each site separately, a cross-site synthesis is necessary to compare how children's activity varies across the three outdoor places and between summer and winter. Figure 7.17 therefore reorganises the hourly behavioural observations into a single spatiotemporal heatmap. This representation makes it possible to identify periods of high and low use more clearly and to compare whether children's activity concentrates at similar hours across the Square, Snoberland, and Martyr Plaza, or whether each site produces a distinct temporal pattern of occupation.

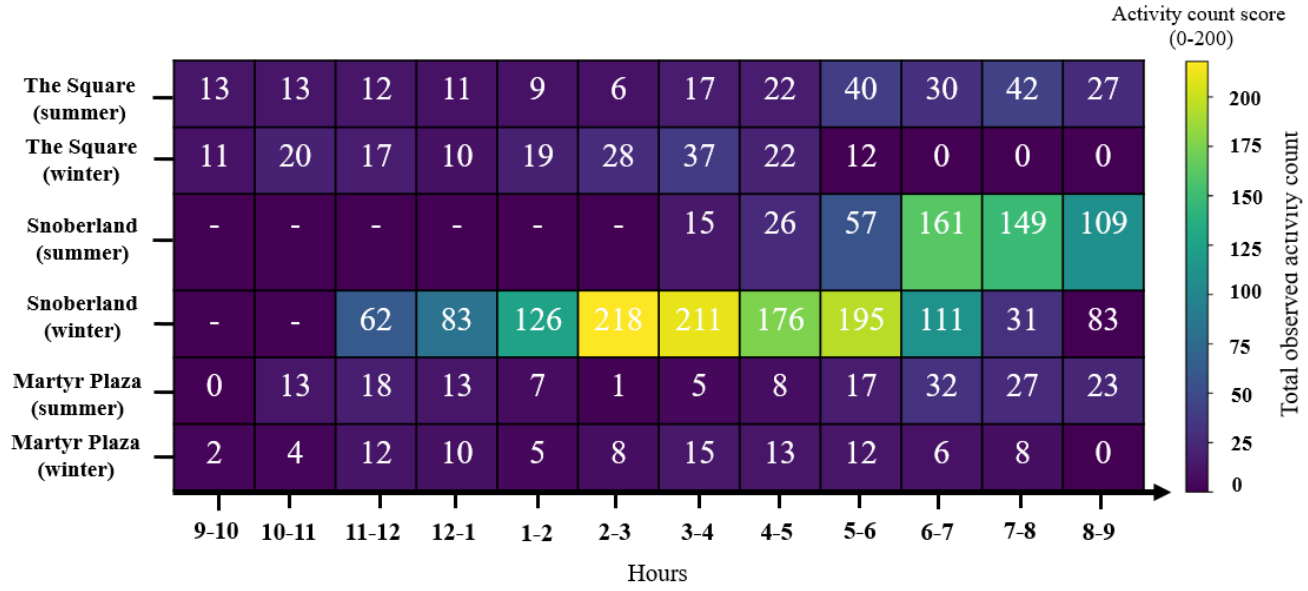


Figure 7. 17*: Cross-site and seasonal intensity of children's outdoor activity by observation hour. Source: Author, 2026.*

In addition to the intensity of use, the type of activity performed by children provides an important indicator of urban liveability. A space that only supports passage or short-term presence cannot be considered equally liveable as a space that supports diverse forms of play, sitting, social interaction, cycling, running, and exploration. For this reason, Figure 7.18 compares the composition of children's activities across the three outdoor places and between the two seasons.

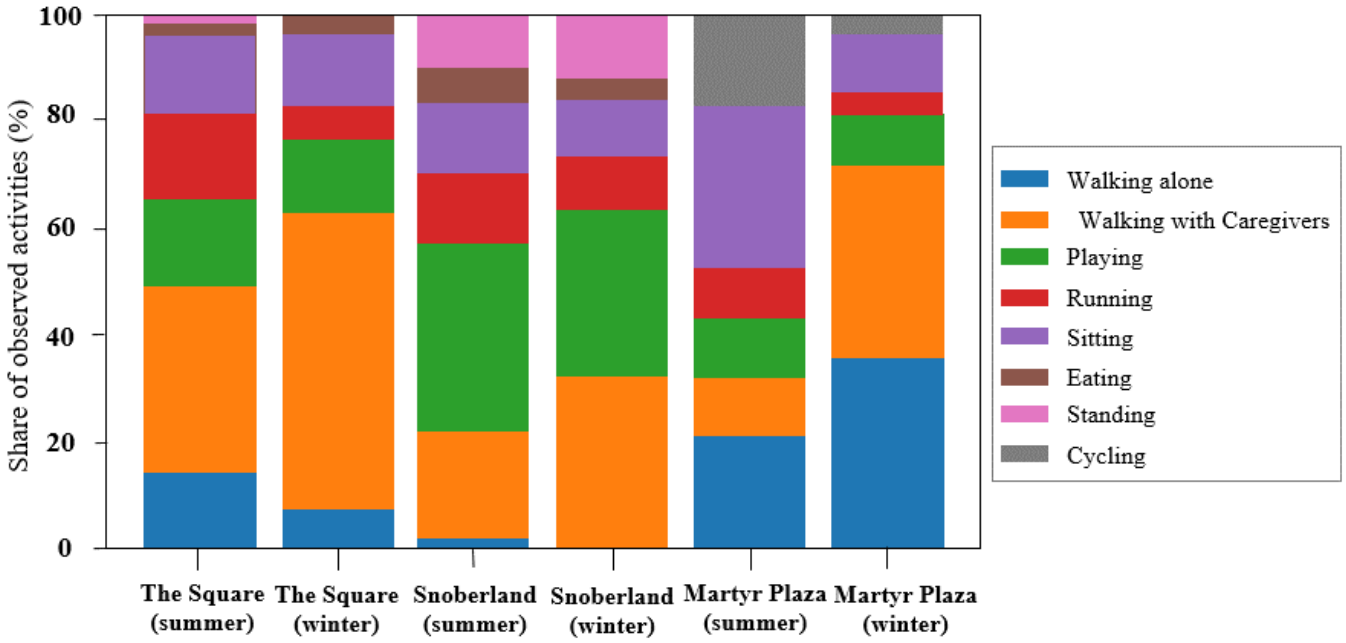


Figure 7. 18: *Composition of children's outdoor activities by site and season. Source: Author, 2026.*

Discussion

- Overall, the behavioural analysis shows that children's use of outdoor space is not simply a matter of spatial availability, but is structured by the interaction between time of day, season, site function, and supervision patterns.
- The three sites support different behavioural profiles. The *Square* functions mainly as a supervised neighbourhood space, *Snoberland* as a family-oriented destination with concentrated play activity, and *Martyr Plaza* as a more open civic space that allows greater independent movement, particularly among boys. These behavioural differences reinforce the central argument of the thesis that CUL cannot be evaluated only through the physical presence of public space. It must also be assessed through the temporal and environmental conditions that allow children to actually occupy, play, and remain in these spaces.
- The activity heatmap confirms that children's use of outdoor space is strongly time-dependent and seasonally variable. Activity does not remain constant throughout the day; instead, it rises and declines according to the combined influence of thermal conditions, site attractiveness, and the availability of play opportunities. Across the three sites, use shifts towards the evening in summer and towards the milder midday or early afternoon hours in winter, indicating that children appropriate space within narrow windows of thermal and social feasibility.
- Day-to-day variability further supports this interpretation. At *the Square*, the second winter observation day, 23 December 2024, recorded no child presence, showing that the same site may be actively used under sunny, cold conditions and entirely avoided under rain. A similar, though less pronounced, pattern was observed at *Martyr Plaza*. At *Snoberland*, the site itself was temporarily closed due to adverse weather, and the investigation was rescheduled to 30 and 31 December 2024. Weather therefore affected not only children's presence but, in this case, the practical availability of the outdoor place itself. Since comparably adverse conditions were not recorded during the rescheduled Snoberland observation days, a direct cross-site comparison of weather sensitivity remains limited. Nevertheless, the available evidence is clear: children's outdoor occupation responds to daily weather variation, not solely to seasonal averages.

3. Microclimatic and OTC assessment

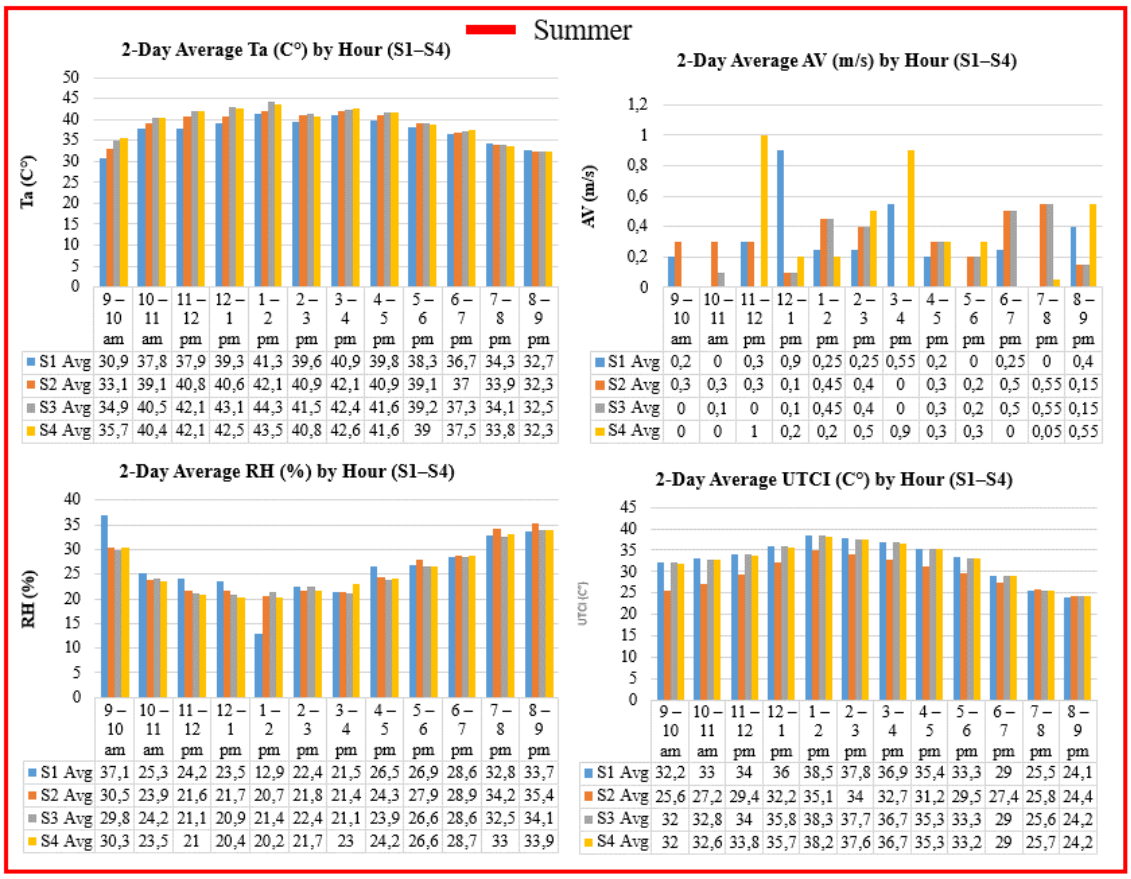
In this section, Ta, RH and AV refer to field-measured microclimatic parameters recorded across four observation spots (S1–S4) within each site during the typical summer week of 20–22 July 2024 and the typical winter period of 22–31 December 2024. UTCI, by contrast, refers to a calculated thermal index generated through the Ladybug Tools workflow using measured Ta, RH and AV together with modelled Tmrt.

3.1 The Square

Meteorological measurements in the Square show marked seasonal and spatial variation in OTC (Figure 7.19).

- In summer, Ta rises rapidly from 33–35°C at 9.00 am in S3 and S4 to peaks of 42–43.5°C between 1.00 pm and 3.00 pm, while RH falls to 21–24%. During the same period, UTCI reaches a strong heat stress levels at S1, S3, and S4 (38.2–38.5°C). By contrast, S2 records a lower peak UTCI of 35.1°C, associated with higher AV of up to 0.6 m/s.
- In winter, OTC is more moderate overall, but variation between observation spots remains evident. Ta ranges from 15–17°C in the morning to daytime maxima below 21°C, with RH between 45% and 60%. UTCI values generally range from 8 to 11.7°C, corresponding to slight cold stress to neutral conditions. However, S4 records a minimum UTCI of 1.9°C at 9.00 am, while S3 maintains relatively higher Ta. AV peaks of 0.7–1.0 m/s at S1 and S2 contribute to stronger cooling in the evening.

Taken together, these results show that the Square produces strongly contrasting OTC across both seasons and between internal observation points. In summer, exposed areas experience intense daytime heat stress, while in winter some shaded or wind-exposed locations become



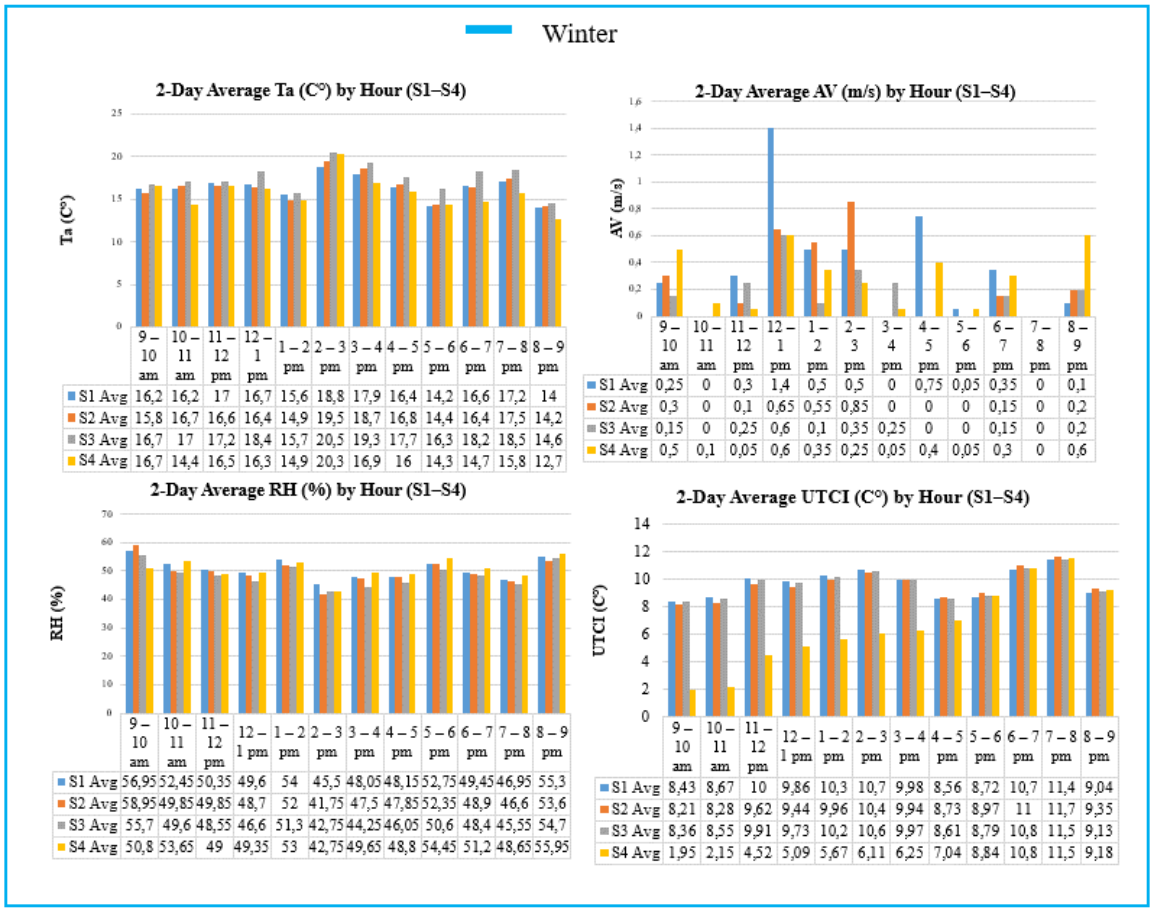


***Figure 7. 19**: Hourly average values for Ta, RH, AV and UTCI measurements across the spots (S1–S4) in the Square during Summer & Winter. Source: Author, 2025.*

role in moderating thermal conditions within the site, particularly at S2. This interpretation is consistent with previous studies on paved and weakly shaded urban spaces, where exposure and airflow strongly influence local thermal conditions (Ali-Toudert & Mayer, 2007; Gál, 2020; A. Labdani, Fezzai, Gherzouli, Boukhelkhal, & Bouarroudj, 2026; Middel et al., 2014; Y. Zhao et al., 2024).

3.2 Snoberland

Meteorological measurements in Snoberland show clear spatial and temporal variation in OTC (Figure 7.20).

- In summer, between 3.00 and 5.00 pm, Ta ranges from 30.8 to 33.85°C across the observation spots, while UTCI remains within the strong heat stress category (33.6–34.2°C). S1 records the most favourable summer conditions, with AV reaching 0.8 m/s and RH ranging from 39.4% to 56.9%, resulting in a lower peak UTCI of 33.8°C. By contrast, S3 records the highest Ta (33.85°C) and UTCI (34.2°C), together with lower AV and lower RH. By the evening period (7.00–9.00 pm), Ta decreases to 24.8–27.8°C and UTCI falls below 20°C across the site.
- In winter, daytime OTC is more moderate overall. Between 2.00 pm and 4.00 pm, Ta ranges from 10.5 to 21.4°C, and UTCI reaches comfortable values of 23.2–23.4°C. S1 again shows more stable AV and slightly higher RH, whereas S3 records lower AV and lower RH. From 5.00 pm onwards, OTC becomes less favourable, with Ta decreasing to 10.5–11.8°C and UTCI falling to 5.8–6.2°C, corresponding to slight cold stress.

Taken together, these results show that Snoberland provides more favourable OTC during the late afternoon in summer and the early afternoon in winter, but that important differences remain between internal observation points. In summer, better-ventilated areas are relatively cooler, whereas more stagnant locations retain more heat. In winter, daytime solar exposure supports more comfortable conditions, while evening cooling reduces thermal comfort across the site. These findings suggest that ventilation and exposure play an important role in shaping the park's internal microclimatic variation, in line with previous studies on airflow and OTC (Nouri & Matzarakis, 2021; K. Wang et al., 2025; T. Zeng, Lu, & Huang, 2023).

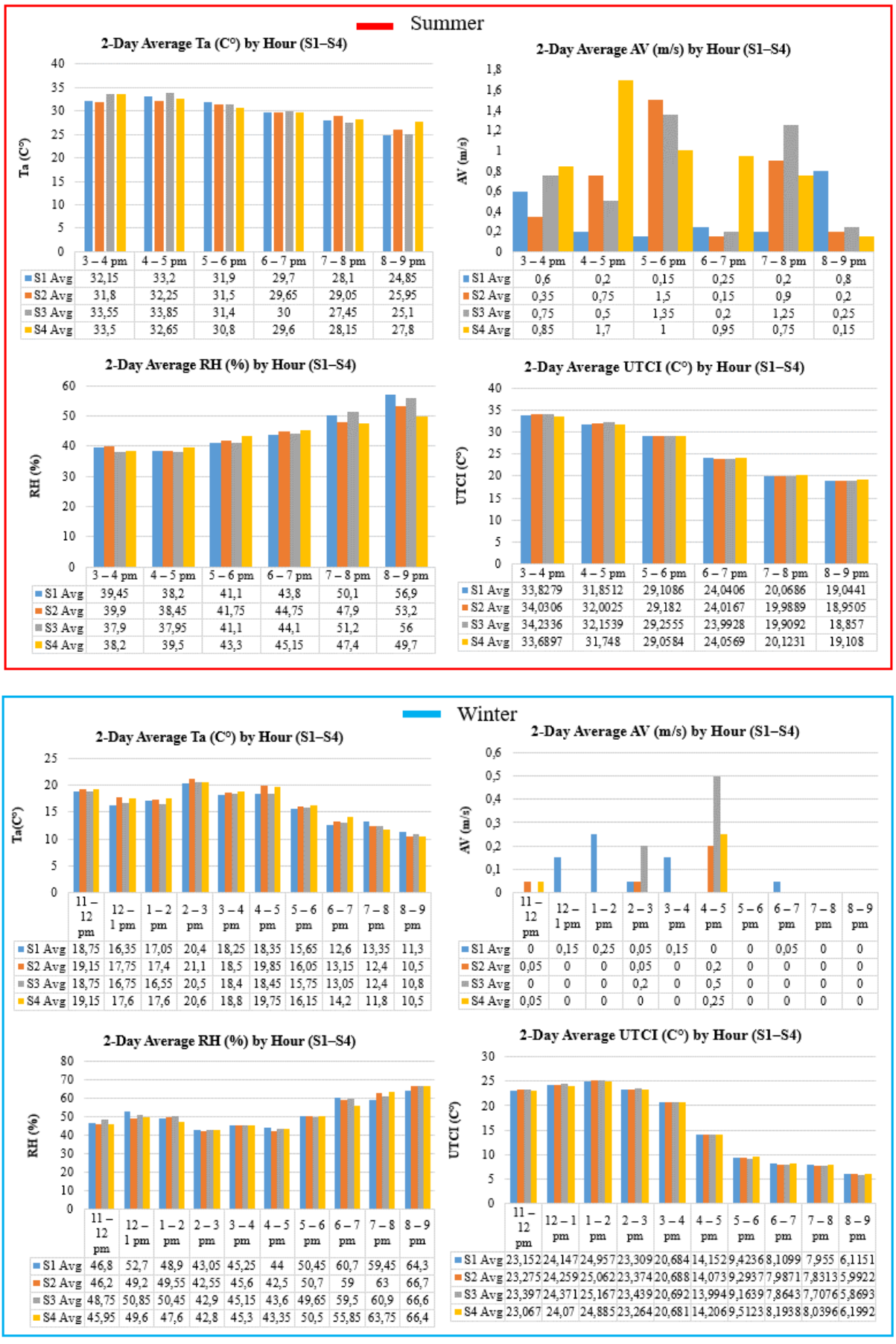


Figure 7. 20: *Hourly average values for Ta, RH, AV and UTCI measurements across the spots (S1–S4) in Snoberland during Summer & Winter. Source: Author, 2025.*

3.3 Martyr Plaza

Meteorological measurements in Martyr Plaza show clear seasonal and spatial variation in OTC (Figure 7.21).

- In summer, during the midday period from 12.00 pm to 3.00 pm, Ta ranges from 37 to 39°C across the observation spots, while UTCI remains within the strong heat stress range (34.7–36.3°C). RH is low, at 25–28% during this period. S3 records the highest Ta, the lowest RH, minimal AV, and the highest UTCI value (36.3°C). By contrast, S1 shows slightly lower Ta, slightly higher RH, better AV, and a lower UTCI of 35.9°C.
- In winter, OTC is more moderate during the middle of the day. Open spots such as S2, S3, and S4 record Ta of 15–22°C and UTCI peaks of 24.7–25.5°C between 11.00 am and 2.00 pm. By contrast, S1 records a lower morning UTCI of 5.9°C at 9.00 am, compared with 15.5–15.7°C at the other points. By 8.00 pm, UTCI declines to around 8–9°C, with stronger cooling observed at S3 and S4 than at the more sheltered S1.

Taken together, these results show that Martyr Plaza presents contrasting seasonal thermal conditions across its internal observation points. In summer, more exposed locations experience stronger heat stress, whereas in winter these same open areas benefit more from daytime solar gain. Conversely, the more sheltered areas appear relatively more favourable in summer but less thermally advantageous during winter mornings. These findings suggest that exposure, shading, and airflow all contribute to the site's internal microclimatic variation (Gider, Ergin, Yildizhan, & Ameen, 2026; Patle & Ghuge, 2025).

Comparative positioning within the Algerian OTC literature. Set within the broader Algerian OTC literature, the summer UTCI peaks recorded across the three sites in El Khroub, ranging from 33.6°C to 38.5°C, are consistent with the strong heat-stress conditions documented in comparable Algerian urban studies (Sayad et al., 2021).

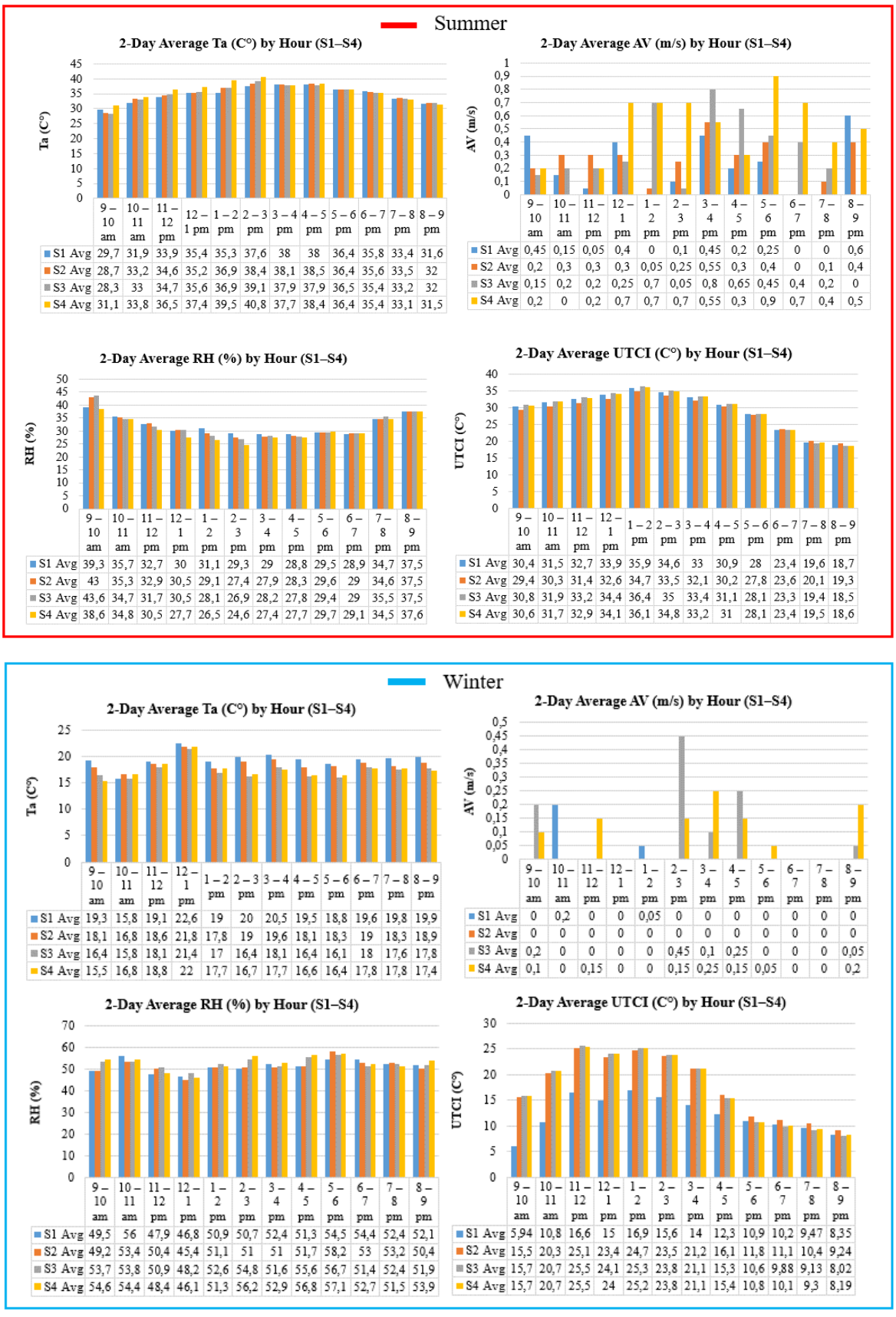


Figure 7. 21*: *Hourly average values for Ta, RH, AV and UTCI measurements across the spots (S1–S4) in Martyr Plaza during Summer & Winter. Source: Author, 2025.

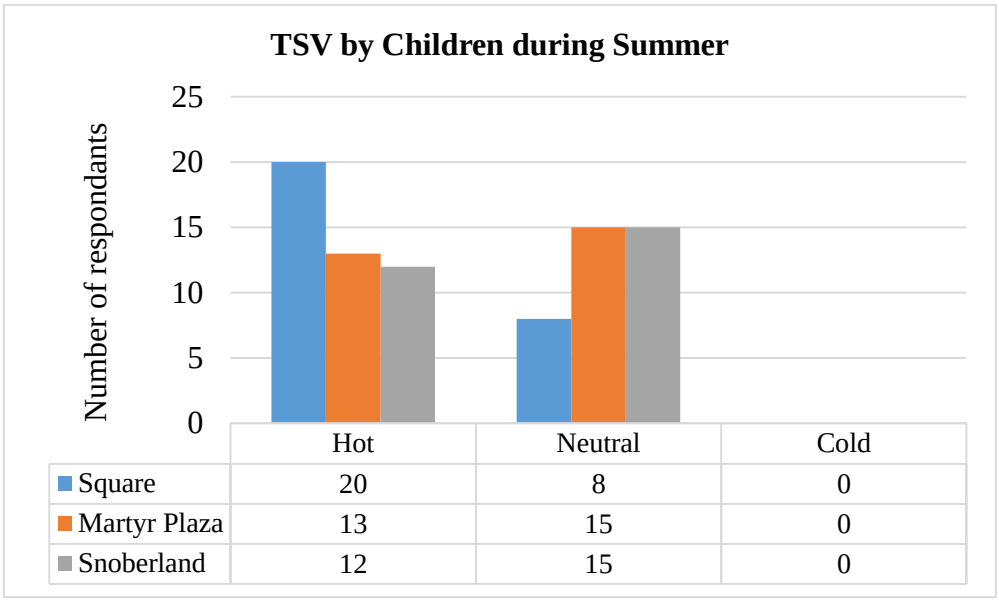
4 Questionnaires analysis

4.1 Summer

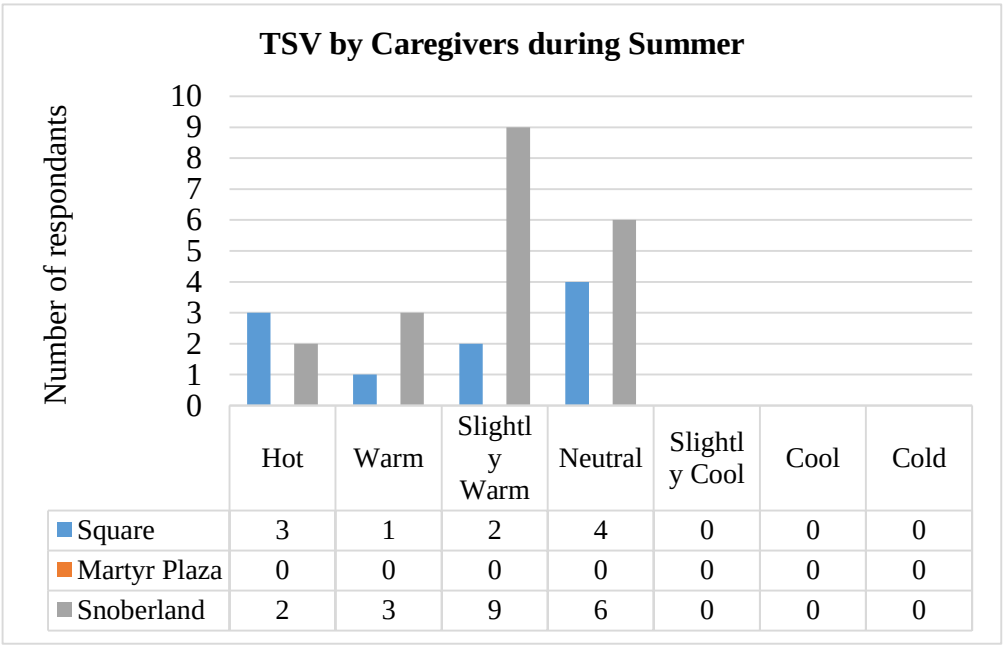
The summer TSV results show clear differences in thermal sensation across the three sites (Figure 7.22).

- Among children, responses in the Square are concentrated mainly in the “Hot” category, with fewer responses in “Neutral” and very limited reports of “Cold”, indicating the least favourable thermal perception.
- In Martyr Plaza, responses are more centred on “Neutral”, although “Hot” sensations remain present.
- Snoberland shows the most favourable distribution, with most children reporting “Neutral” sensations and fewer reporting “Hot”, while “Cold” remains marginal.
- A further difference appears between children and caregivers (Figure 7.21b). Across all three sites, caregivers report fewer “Hot” sensations than children and tend to describe conditions more often as “Neutral”. This contrast suggests that children and adults do not perceive the same OTC in the same way.

Taken together, these results indicate that summer thermal perception varies both by site and by user group. The Square is perceived as the warmest environment by children, whereas Snoberland appears comparatively more comfortable. The difference between children’s and caregivers’ responses also suggests that adults may underestimate the intensity of children’s thermal discomfort. This interpretation is consistent with previous studies linking TSV to site characteristics such as shade, vegetation, and surface exposure, and showing that children are often more thermally sensitive than adults (Antoniadis et al., 2020; M. Elnabawi & Hamza, 2020; D. Lai et al., 2020; Qi et al., 2022; Jennifer K Vanos, Herdt, & Lochbaum, 2017; X. Yuan & Y. Ryu, 2022; Y. Zhang, Mavoa, Zhao, Raphael, & Smith, 2020).



(a)



(b)

Figure 7. 22: *(a) & (b) Analysis of Children's and Caregivers' TSV in the outdoor places during Summer. Source: Author, 2025.*

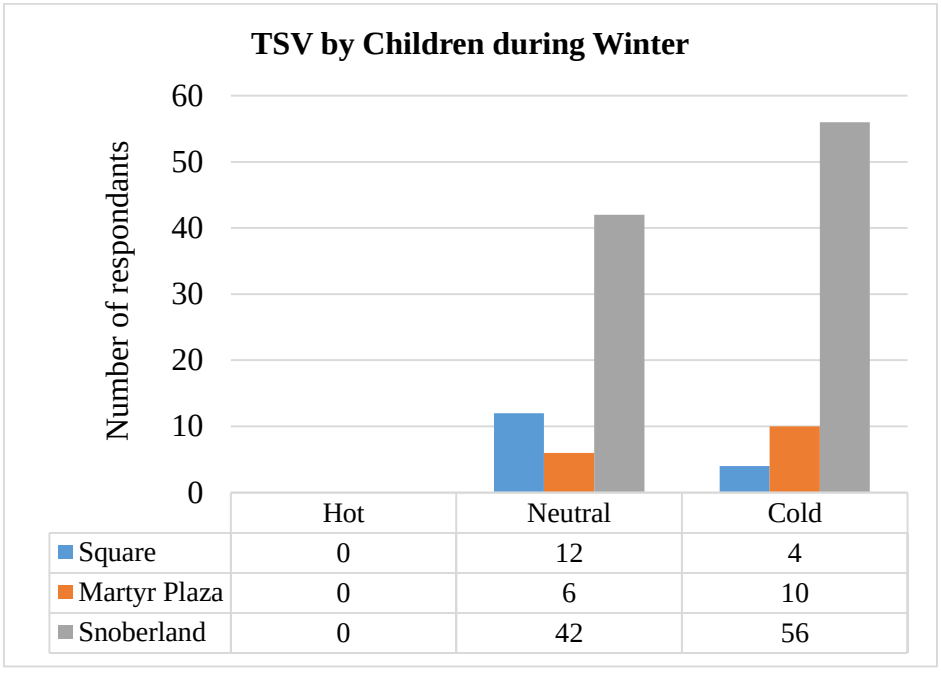
4.2 Winter

The winter TSV results indicate predominantly neutral to cold thermal sensations across the three sites (Figure 7.23a).

- In the Square, children's responses are concentrated mainly in the "Neutral" category, with a smaller number of "Cold" votes.
- In Martyr Plaza, "Cold" responses are more frequent and "Neutral" votes are fewer, indicating a less favourable winter thermal perception.

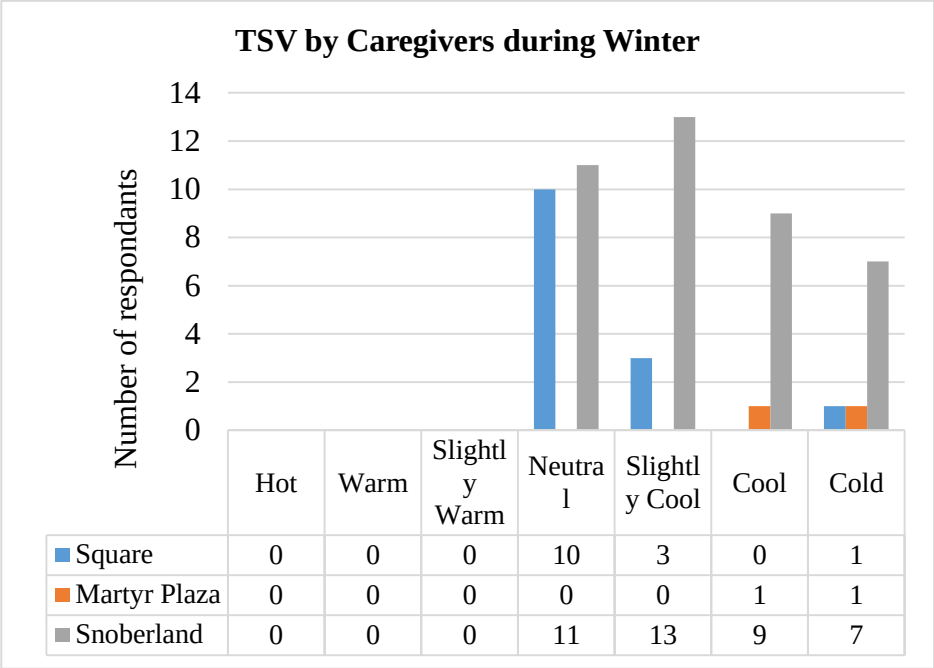
- In Snoberland, responses are distributed mainly between “Neutral” and “Cold,” suggesting a broader range of winter thermal experience, while “Hot” remains absent or marginal.
- A similar contrast to that observed in summer appears between children and caregivers (Figure 7.23b). Across the three sites, caregivers report a narrower range of sensations and tend to describe conditions mainly as “Neutral.” Children, by contrast, report “Cold” sensations more often, particularly in Martyr Plaza and Snoberland.

Taken together, these results indicate that winter thermal perception differs both by site and by user group. Martyr Plaza appears to generate the least favourable winter thermal perception among children, while the Square remains relatively more moderate. The difference between children’s and caregivers’ responses again suggests that adults may underestimate the intensity of children’s thermal discomfort. This interpretation is consistent with previous studies showing that winter thermal perception is influenced by exposure, wind conditions, and users’ different levels of thermal sensitivity (G. Bian, Z. Sheng, K. Min, & Y. Zhao, 2025; S. Chen & Knöll, 2023; X. He et al., 2023; H. Luyao et al., 2025; Hu Luyao et al., 2025; Wei, Yang, Bao, Lu, & Yang, 2022).



	Hot	Neutral	Cold
Square	0	12	4
Martyr Plaza	0	6	10
Snoberland	0	42	56

(a)



	Hot	Warm	Slightly Warm	Neutral	Slightly Cool	Cool	Cold
Square	0	0	0	10	3	0	1
Martyr Plaza	0	0	0	0	0	1	1
Snoberland	0	0	0	11	13	9	7

(b)

Figure 7. 23*: (a) & (b) Analysis of Children's and Caregivers' TSV in the three outdoor places during Winter. Source: Author, 2025.*

Discussion

Overall, the combined microclimatic and questionnaire results show that the three sites differ not only in their measured thermal performance but also in how these conditions are perceived by users.

- In **summer**, *the Square* emerges as the most thermally hostile site both objectively and subjectively, with the highest heat stress and the greatest concentration of 'Hot' votes among children, whereas *Snoberland* records the most favourable perceptions, reflecting the moderating effect of vegetation, shade and water features; *Martyr Plaza* occupies an intermediate position, with more neutral responses despite persistent thermal exposure.
- In **winter**, the pattern shifts again: *Martyr Plaza* generates the strongest cold-related discomfort, while *the Square* records the most favourable perceptions, and *Snoberland* shows mixed perceptions, partly because its facilities encourage longer stays and therefore longer exposure.
- A further important finding is the consistent gap between children's and caregivers' TSV across both seasons. Children reported "hot" sensations in summer and "cold" sensations in winter more frequently than the accompanying adults, indicating that caregiver-based thermal assessment systematically underestimates children's thermal stress. This finding

has direct implications for outdoor-space management: adult-based decisions about when an outdoor place is "comfortable enough" for children to use may consistently overestimate the thermally acceptable window from the child's perspective.

Conclusion

This chapter examined how OTC shapes CUL in three outdoor spaces in El Khroub: the Square, Martyr Plaza, and Snoberland. Drawing on behavioural observations, microclimatic measurements, and questionnaire results, it sought to understand when these spaces become more or less usable for children, and how variations in thermal conditions across time and space influence their presence and activity. Overall, the findings show that OTC plays a decisive role in the timing, intensity, and duration of children's outdoor use. Across the three sites, children's presence tended to increase during thermally acceptable periods and to decline under conditions of heat or cold stress. The results also reveal clear differences between the sites: the Square appears the most thermally challenging, Snoberland the most moderated, and Martyr Plaza occupies an intermediate position, with contrasting seasonal conditions. Questionnaire findings further indicate that children and caregivers do not perceive thermal conditions in the same way, as adults tend to report fewer extreme sensations than children. Taken together, these results confirm that OTC, as a dynamic factor varying across both time and space, is central to explaining the temporal variability of CUL.

These findings confirm the first hypothesis of the thesis: children's occupation density and duration of stay decrease when UTCI values move away from thermally acceptable ranges. Across the three sites, children's presence declined markedly under strong summer heat stress, particularly when UTCI exceeded 30°C, and under slight winter cold stress when UTCI fell below 10°C. This decline was most evident in the Square, the most thermally exposed site. Conversely, children's use increased during thermally moderate periods, particularly in late afternoon and evening in summer and early to mid-afternoon in winter.

While this chapter has shown when outdoor spaces become more or less liveable for children from a thermal perspective, it does not fully explain why children concentrate in some parts of each site more than in others. The following chapter therefore, turns to the role of spatial configuration in order to examine how visibility, accessibility, and spatial structure influence the internal distribution of children's presence and use.

CHAPTER VIII: RESULTS AND DISCUSSION: SPATIAL CONFIGURATION AND CHILDREN'S URBAN LIVEABILITY

"*Movement is not random. It is a response to the spatial logic of the city*."

— Bill Hillier & Julienne Hanson, the Social Logic of Space (1984)

Introduction

This chapter examines the role of spatial configuration in shaping CUL across the three selected outdoor spaces: the Square, Martyr Plaza, and Snoberland. Its objective is to assess how spatial configuration contributes to children's presence, movement, perception, and spatial experience, while positioning this analysis in relation to the broader methodological framework of the thesis.

It is organised into four complementary parts (Figure 8.1): (1) A spatial reading of the sites through users' perceptions of safety, visibility, accessibility, visit frequency, and attraction. (2) An objective reading based on syntactic analysis, followed by the relationship between spatial configuration, users' perceptions, and behavioural maps. (3) A qualitative reading through children's cognitive drawings. (4) An integrative reading that examines, across the three sites, the relationship between children's presence, spatial configuration, and OTC, before discussing the implications of these results. This progression is intended to explain where children tend to concentrate within the spaces under study, and how spatial structure contributes to patterns of occupation.

The chapter therefore tests the hypothesis that spatial configuration constitutes a relatively stable spatial framework for CUL. Unlike OTC, which varies across both space and time, spatial configuration varies primarily across space and provides a structural basis for understanding where children tend to concentrate. Through the combined use of questionnaires, syntactic analysis, behavioural mapping, and children's drawings, the chapter aims to provide an empirical account of the spatial dimension of CUL in a semi-arid urban context.

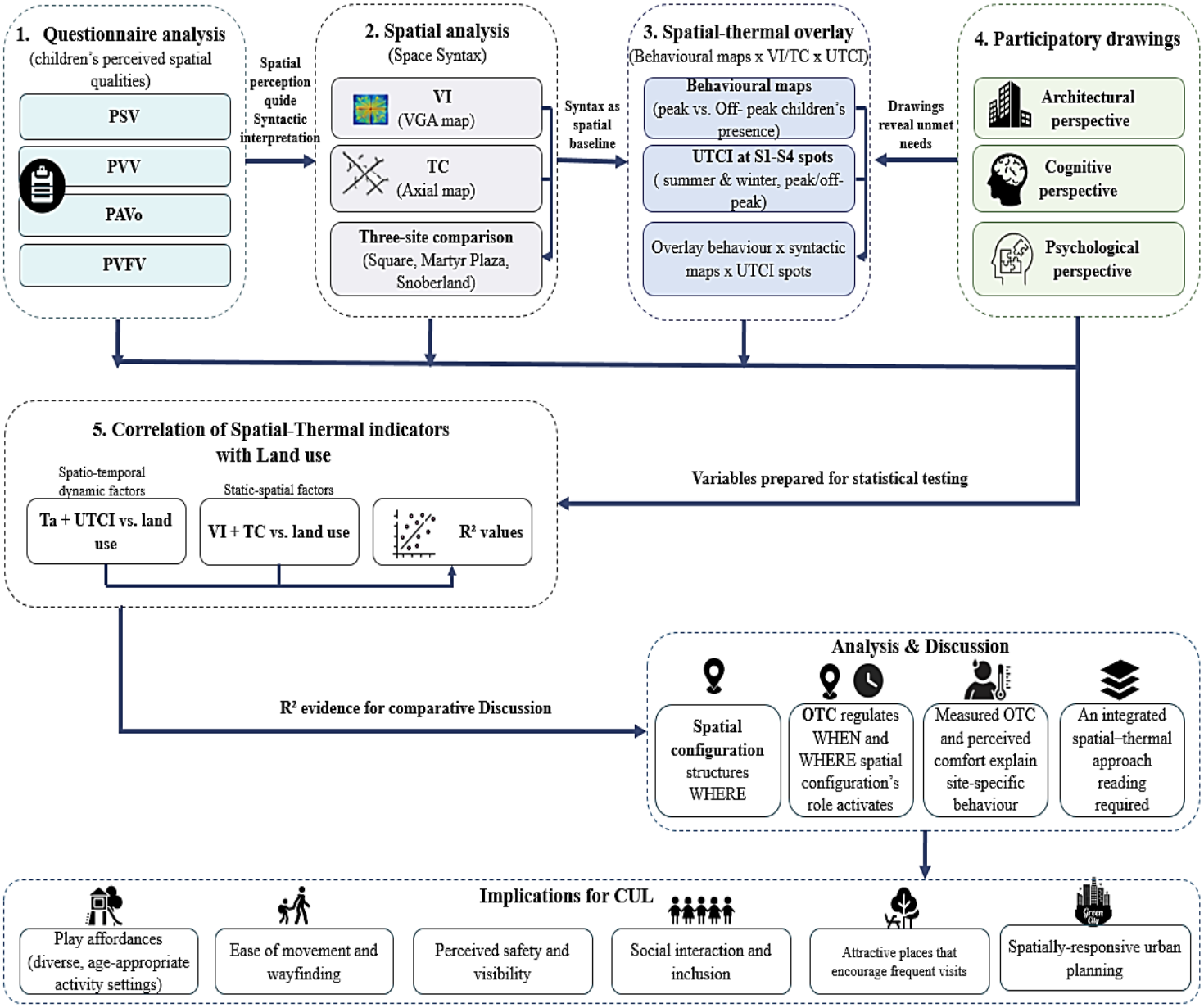


Figure 8. 1: *Structure of Chapter VIII. Source: Author, 2026.*

1. Spatial Configuration and perceived spatial qualities

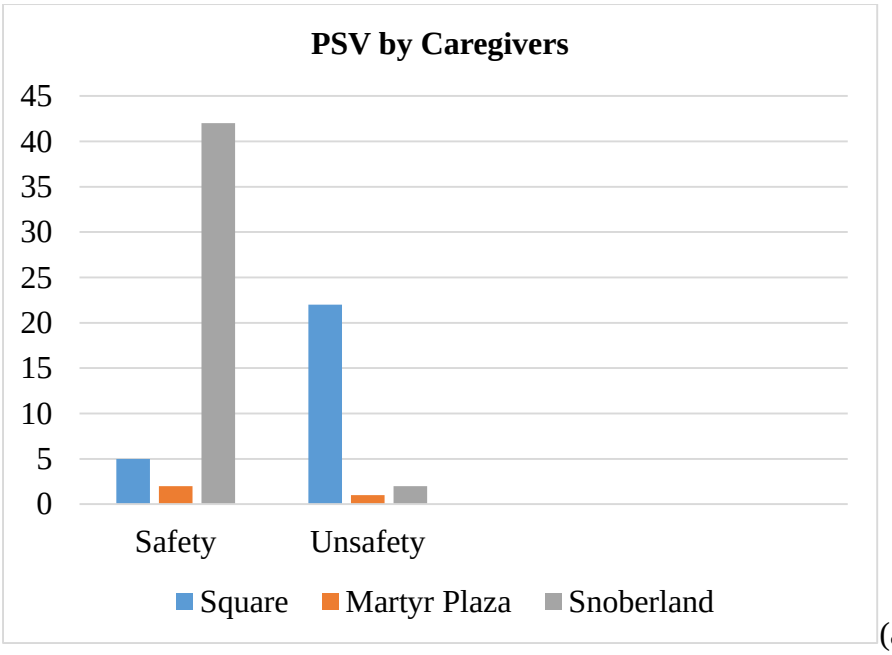
1.1. Questionnaire analysis

1.1.1. Children's perceived safety vote

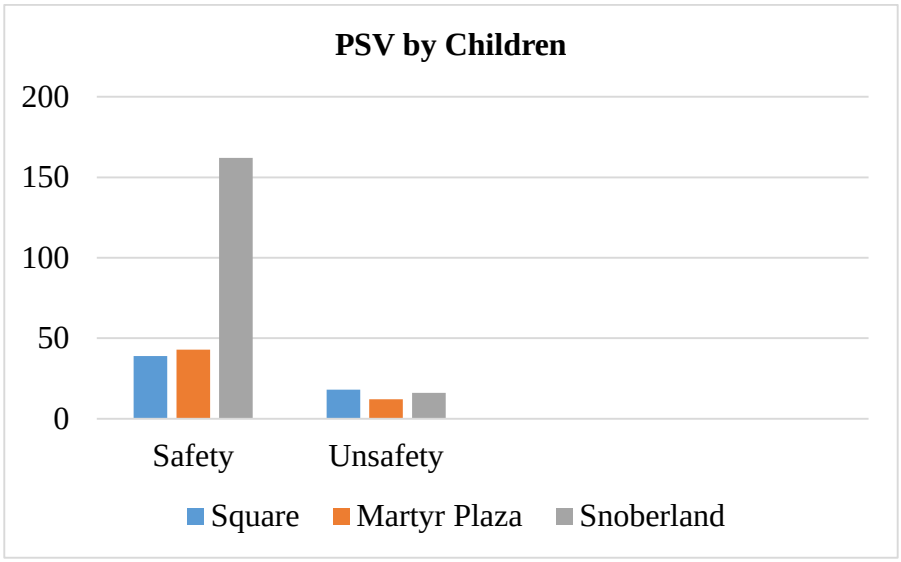
Perceived safety vote (PSV) results show differences across the three sites and between children and caregivers (Figure 8.2).

- Snoberland receives mostly safety votes from both groups, with few unsafety reports. This reflects its enclosed layout, child facilities, visibility, and family presence (P. Tang & Woolley, 2023).
- In contrast, the Square reveals differing perceptions among groups. Caregivers report more safety concerns than children, due to traffic, openness, undefined play areas, and limited surveillance. Caregivers assess safety based on environmental risks.
- Martyr Plaza results fall between the other sites. Children report moderate safety (Figure 8.2b), while caregivers report lower safety (Figure 8.2a). This relates to unclear boundaries, crowding, and movement control (M. Elnabawi & Hamza, 2020).

Across all sites, children consistently perceived higher levels of safety than caregivers. Their views depend on play opportunities, social presence, and familiarity. Caregivers focus on risk, visibility, and layout clarity (Z. Liu et al., 2023b). Overall, green, enclosed environments like Snoberland support safety perceptions alongside thermal comfort.



(a)



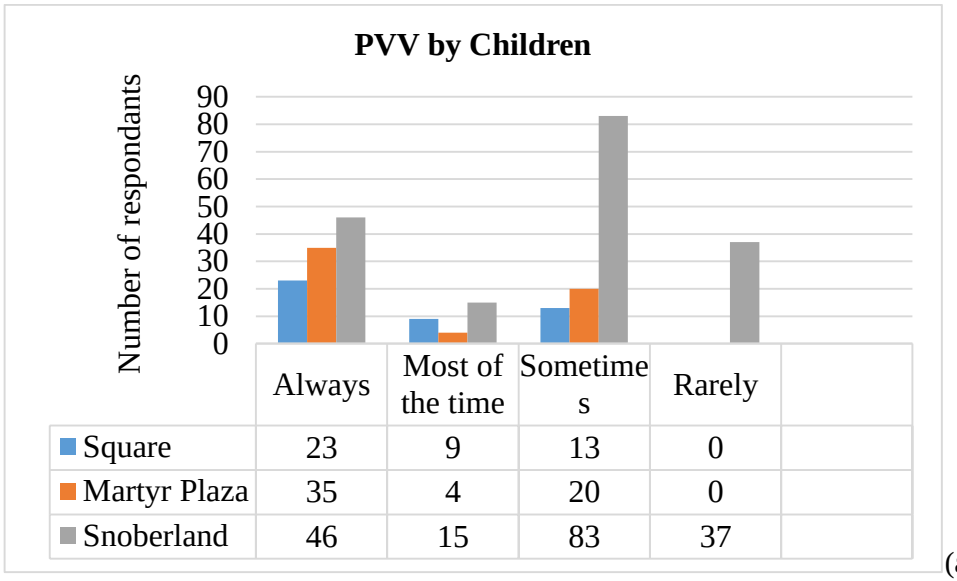
(b)

Figure 8. 2*: *(a) & (b) Analysis of Children's and Caregivers' PSV in the three outdoor spaces. Source: Author, 2025.

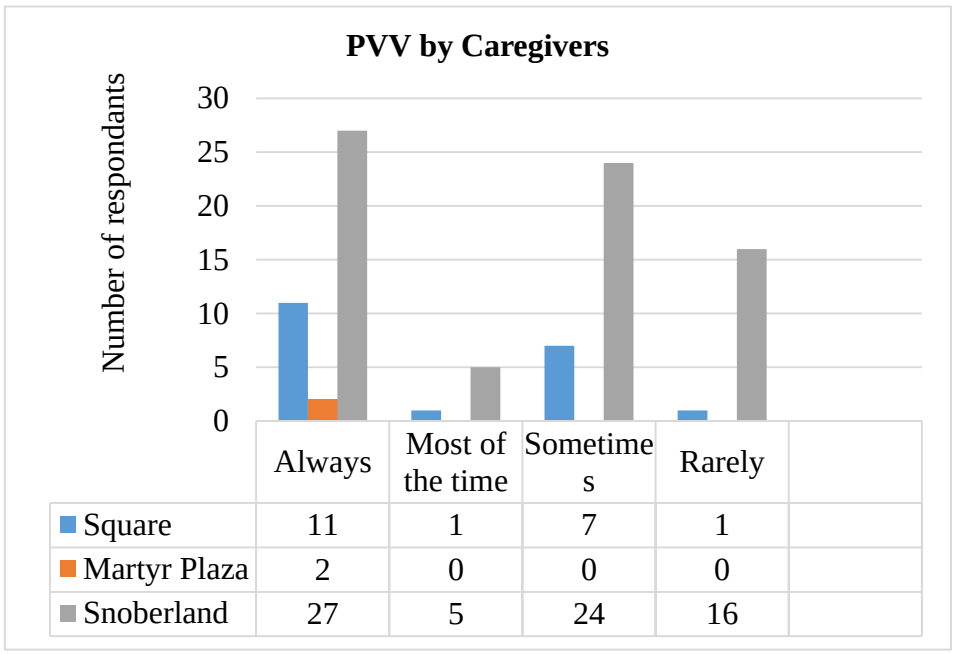
1.1.2. Children's perceived visibility vote

The perceived visibility vote (PVV) results reveal clear differences between the three outdoor places, as well as a consistent divergence between children's and caregivers' perceptions (Figure 8.3).

- Martyr Plaza records the highest PVV. Children report being visible "Always" or "Sometimes," with no negative responses (Figure 8.3a). This reflects its open layout and clear sightlines, supporting natural surveillance.
- The Square also shows good PVV, particularly among children, due to its accessible open areas. Tree-covered edges create some visual separation. Children note fewer hiding opportunities for play, which can limit exploratory activities while aiding supervision (J.-H. Lee et al., 2016).
- Snoberland records lower PVV, with "Sometimes" and "Rarely" responses from both groups (Figure 8.3a,b). Varied topography, dense vegetation, and spatial layering reduce visual continuity. Caregivers consistently rate visibility lower than children across sites. Caregivers focus on risk and supervision needs. Children assess visibility based on play experience and movement freedom (Visser, Van Aalst, & Meijer, 2024).



(a)



(b)

Figure 8. 3*: (a) & (b) Analysis of Children's and Caregivers' PVV in the three outdoor spaces. Source: Author, 2025.*

1.1.3. Children's perceived accessibility vote

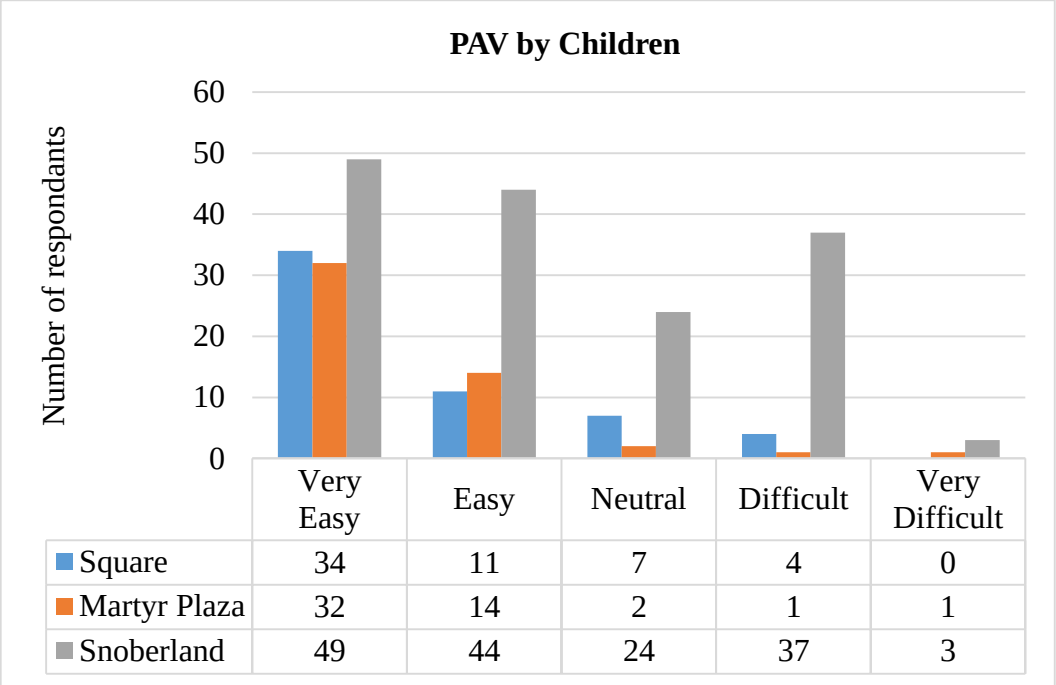
The perceived accessibility vote (PAV) results indicate significant differences in how children perceive accessibility across the three outdoor spaces (Figure 8.4).

- Snoberland receives the highest ratings, with 49 children reporting "Very Easy" and 44 "Easy" access.
- Martyr Plaza and the Square receive fewer positive ratings. Both sites record similar "Very Easy" votes (32 for Martyr Plaza, 34 for the Square), but the Square has more

"Neutral" and "Difficult" responses. This suggests children find the Square slightly less navigable than Martyr Plaza.

- Snoberland also records higher "Difficult" and "Very Difficult" responses. Its larger size, multi-level topography, and complex layout create navigation challenges for some children, depending on familiarity and route choice.

These findings align with research on children's urban mobility (Sharmin & Kamruzzaman, 2017). Spaces with multiple entry points, clear sightlines, and interactive features support accessibility perceptions. Spatial complexity and crowding can create perceptions of difficulty. The differences between sites show how configuration and pathway variety affect children's movement ease.



	Very Easy	Easy	Neutral	Difficult	Very Difficult
Square	34	11	7	4	0
Martyr Plaza	32	14	2	1	1
Snoberland	49	44	24	37	3

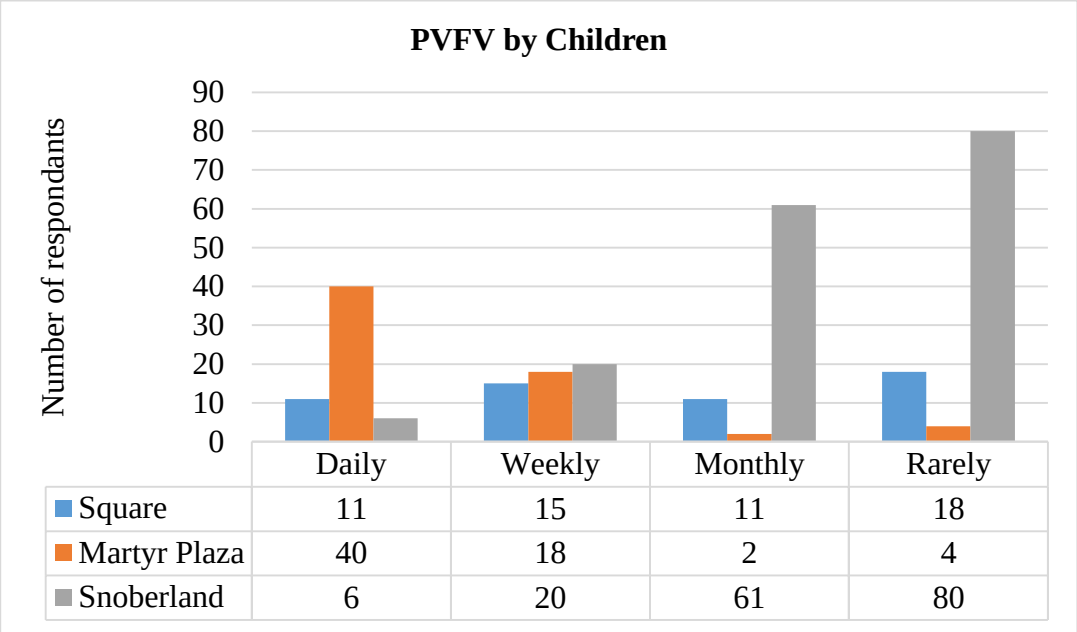
***Figure 8. 4**: Analysis of Children's PAV in the three outdoor spaces. Source: Author, 2025.*

1.1.4. Children's place visit frequency vote

As illustrated in Figure 8.5, the analysis of children's Place Visit Frequency Vote (PVFV) in the three outdoor spaces reveals that visitation patterns vary markedly across the sites.

- Martyr Plaza has the highest daily visitation (40 children), indicating regular use. This matches research showing centrally located urban spaces attract frequent child visits (Kyttä et al., 2018; Refshauge et al., 2012).
- The Square shows more weekly and rare visits, reflecting moderate neighbourhood use. Both open-access sites support typical local accessibility patterns.

- Snoberland has the highest total respondents (183 children across seasons, compared to 62 at each other site), but mainly monthly or rare visits (61 and 80 children). This reflects its role as a destination park. The entrance fee and broad catchment area limit frequent visits, attracting families from other areas for special trips.
- Martyr Plaza and the Square serve as routine neighbourhood spaces. Snoberland functions as a high-volume destination with less frequent use, showing how design, costs, and location affect CUL patterns.



	Daily	Weekly	Monthly	Rarely
Square	11	15	11	18
Martyr Plaza	40	18	2	4
Snoberland	6	20	61	80

Figure 8. 5*: Analysis of Children's PVFV in the three outdoor spaces. Source: Author, 2025.*

1.1.5. Children's place attraction vote

- Children's Place Attraction Vote (PAVo) results show different preferences across the three sites. As illustrated in Figure 8.6, Snoberland receives the highest engagement for play equipment (121) and urban furniture (70), indicating interactive elements attract children.
- Martyr Plaza scores highest for safety (12) and location (17).
- The Square has the lowest overall appeal, with some interest in play equipment (39) and weather (16).

Overall the results shows that interactive play areas and comfortable facilities influence CUL most. Design and aesthetics rank lower across sites. These patterns match research showing children prefer engaging play structures and safe environments over aesthetic elements (P. Tang & Woolley, 2023; Yin Wang, Sun, Sun, & He, 2024).

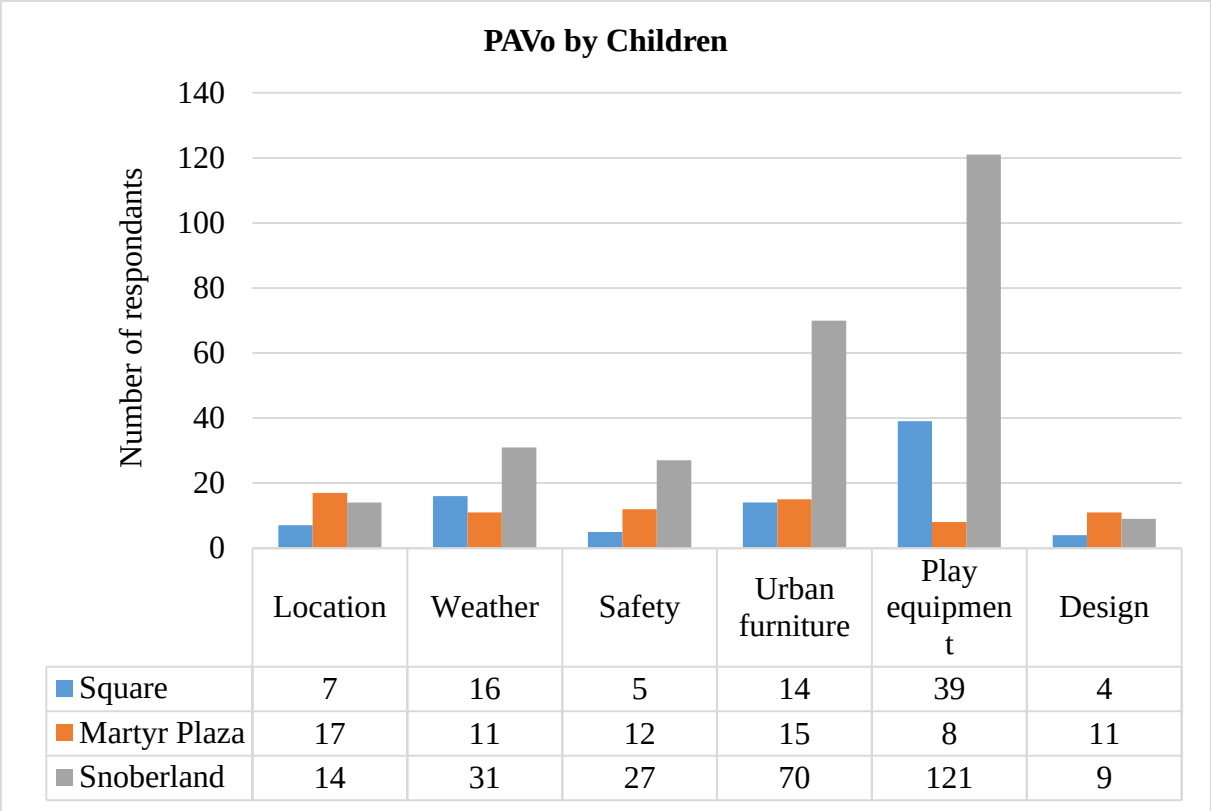


Figure 8. 6: *Analysis of Children's PAVo in the three outdoor spaces. Source: Author, 2025.*

2. Spatial analysis

The spatial analysis objectively assessed the morphological properties of the three sites using DepthmapX, generating VGA and Axial maps. The focus was on calculating VI and syntactic TC to evaluate visibility and movement potential (Table 8.1). Visualisations employ a standard colour spectrum, where cooler shades (blue) denote low syntactic values and warmer tones (orange/red) indicate high VI and TC.

Table 8. 1*: Values of TC and VI in the outdoor places. Source: Author 2025.*

Attribute	**The Square**			**Snoberland**			**Martyr Plaza**		
	Min	Average	Max	Min	Average	Max	Min	Average	Max
TC R400	0	242.676	1554	0	7205,92	702508	0	26,1587	127
VI R3 [HH]	3.622	13.101	22.345	2,10231	5,30194	16,106	7,39292	16,052	24,2369

2.1. The Square

Figure 8.7 illustrates the spatial analysis results for the Square. The VGA shows a moderately to well-integrated spatial field, with an average VI (R3) value of 13.10 and a maximum of 22.34 (Figure 8.7a). This reflects a relatively open and visually coherent layout, in which most areas of the Square remain mutually visible and accessible to the surrounding pedestrian environment. The axial analysis, by contrast, indicates a comparatively low distribution of through-movement potential, with an average TC (R400) value of 242.67 and a maximum of 1,554 (Figure 8.7b).

Taken together, these results suggest a configurational pattern that enables diagonal shortcuts and relatively flexible pedestrian movement, while remaining partly segmented by tree edges.

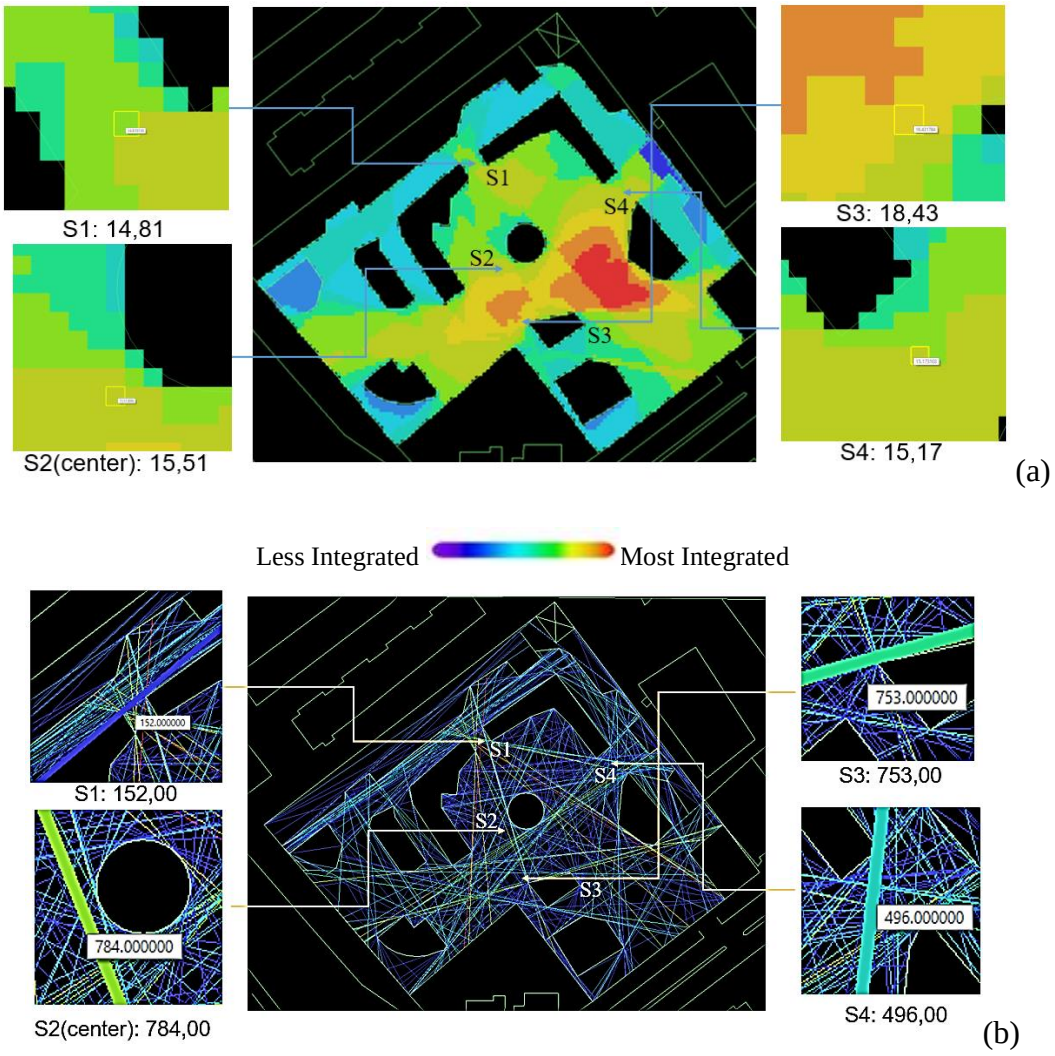


Figure 8. 7: *(a) VGA for the VI values. (b) Axial map for TC values of children in the Square. Source: Author, 2025.*

2.2. Martyr Plaza

As shown in Figure 8.8, Martyr Plaza exhibits the highest degree of VI among the three sites, with an average R3 value of 16.05 and a maximum of 24.24 (Figure 8.8a). The VGA reveals a distinct central visibility core, indicating an open geometry and strong spatial legibility, in which the central area maintains visual continuity with almost every part of the plaza. At the same time, its very low average TC value of 26.16, with a maximum of only 127 (Figure 8.8b), suggests that, although the space is visually cohesive, it does not function as a strong through-movement attractor; pedestrian movement is broadly distributed across the open field rather than strictly channelled along dominant corridors, thereby creating a highly permeable but weakly traversed spatial field.

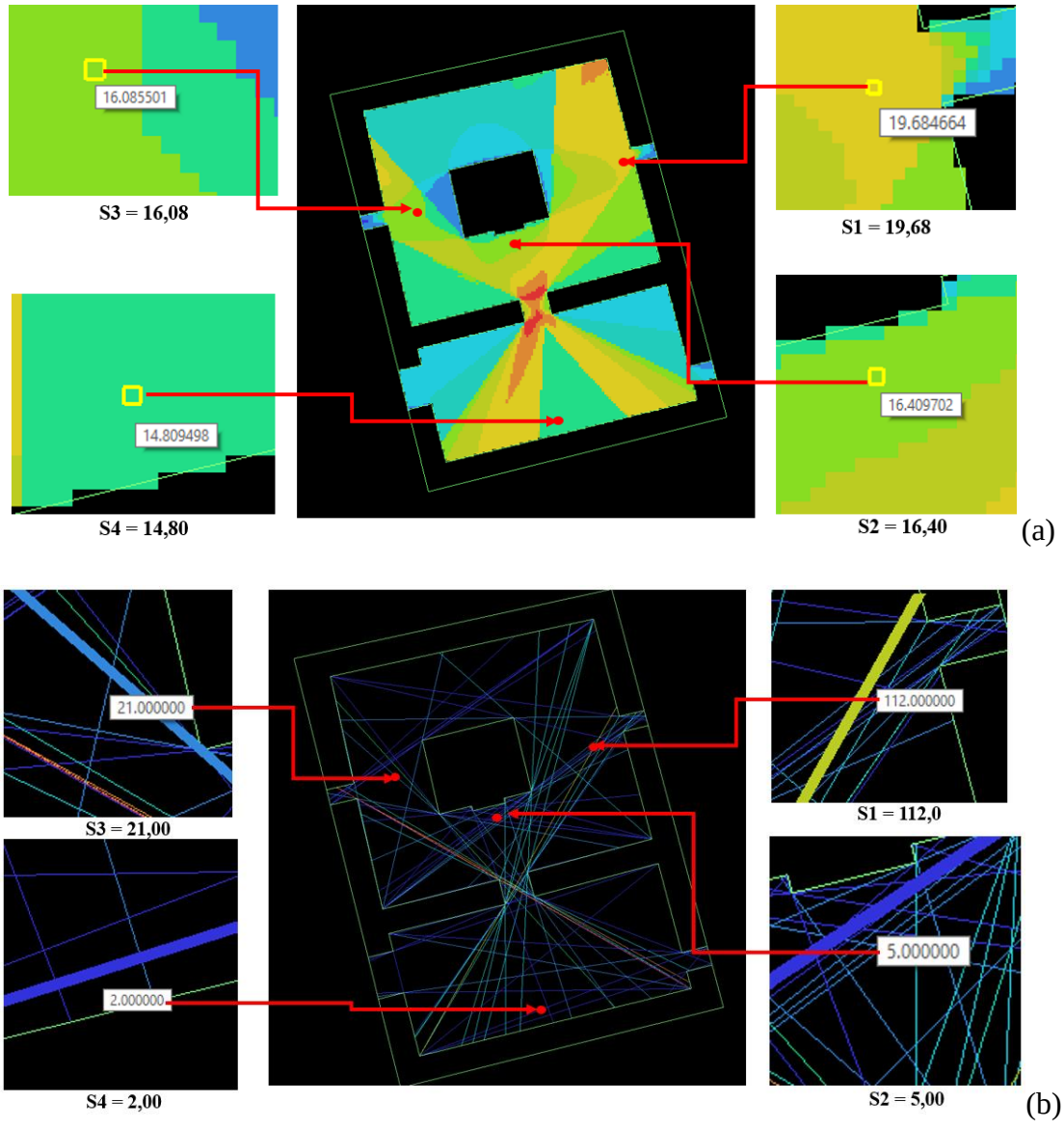


Figure 8. 8*: (a) VGA for the VI values. (b) Axial map for TC values of children in Martyr Plaza. Source: Author, 2025.*

2.3. Snoberland

As shown in Figure 8.9, Snoberland exhibits the weakest VI among the three sites, with an average R3 value of 5.30 and a maximum of 16.11 (Figure 8.9a). Its lower minimum and average values suggest a fragmented visual field shaped by topography, spatial layering, and dense vegetation, in which sub-areas of the park are visually disconnected from one another and from the main circulation routes. By contrast, the axial analysis indicates an exceptionally high average TC value of 7,205.92 and a maximum reaching 702,508 (Figure 8.9b), reflecting movement concentrated along dominant and restrictive corridors rather than distributed across a more permeable field. Together, these results characterise Snoberland as a site of low visual integration but strong channelled movement, where pedestrian flow is structured by a small number of high-choice axes that organise circulation through the park.

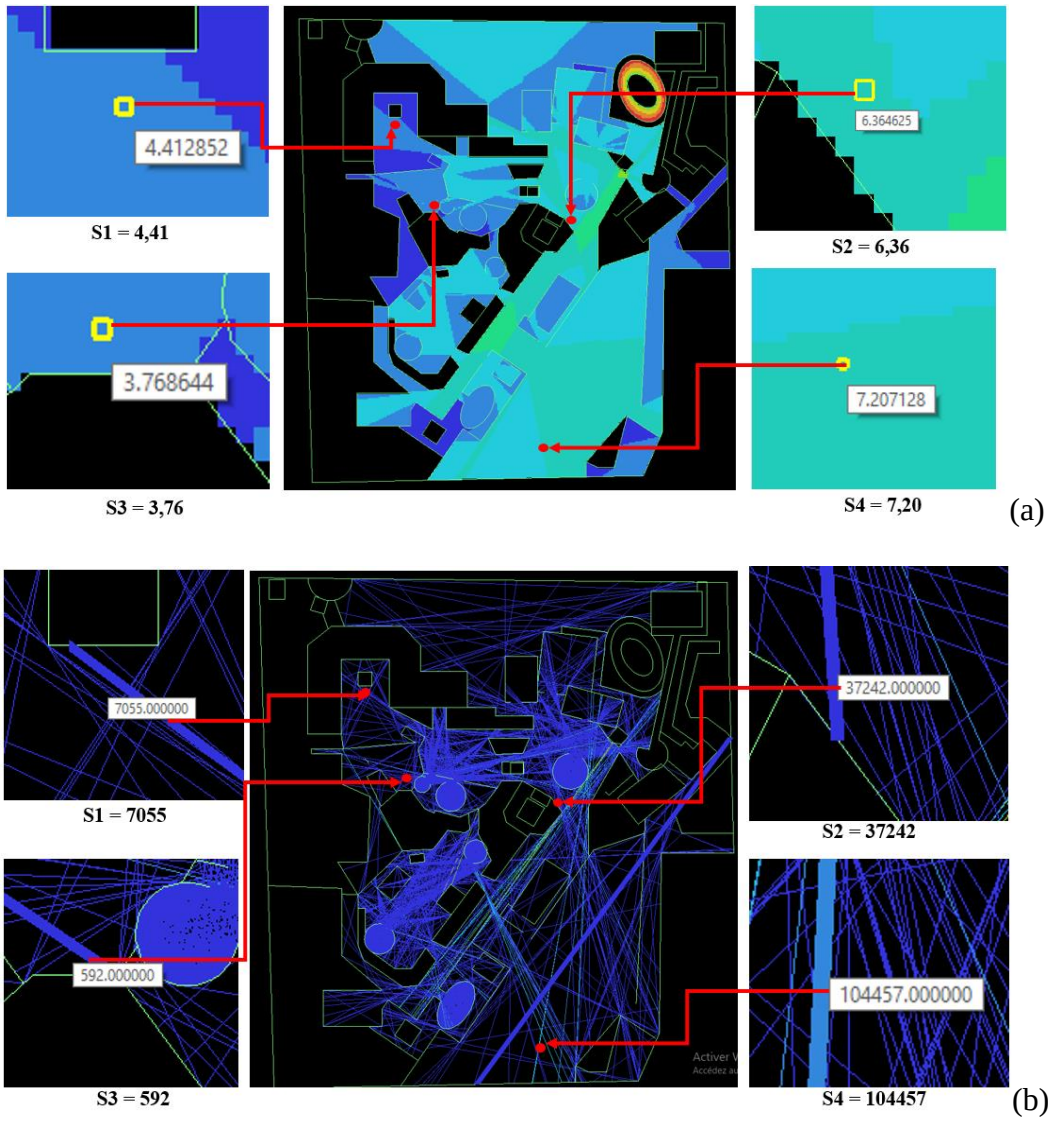


Figure 8. 9*: (a) VGA for the VI values. (b) Axial map for TC values of children in Snoberland. Source: Author, 2025.*

Discussion

By linking the syntactic analysis with the questionnaire results (PVV, PSV, PAV, PVFV, and PAVo), a clearer relationship emerges between spatial configuration and CUL. The findings show that configurational performance alone does not determine children's use or perception: safety, play value, familiarity, and supervision also shape how spaces are experienced. In general, caregivers focus more on risk and control, whereas children place greater emphasis on play opportunities and freedom of movement. The three sites illustrate this contrast in different ways:

- *Martyr Plaza* confirms the value of visual openness. Its high VI corresponds to strong PVV, suggesting that visibility supports legibility and surveillance. However, this does not produce the highest PSV, particularly among caregivers, because openness without clear boundaries or child-oriented facilities can also generate uncertainty. Its low TC further indicates that movement is broadly distributed rather than strongly channelled.
- *Snoberland* presents the opposite condition. Although its VI is weakened by vegetation and topography, it records the strongest PSV, PAV and PAVo. This shows that children's liveability is not reducible to visibility: enclosure, facilities, play diversity and family presence can compensate for weaker visual continuity. Its very high TC reflects controlled and concentrated movement corridors, but PVFV reveals a critical limitation: high attraction does not mean frequent use.
- *The Square* presents a contrasting configurational profile. Its moderate-to-high VI suggests good integration and spatial accessibility, but its low-to-moderate TC indicates limited through-movement potential, meaning that the Square is visually open without functioning as a strong pedestrian corridor. This configurational advantage in terms of visibility is, however, undermined by traffic exposure, weak maintenance and limited play provision. Its lower PSV and PAVo show that VI alone cannot compensate for poor environmental quality or insufficient child-centred facilities. PVFV confirms this ambiguity: the Square is available as a neighbourhood space, but it lacks the attraction needed to sustain stronger child presence.
- The results also reflect each site's broader function. *Martyr Plaza* and *the Square* operate mainly as everyday neighbourhood spaces. *Snoberland* functions more as a destination park, with stronger attractions but less PVFV due to its enclosed layout and entrance fee.

Overall, this provides a useful basis for the final discussion and for GUD recommendations centred on legibility, child-friendly safety, and inclusive access.

3. Spatial–thermal overlay analysis of behavioural and syntactic maps

The spatial–thermal overlay analysis was conducted to examine whether the configurational potential of each spot per site was realised differently under contrasting thermal conditions. Behavioural maps for peak and off-peak periods were overlaid with VGA and Axial maps, while the UTCI values of the four observation spots (S1–S4) were added to the maps and summarised in Table 8.2. This made it possible to interpret children's spatial occupation in relation to both syntactic properties and thermal stress, rather than in relation to spatial configuration alone.

Table 8. 2: *UTCI values and thermal interpretation for S1–S4 during peak and off-peak periods. Source: Author, 2026.*

				UTCI (°C) values per spot			
Sites	**Seasons**	**Period**	**Time**	**S1**	**S2**	**S3**	**S4**
The Square	Summer	Off peak	2.00 to 3.00 pm	37.8492	34.0272	37.6696	37.5755
		Peak	7.00 to 8.00 pm	25.5142	25.8251	25.6081	25.6547
	Winter	Off peak	6.00 to 9.00 pm	10.6748	10.9691	10.7637	10.8105
		Peak	3.00 to 4.00 pm	9.9808	9.9415	9.9690	6.2483
Martyr Plaza	Summer	Off peak	9.00 to 10.00 am	30.4079	29.4087	30.7818	30.5911
		Peak	6.00 to 7.00 pm	23.4087	23.6490	23.3175	23.3641
	Winter	Off peak	8.00 to 9.00 pm	8.3532	9.2421	8.0160	8.1883
		Peak	3.00 to 4.00 pm	14.0115	21.2068	21.1236	21.1353
Snoberland	Summer	Off peak	3.00 to 4.00 pm	33.8279	34.0306	34.2336	33.6897
		Peak	6.00 to 7.00 pm	24.0406	24.0167	23.9928	24.0569
	Winter	Off peak	8.00 to 9.00 pm	6.1151	5.9922	5.8693	6.1992
		Peak	3.00 to 4.00 pm	20.6838	20.6879	20.6919	20.6811

UTCI thermal interpretation legend

Slight cold stress (0-10 °C)	No thermal stress (10-23 °C)	Moderate heat stress (23-30 °C)	Strong heat stress (30-38 °C)	Very strong heat stress (38-45 °C)	Extreme heat stress (>45 °C)

3.1. The Square

A comparative seasonal analysis of the Square demonstrates that children's activity is shaped by the interaction between spatial configuration and OTC, rather than by configurational properties alone. Figures 8.10 and 8.11 illustrate children's behavioural patterns in relation to VI and TC during the summer and winter periods, respectively.

- In summer, off-peak use during 2.00 to 3.00 pm declines to near zero despite unchanged values of VI and TC (Figure 8.10b, d). While UTCI ranges from 34.03 °C to 37.85 °C indicating strong heat stress. By contrast, during the summer peak period from 7.00 to 8.00 pm, when the UTCI range decreases to 25.51 °C–25.83 °C, indicating moderate heat stress, a strong overlap re-emerges between the behavioural and syntactic maps, with children concentrating in the most integrated and connected central zones (Figure 8.10a, c).

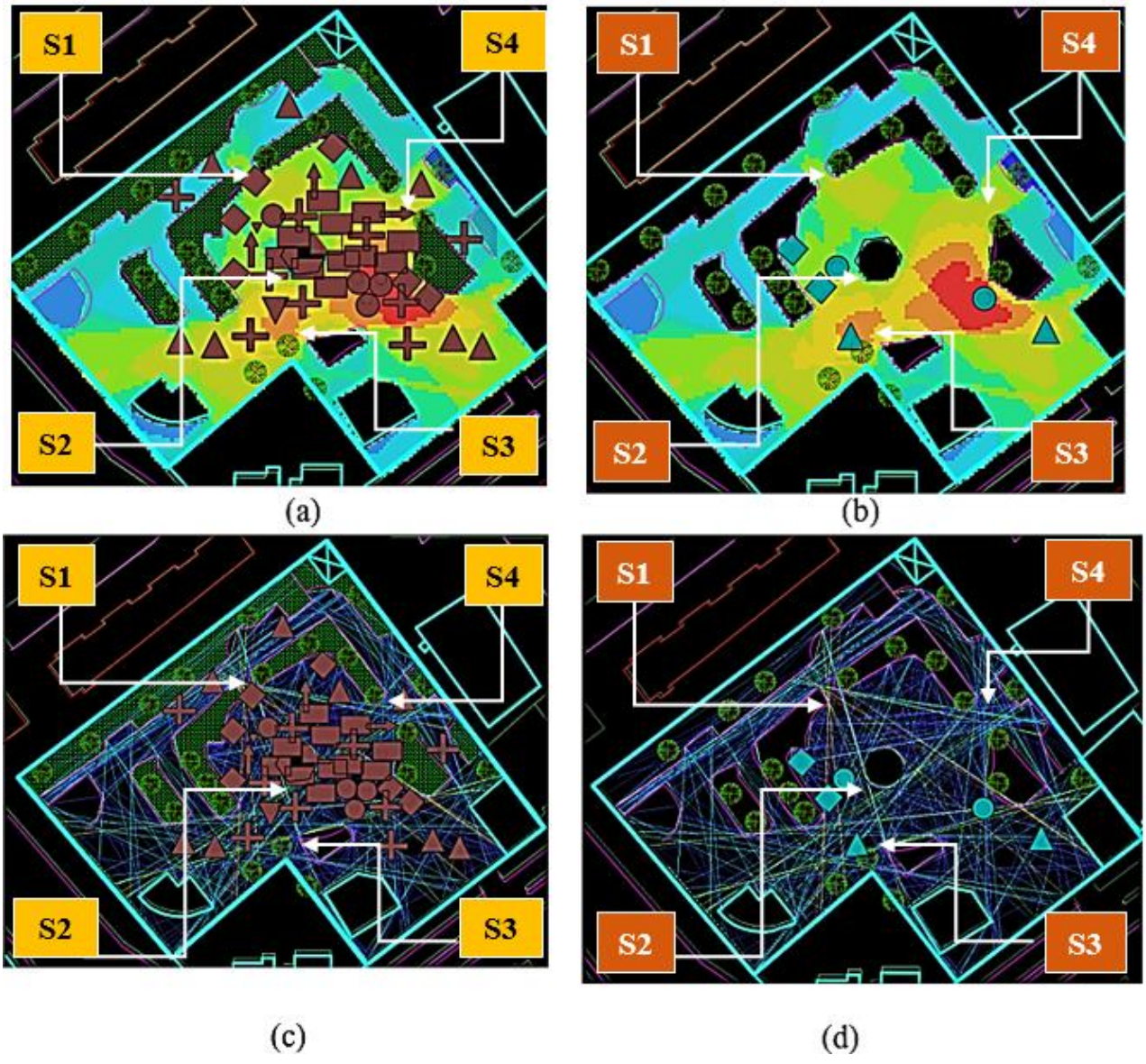


Figure 8. 10: *Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in the Square during summer: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

- In winter, off-peak use during 6.00 to 9.00 pm decreases but does not disappear despite relatively stable values of VI and TC (Figure 8.11b, d), while UTCI ranges from 10.67 °C to 10.97 °C, indicating no thermal stress. By contrast, during the winter peak period

from 3.00 to 4.00 pm, when the UTCI range varies between 6.25 °C and 9.98 °C, indicating slight cold stress to no thermal stress, a stronger overlap appears between the behavioural and syntactic maps, with children concentrating in the integrated and connected core of the Square (Figure 8.11a, c).

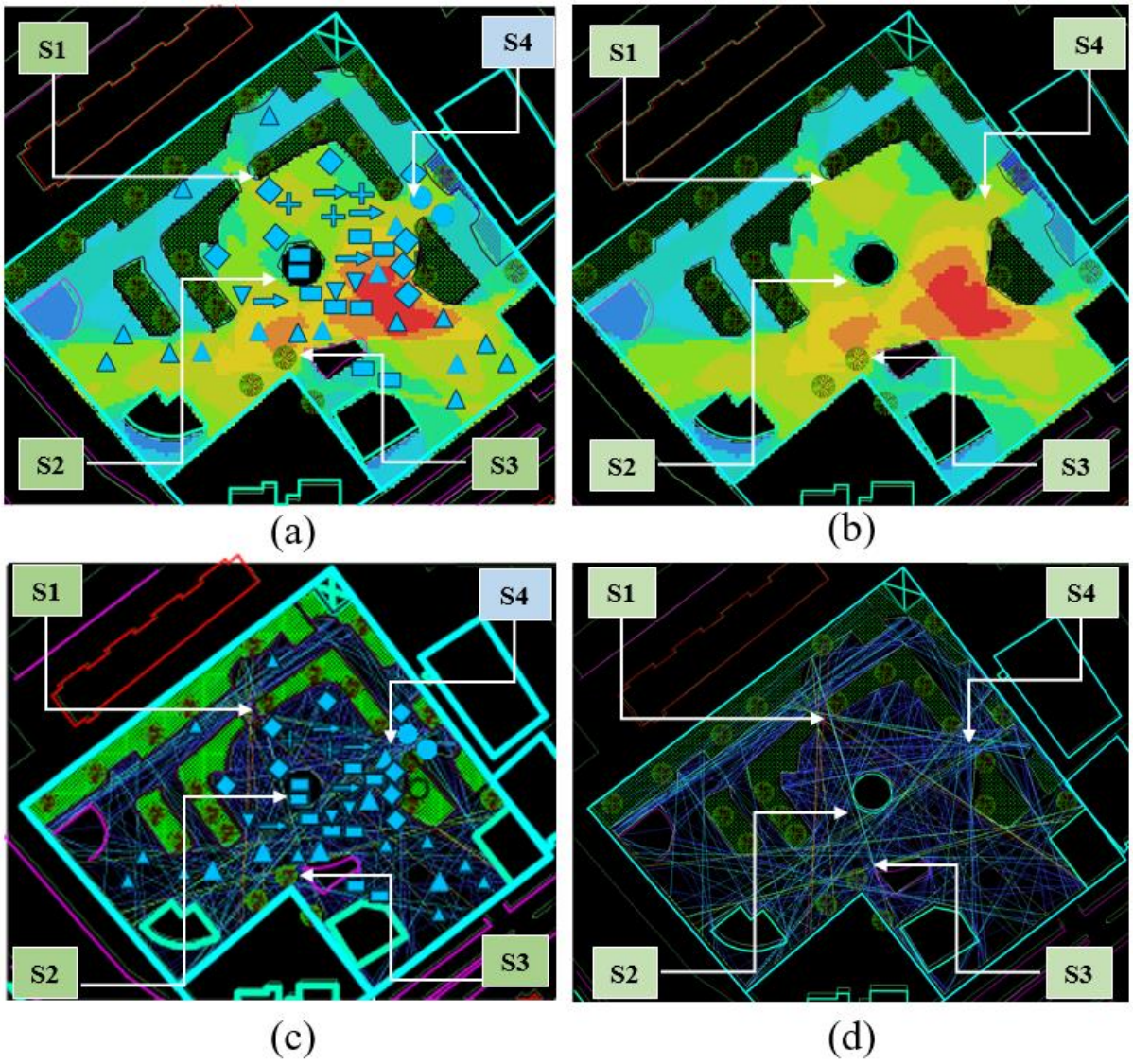


***Figure 8. 11**: Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in the Square during winter: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

3.2. Martyr Plaza

Seasonal data for Martyr Plaza show that children's activity patterns are shaped by the interaction between spatial configuration and OTC, although the temporal structure differs from that observed in the Square. Figures 8.12 and 8.13 illustrate children's behavioural patterns in relation to VI and TC during the summer and winter periods, respectively.

- In summer, off-peak use during 9.00 to 10.00 am remains limited and selectively distributed despite unchanged values of VI and TC (Figure 8.12b, d), while UTCI ranges from 29.41 °C to 30.78 °C, indicating strong heat stress. By contrast, during the evening peak period from 6.00 to 7.00 pm, when the UTCI range decreases to 23.32 °C–23.65 °C, indicating no thermal stress, a clearer overlap emerges between the behavioural and syntactic maps, with children gathering more visibly in the integrated and accessible parts of the plaza (Figure 8.12a, c).

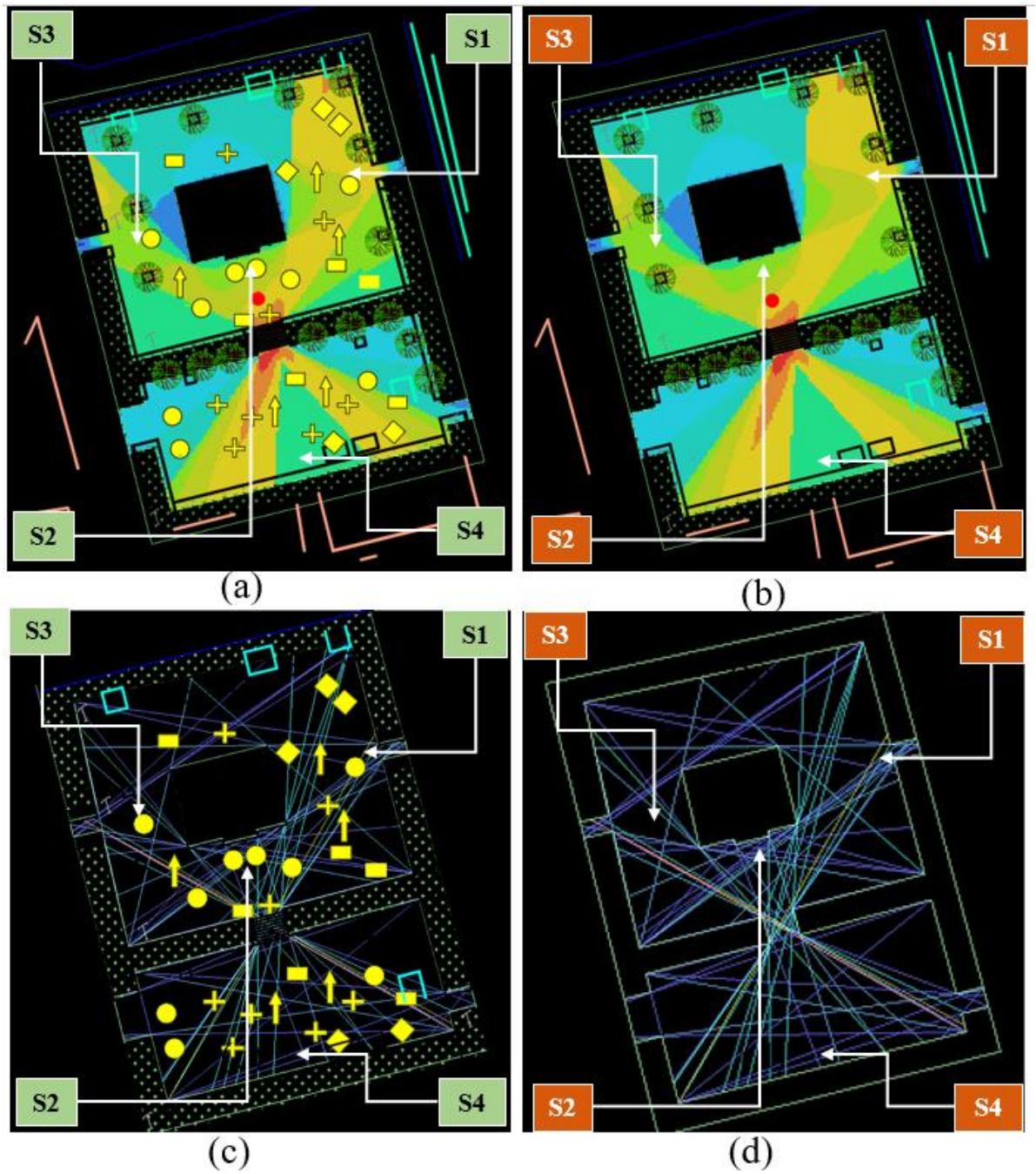


Figure 8. 12*: Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in Martyr Plaza during summer: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

- In winter, off-peak use during 8.00 to 9.00 pm decreases despite stable values of VI and TC (Figure 8.13b, d), while UTCI ranges from 8.02 °C to 9.24 °C, indicating slight cold stress. By contrast, during the winter peak period from 3.00 to 4.00 pm, when the UTCI range increases to 14.01 °C–21.21 °C, indicating no thermal stress, a stronger overlap occurs between the behavioural and syntactic maps, with children concentrating in the more integrated and connected parts of the site (Figure 8.13a, c).

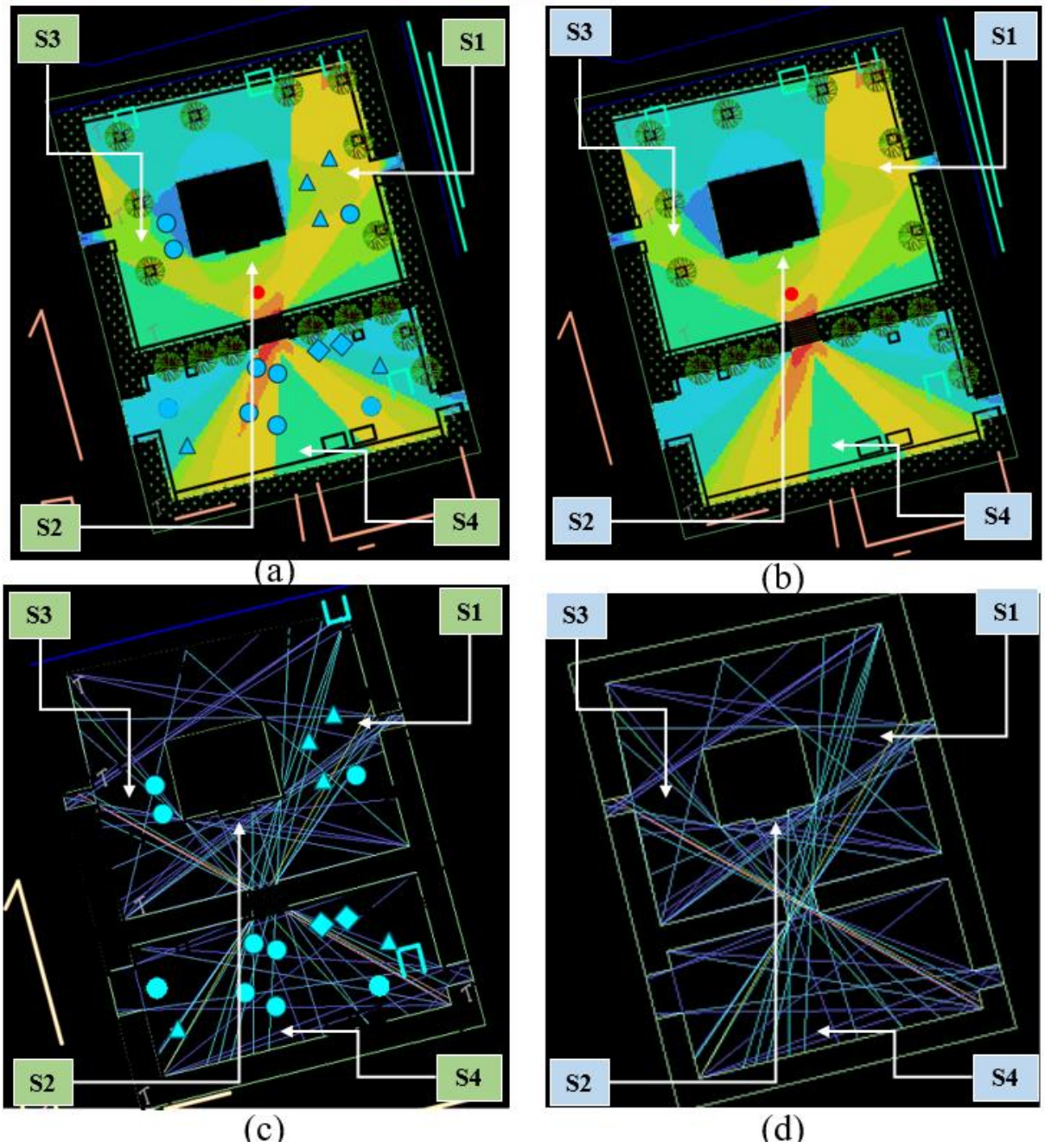


Figure 8. 13*: Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in Martyr Plaza during winter: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

3.3. Snoberland

Seasonal data for Snoberland show that children's activity patterns are shaped by the interaction between spatial configuration and OTC. Figures 8.14 and 8.15 illustrate children's behavioural patterns in relation to VI and TC during the summer and winter periods, respectively.

- In summer, off-peak use during 3.00 to 4.00 pm remains lower despite unchanged values of VI and TC (Figure 8.14b, d), while UTCI ranges from 33.69 °C to 34.23 °C, indicating strong heat stress. By contrast, during the summer peak period from 6.00 to 7.00 pm, when the UTCI range decreases to 23.99 °C–24.06 °C, indicating moderate heat stress, a stronger overlap reappears between the behavioural and syntactic maps, with children clustering more clearly in the integrated and connected areas of the park (Figure 8.14a, c).

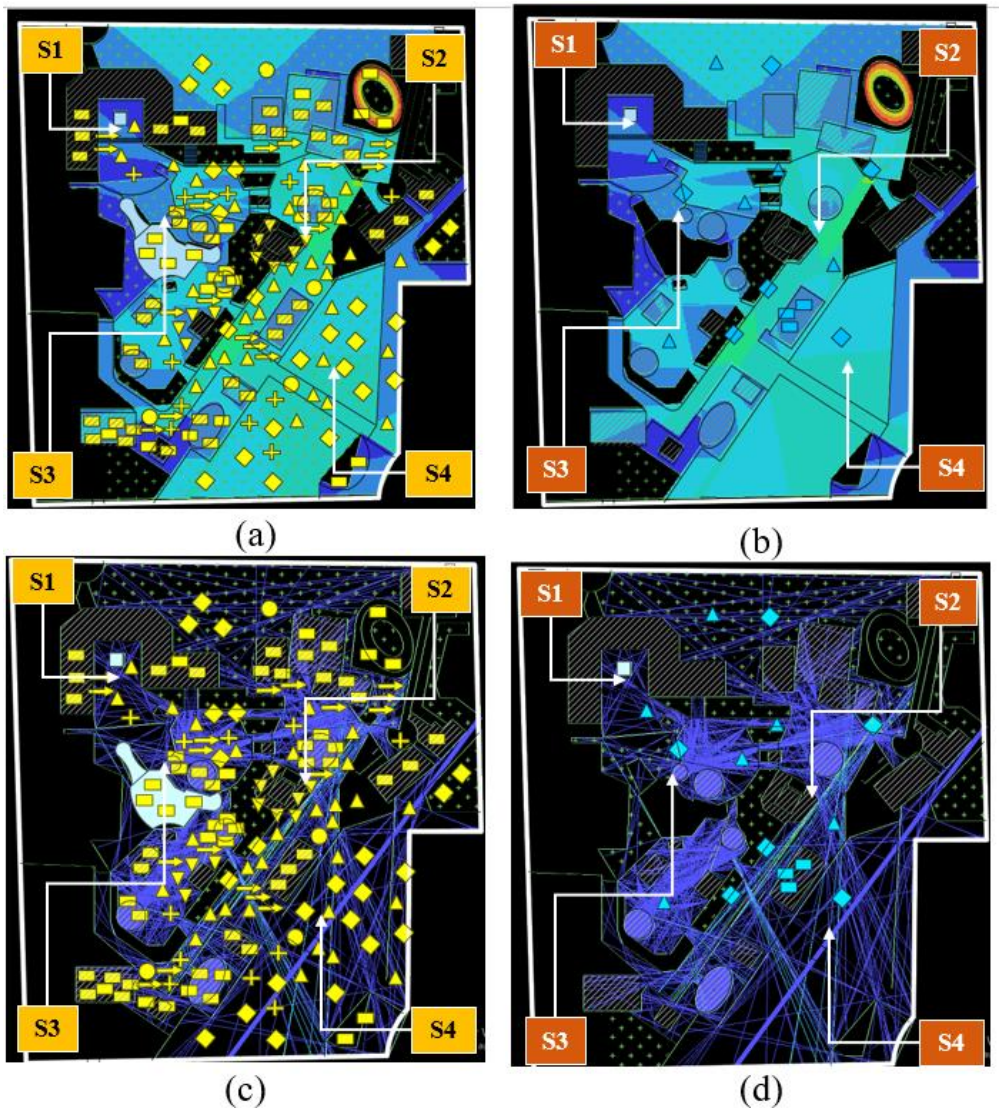


***Figure 8. 14**: Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in Snoberland during summer: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

- In winter, off-peak use during 8.00 to 9.00 pm decreases despite stable values of VI and TC (Figure 8.15b, d), while UTCI ranges from 5.87 °C to 6.20 °C, indicating slight cold stress. By contrast, during the winter peak period from 3.00 to 4.00 pm, when the UTCI range increases to 20.68 °C–20.69 °C, indicating no thermal stress, a clear overlap emerges between the behavioural and syntactic maps, with children concentrating in the most integrated and connected parts of the park (Figure 8.15a, c).

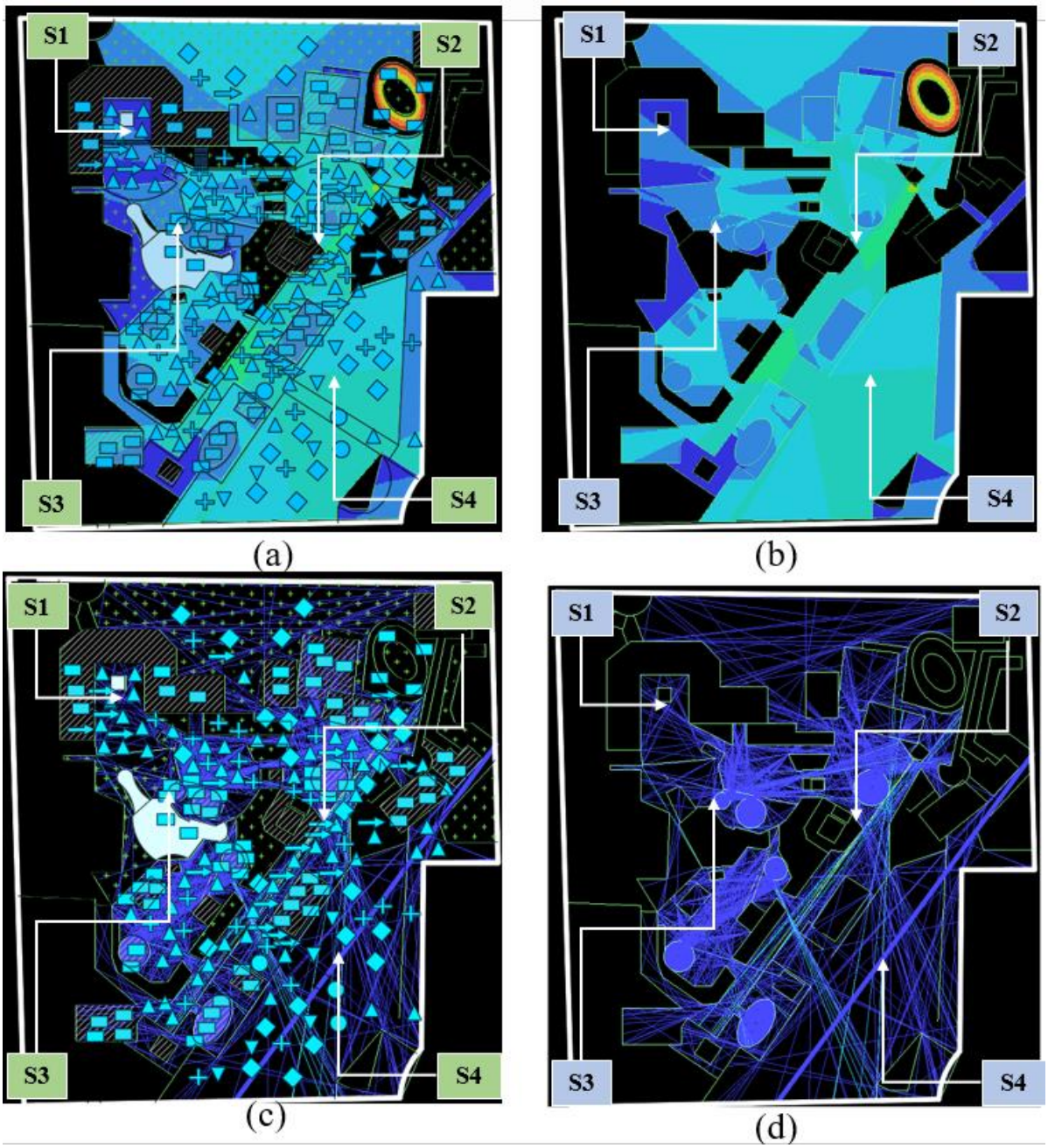


***Figure 8. 15**: Spatial–thermal overlay of children's behavioural patterns, VI, TC and UTCI values in Snoberland during winter: (a, c) peak activity; (b, d) off-peak activity. Source: Author, 2025.*

Discussion

Overall, the spatial–thermal overlay analysis confirms that spatial configuration alone does not explain children's occupation of outdoor spaces. Although spots with higher VI and TC generally present stronger spatial potential, this potential is not consistently realised under thermally stressful conditions. Instead, children's use becomes more clearly aligned with syntactically favourable areas when UTCI values indicate thermally acceptable or more tolerable conditions. This suggests that spatial configuration defines the potential for occupation, while OTC regulates the temporal activation of that potential.

- This pattern is particularly evident in summer. During the *off-peak periods*, when UTCI values indicate **moderate to strong heat stress**, **children's occupation weakens** even in **visually integrated** and **accessible spots**. Conversely, during the *evening peak periods*, when UTCI values **decrease** substantially, the overlap between behavioural concentration and syntactic centrality becomes **stronger** across the three sites. This indicates that **integrated and connected spots** do not automatically attract children; rather, their attractiveness depends on whether thermal conditions allow children to remain outdoors comfortably.
- In winter, the same relationship appears through an *opposite temporal rhythm*. *Peak overlap* occurs during the **milder afternoon period**, when UTCI values are more **favourable**, whereas *evening off-peak periods* show reduced occupation despite the persistence of the same spatial structure. This confirms that the influence of spatial configuration on children's behaviour is not fixed throughout the day. It is mediated by seasonal and diurnal thermal conditions, which can either enable or suppress the use of syntactically favourable spaces.
- The findings therefore support the hypothesis that *static spatial parameters influence CUL most clearly when dynamic spatiotemporal parameters are thermally favourable*.
- In relation to Hillier's theory of *natural movement*, the results suggest that **integrated and accessible spaces** generate movement potential; however, for children, this potential becomes more evident when UTCI values correspond **to no thermal stress or more thermally acceptable conditions**.

4. Participatory drawing exercise

The participatory drawing exercise produced 269 drawings across the three study sites during the summer and winter field campaigns. Snoberland generated the largest number (159 drawings), followed by Martyr Plaza (56) and the Square (54). This material provides an

additional perspective on how children imagine, evaluate, and emotionally relate to the outdoor environments they use. The distribution of drawings also reflects differences in site context and participation conditions. In Snoberland, although the total number of drawings was highest, participation was more difficult because many children preferred to engage directly with the park's rides and play facilities. In Martyr Plaza and the Square, children were generally more willing to stop and complete the activity, which made participation easier in these more static settings. The drawings were analysed through an interdisciplinary framework combining architectural, cognitive, and psychological perspectives:

From an *architectural perspective*, the analysis focused on children's representations of spatial configuration, OTC, and play infrastructure. From a *cognitive perspective*, the drawings were interpreted with reference to Jean Piaget's stages of cognitive development and Viktor Lowenfeld's stages of artistic development. From a *psychological perspective*, they were treated with the help of an *educational psychologist* as a projective material that helps reveal children's emotional responses, perceived needs, and spatial preferences (Ülger, 2023).

4.1. The Square

The 54 drawings collected in the Square show a clear preference for greenery, shade, open space, and familiar social elements, as illustrated in Figure 8.16. Compared with the other two sites, they place less emphasis on intense play and greater emphasis on calm, protected, and nature-oriented settings.

- From an *architectural perspective*, the drawings frequently include trees, shaded areas, houses, benches, and kiosks, suggesting a preference for a greener and more comfortable outdoor environment.
- From a *cognitive perspective*, many drawings show a simple and ordered composition, often separating the sky from the ground and arranging elements in a stable way, which is consistent with developing spatial organisation (Golomb, 2003; Lowenfeld, 1957). According to Gestalt principles of visual perception, the use of symmetry and size hierarchy further suggests an emerging sense of visual order and balance (Arnheim, 1954).

- From a *psychological perspective*, the drawings often convey security, familiarity, and emotional reassurance. Utilising Buck's (1948) House-Tree-Person (HTP) projective framework, the frequent central placement of houses may be read as reflecting a need for familial security and socio-emotional stability (Buck, 1966). This interpretation is reinforced by drawings in which children depict themselves with a parent or caregiver,

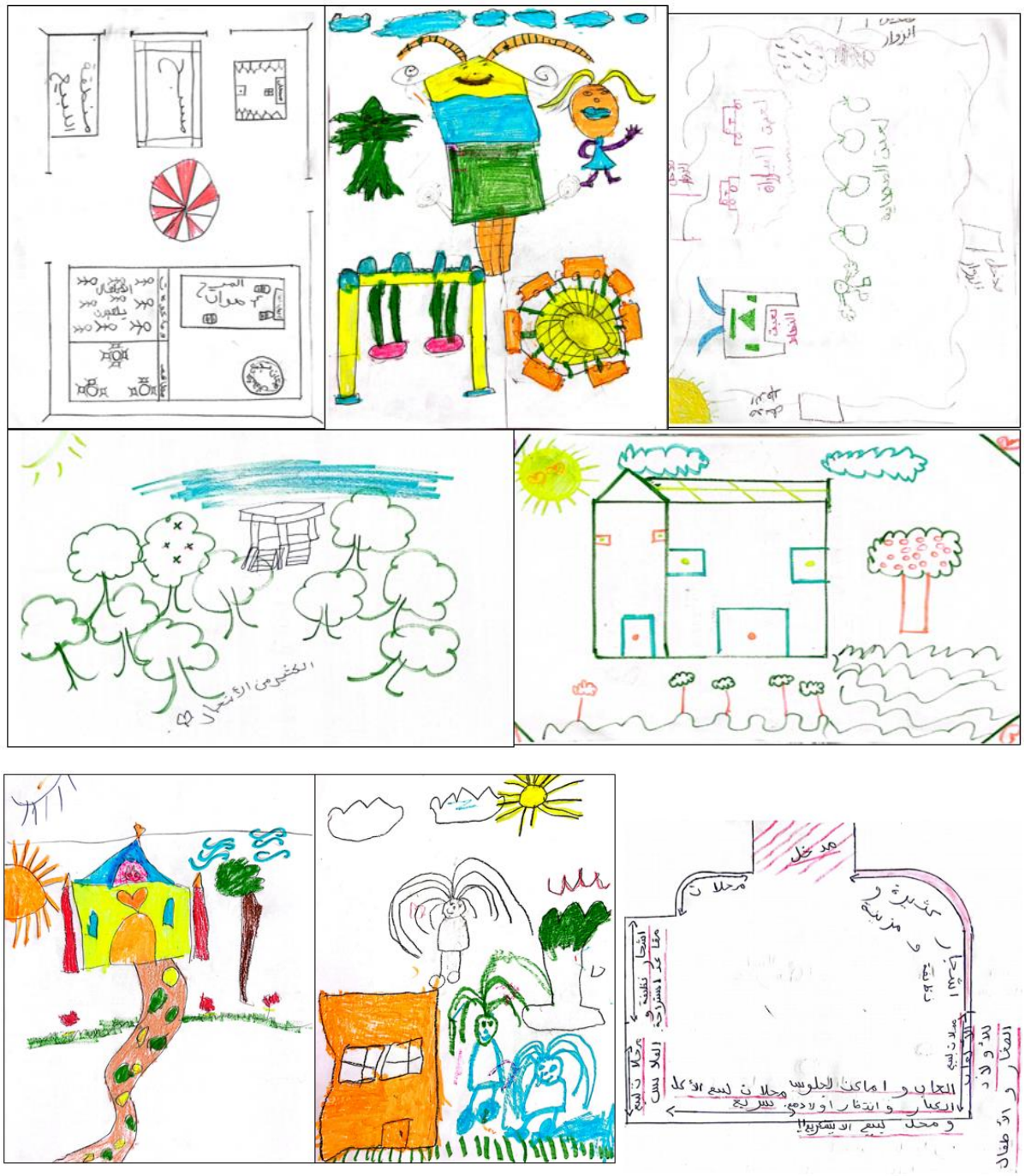


***Figure 8.* 16**: *Selected children's drawings from the Square illustrating nature-oriented and socially grounded preferences. Source: Author, 2024.*

suggesting that the Square is associated with protection and supportive social presence rather than with intense challenge or high stimulation (Koppitz, 1968).

4.2. Martyr Plaza

The 56 drawings collected from Martyr Plaza, presented in Figure 8.17, show a clear preference for active and structured outdoor settings, especially football pitches, boxing rings, pools, and waterfalls. Overall, the drawings suggest that children associate this site with movement, challenge, social interaction, and the need for cooling elements.

- From an *architectural perspective*, many drawings represent organised and functional spaces with clear boundaries, such as sports fields and enclosed pools. This suggests a preference for spaces designed for specific activities rather than undefined open areas (Burkut, 2025). Read through Kyttä's (2004) theory of affordances, these elements indicate a demand for both active play and water-based thermal relief (Kyttä, 2004).
- From a *cognitive perspective*, several children label their drawings with terms such as "football pitch" or "boxing ring," linking image and function in a direct way (Kendrick & McKay, 2004).
- From a *psychological perspective*, the drawings combine collective play, self-assertion, and emotional regulation. Team sports suggest social belonging, while boxing imagery points to controlled challenge. The contrast between warm colours in active scenes and blue tones in water scenes may also reflect a balance between stimulation and calmness (Kramer, 1971; Malchiodi, 2012).

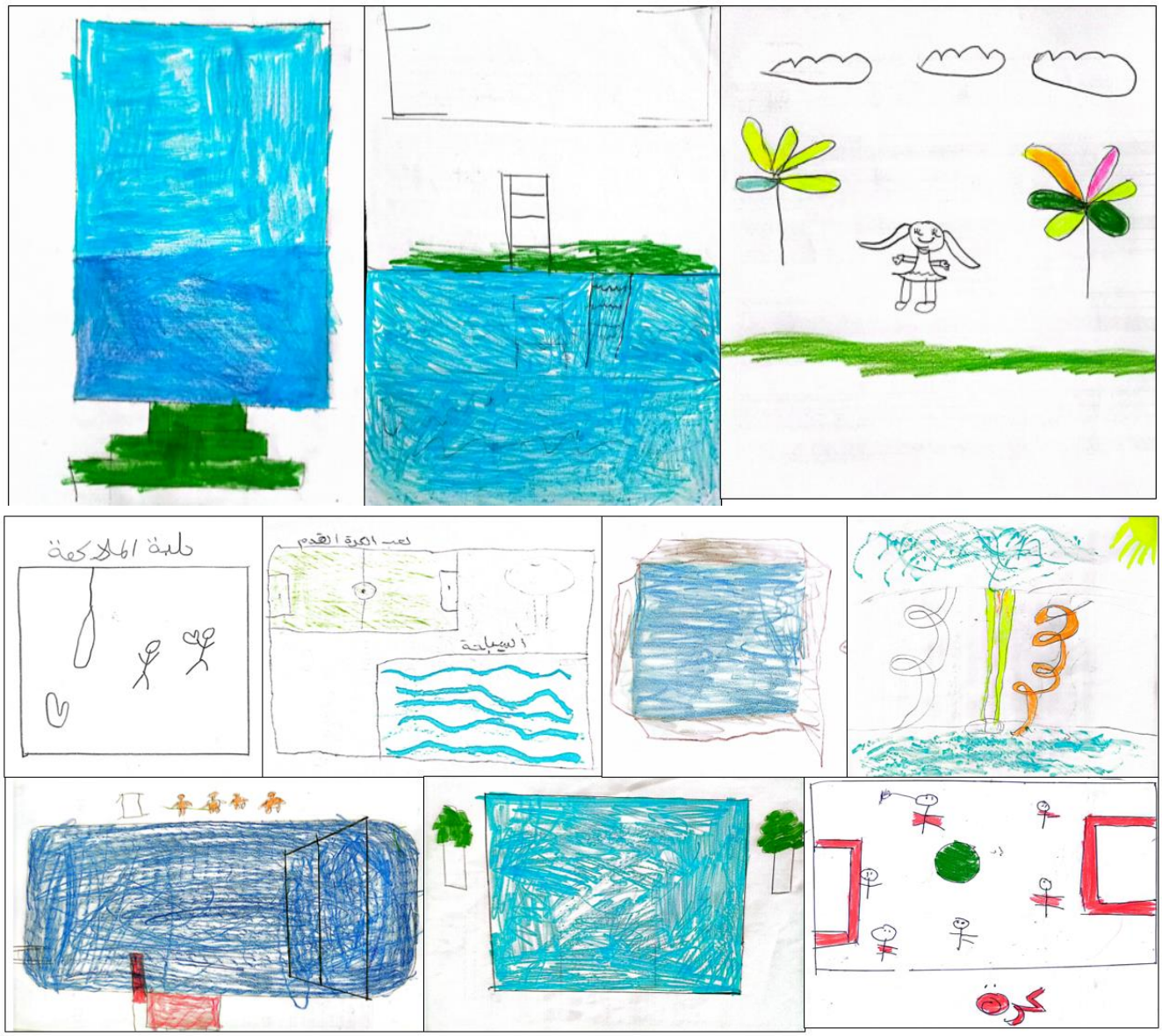


Figure 8. 17*: Selected children's drawings from Martyr Plaza illustrating preferred spatial elements. Source: Author, 2024.*

4.3 Snoberland

The 159 drawings collected in Snoberland, presented in Figure 8.18, show a clear preference for varied, stimulating, and multifunctional play environments. The most frequently represented elements include playgrounds, ferris wheels, aqua parks, pools, and gardens, suggesting that children perceive the park as a place combining excitement, recreation, and comfort.

- From an *architectural perspective*, the drawings often represent distinct functional zones, indicating a preference for an environment that combines active play with areas for rest and familiarity (Moore, 1986).

- From a *cognitive perspective*, many drawings take the form of map-like or layout compositions, with separated zones, labels, and directional organisation. This suggests a more advanced level of spatial planning, consistent with Piaget's concrete operational stage and Lowenfeld's dawning realism (Lowenfeld, 1957; Piaget, 2013a).
- From a *psychological perspective*, the drawings combine stimulation and reassurance. Dynamic lines and bright colours suggest exploratory freedom, while the repeated presence of houses or a parent-child figure indicates a parallel need for security. Read through Machover's Draw-A-Person approach, these elements suggest that caregivers remain an important emotional anchor within a highly stimulating environment (Machover, 1949).

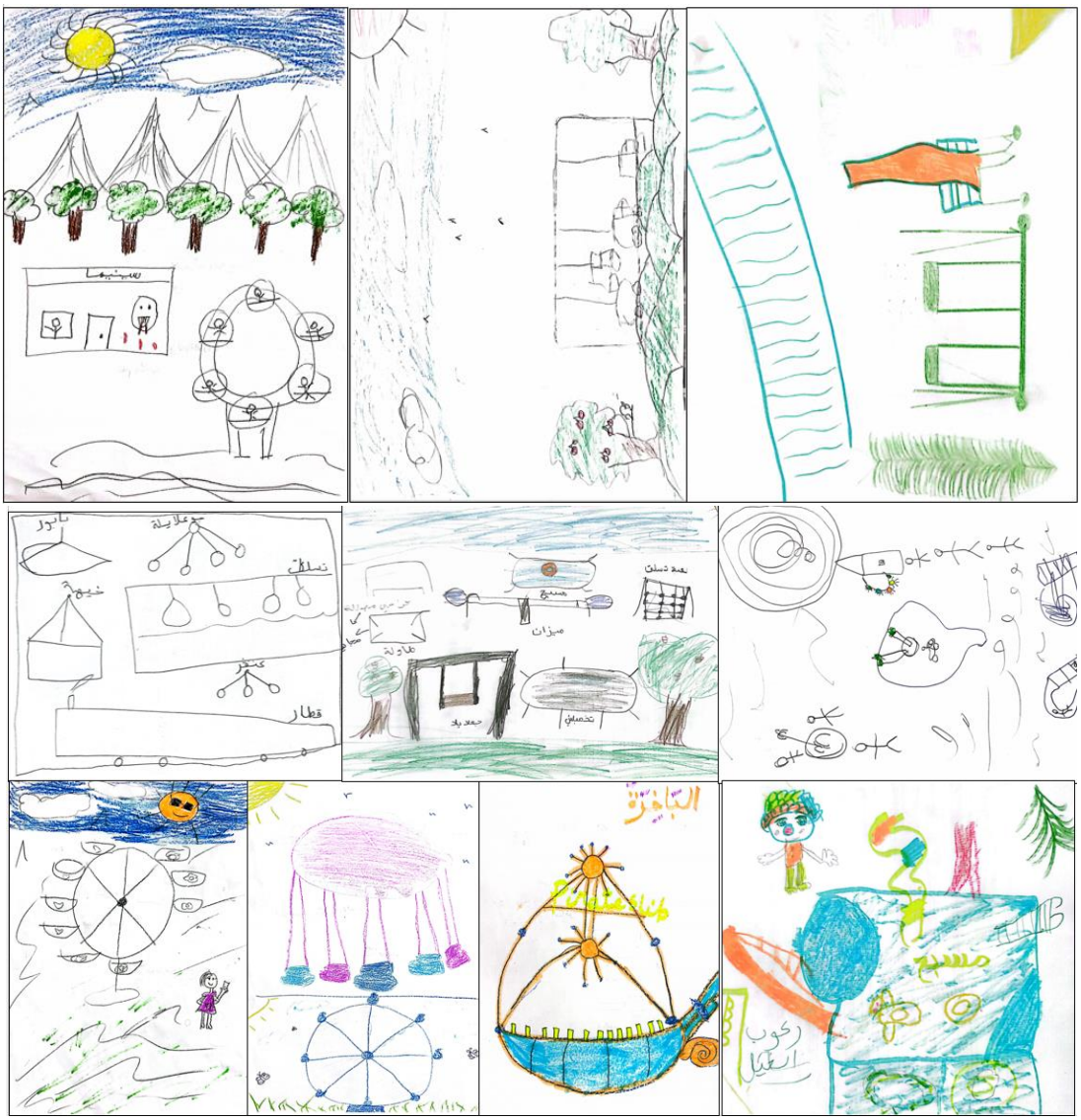


Figure 8. 18: *Selected children's drawings from Snoberland illustrating children's spatial imagination and play preferences. Source: Author, 2024.*

Discussion

The participatory drawings function as a triangulation device operating across the three analytical perspectives that structure the interpretation of this thesis, architectural, cognitive, and psychological. Where the drawings converge with the questionnaires and the behavioural maps, the finding is methodologically robust; where they diverge, the divergence itself is informative. Across the three sites, children's representations consistently combine spatial preferences with emotional, social, and thermal expectations, but each site produces a distinctive convergence-divergence pattern.

- In *the Square*, the drawings foreground nature, shade, and proximity to caregivers. The behavioural maps converge on the last point, confirming the psychological importance of supervised co-presence, but diverge on vegetation at the architectural level: children depict abundant greenery that the site does not provide. The gap is diagnostic, it identifies an unmet need rather than an existing affordance.
- In *Martyr Plaza*, the drawings emphasise structured challenge, social interaction, and water-based relief. The behavioural maps confirm the social and active dimension, but diverge sharply on cooling features: children repeatedly imagine water elements the site lacks, even though UTCI values indicate moderate-to-strong heat stress during summer afternoons. This divergence is prescriptive, children are translating a psychological experience of thermal discomfort into a cognitive, spatial-design language the questionnaires alone cannot capture.
- In *Snoberland*, the drawings reveal a preference for multifunctional, well-equipped environments combining excitement with reassurance. The behavioural maps converge on multifunctional comfort but diverge on emphasis: the drawings foreground emotional security and play diversity, while the maps foreground concentration around shaded zones. The two readings are compatible only when CUL is understood as the product of both the child's imagined ideal, a cognitive and psychological construct, and the architectural constraints under which that ideal is actually enacted.

Taken together, the drawings produce three distinct types of analytical insight across the three sites, diagnostic, prescriptive, and layered, none of which are available from the quantitative methods alone. CUL therefore depends not only on what is physically present in a site, but also on whether the space responds to children's deeper needs for play, comfort, identity, and emotional security. The drawings add an interpretive layer to the behavioural, thermal, and

spatial findings, and strengthen the basis for GUD recommendations aimed at creating outdoor spaces that are not only usable, but meaningfully desirable from the child's point of view.

5. Correlation of Spatial-Thermal indicators with Land use

To examine the relationship between land use, OTC, and spatial configuration in the three sites, this section distinguishes between *spatio-temporal factors* ("when" and "where" children use the space) and *spatial factors* ("where" they concentrate within it). This distinction is methodologically necessary because the two groups of factors do not vary in the same way. Ta and UTCI are treated here as *dynamic spatiotemporal factors*, since they vary not only over the course of the day but also between the four observation spots. By contrast, VI and TC are treated as *static spatial factors*: they differ between S1 and S4, but remain constant over time within each spot. For this reason, their relationship with children's behaviour is interpreted through *inter-spot comparison*, using the mean observed land use for each spot rather than hourly within-spot regression. Accordingly, Ta and UTCI are analysed through hourly associations, whereas VI and TC are examined through scatterplots comparing the four selected spots. Given this design, all R^2 values reported in the following subsections should be read descriptively, not inferentially: within-spot thermal regressions are based on twelve hourly observations per spot per season, and inter-spot syntax comparisons on four spots per site. P-values are reported solely as conventional reference points, and the configurational scatterplots are intended to indicate the direction and relative strength of association rather than to support statistical generalisation.

5.1. The Square

- As shown in Figure 8.19, in summer, children's presence generally tends to decline as Ta and UTCI increase. For Ta, the relationship is almost absent at S1 ($R^2 = 0.0005$, $p \geq 0.05$), weak at S2 ($R^2 = 0.1580$, $p \geq 0.05$) and S3 ($R^2 = 0.1068$, $p \geq 0.05$), but stronger and significant at S4 ($R^2 = 0.5827$, $p < 0.05$). A similar pattern appears for UTCI, with negligible or weak relationships at S1 ($R^2 = 0.0041$, $p \geq 0.05$), S2 ($R^2 = 0.1313$, $p \geq 0.05$), and S3 ($R^2 = 0.0956$, $p \geq 0.05$), but a clearer and significant association at S4 ($R^2 = 0.6126$, $p < 0.05$). This suggests that summer thermal stress is associated with reduced occupation in the Square, although the effect is not equally visible in all spots.

- In winter, Ta shows a clearer relationship with children's presence at S2 ($R^2 = 0.3773$, $p < 0.05$) and, more moderately, at S3 ($R^2 = 0.2763$, $p \geq 0.05$), whereas the relationship remains weak at S1 ($R^2 = 0.0324$, $p \geq 0.05$) and almost absent at S4 ($R^2 = 0.0029$, $p \geq 0.05$). By contrast, UTCI remains weak overall, with very low coefficients at S1 ($R^2 = 0.0214$, $p \geq 0.05$), S2 ($R^2 = 0.0360$, $p \geq 0.05$), S3 ($R^2 \approx 0.0000015$, $p \geq 0.05$), and S4 ($R^2 = 0.0464$, $p \geq 0.05$).

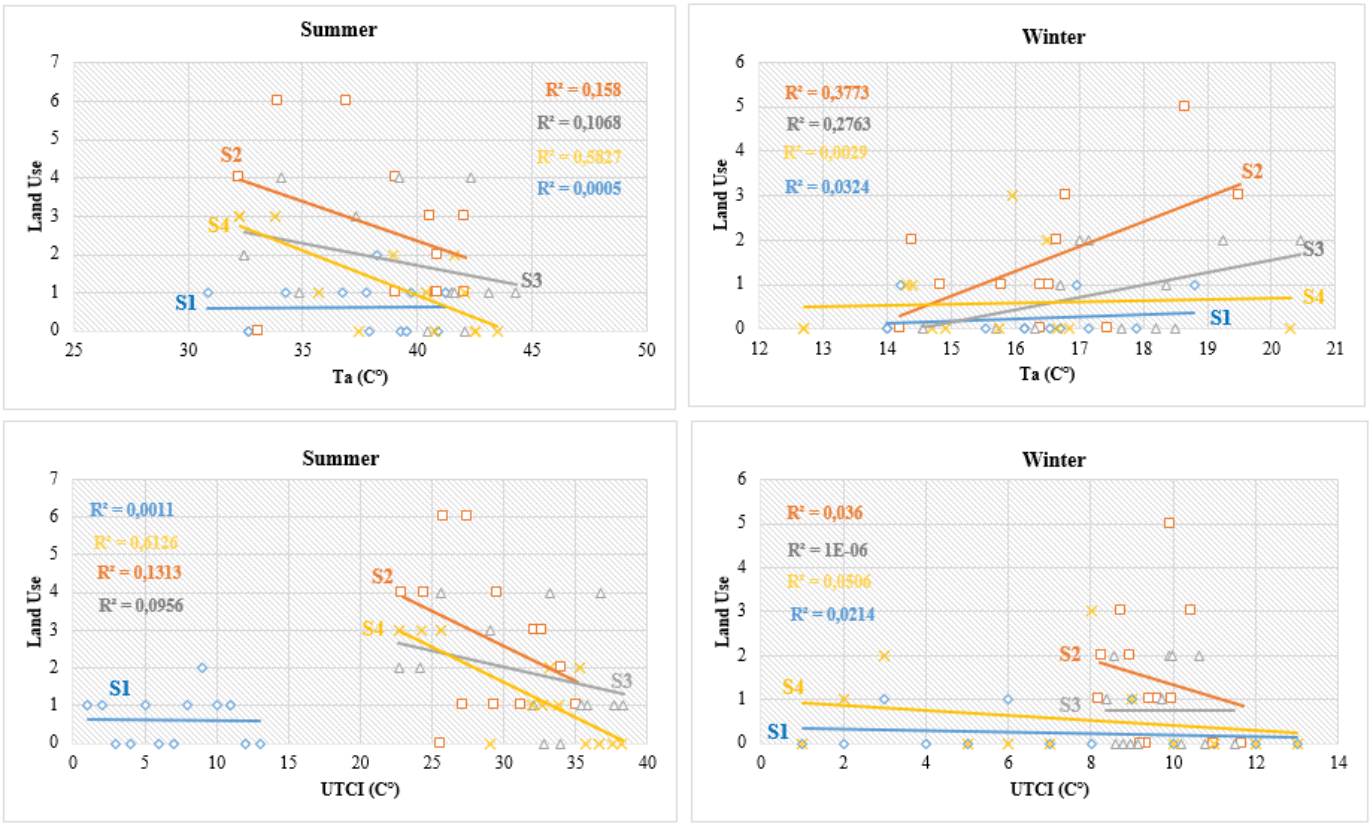


***Figure 8. 19**: Seasonal correlations of land use and OTC in the Square (S1–S4). Relationships with Ta and UTCI are shown for summer and winter. Source: Author, 2025.*

- With regard to spatial configuration, Figure 8.20 suggests that the relationship between VI and mean land use in the Square is weak in both *winter* ($R^2 \approx 0.03$) and *summer* ($R^2 \approx 0.11$). This indicates that visual integration alone explains little of the variation in children's occupation across the four selected spots. By contrast, TC shows a notably stronger descriptive association with occupation, particularly in *summer* ($R^2 \approx 0.79$) and also in *winter* ($R^2 \approx 0.67$). This suggests that, within the Square, *through-movement potential* provides a stronger explanation of children's spatial concentration than visibility alone. The results therefore indicate that children do not simply gather in the most visually integrated locations, but more often in spots that combine greater configurational accessibility with thermally and functionally supportive conditions.

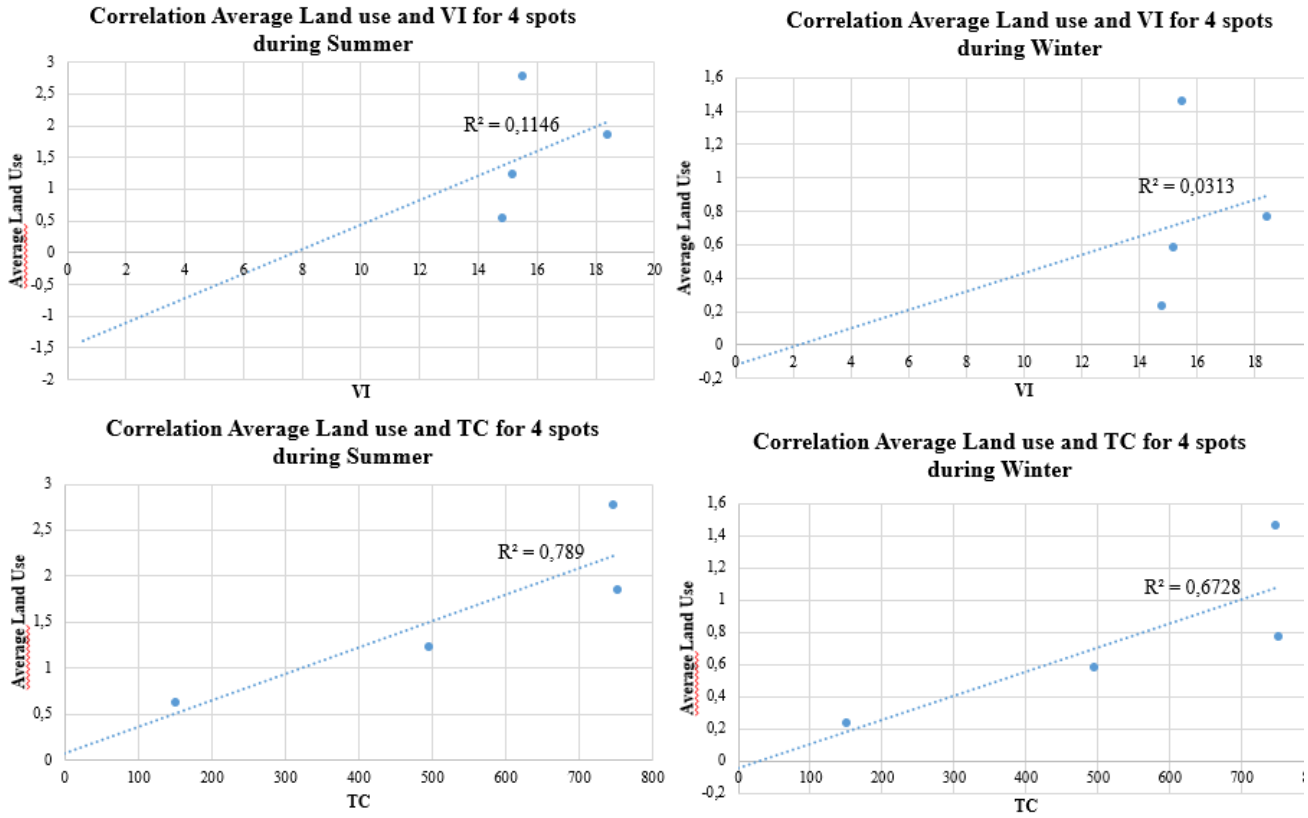


Figure 8. 20: *Correlations of mean land use and Space Syntax measures in the Square (S1–S4). Relationships with VI and TC. Source: Author, 2025.*

5.2. Snoberland

In Snoberland, the relationship between children's presence, OTC, and spatial configuration is shaped by the park's controlled access and opening hours.

As shown in Figure 8.21, in summer, children's presence in Snoberland generally tends to decline as Ta and UTCI increase. For Ta, the relationship is strong and significant at S1 (R^2 = 0.7450, $p < 0.05$) and S2 (R^2 = 0.7666, $p < 0.05$), but weak at S3 (R^2 = 0.0223, $p \geq 0.05$) and modest at S4 (R^2 = 0.2132, $p \geq 0.05$). A similar pattern appears for UTCI, with strong and significant associations at S1 (R^2 = 0.7532, $p < 0.05$) and especially S2 (R^2 = 0.8719, $p < 0.05$), whereas the relationship remains almost absent at S3 (R^2 = 0.0009, $p \geq 0.05$) and weak at S4 (R^2 = 0.1538, $p \geq 0.05$). This suggests that summer thermal stress is clearly associated with reduced occupation in the most active spots, particularly S1 and S2.

In winter, the pattern becomes more differentiated. For Ta, the relationship remains weak at S1 (R^2 = 0.0697, $p \geq 0.05$), but becomes clearer and significant at S2 (R^2 = 0.3843, $p < 0.05$), S3 (R^2 = 0.5217, $p < 0.05$), and S4 (R^2 = 0.4971, $p < 0.05$). For UTCI, the relationship is almost absent at S1 (R^2 = 0.0002, $p \geq 0.05$), weak at S2 (R^2 = 0.1068, $p \geq 0.05$) and S4 (R^2 = 0.1324, $p \geq 0.05$), but more visible and significant at S3 (R^2 = 0.4820, $p < 0.05$).

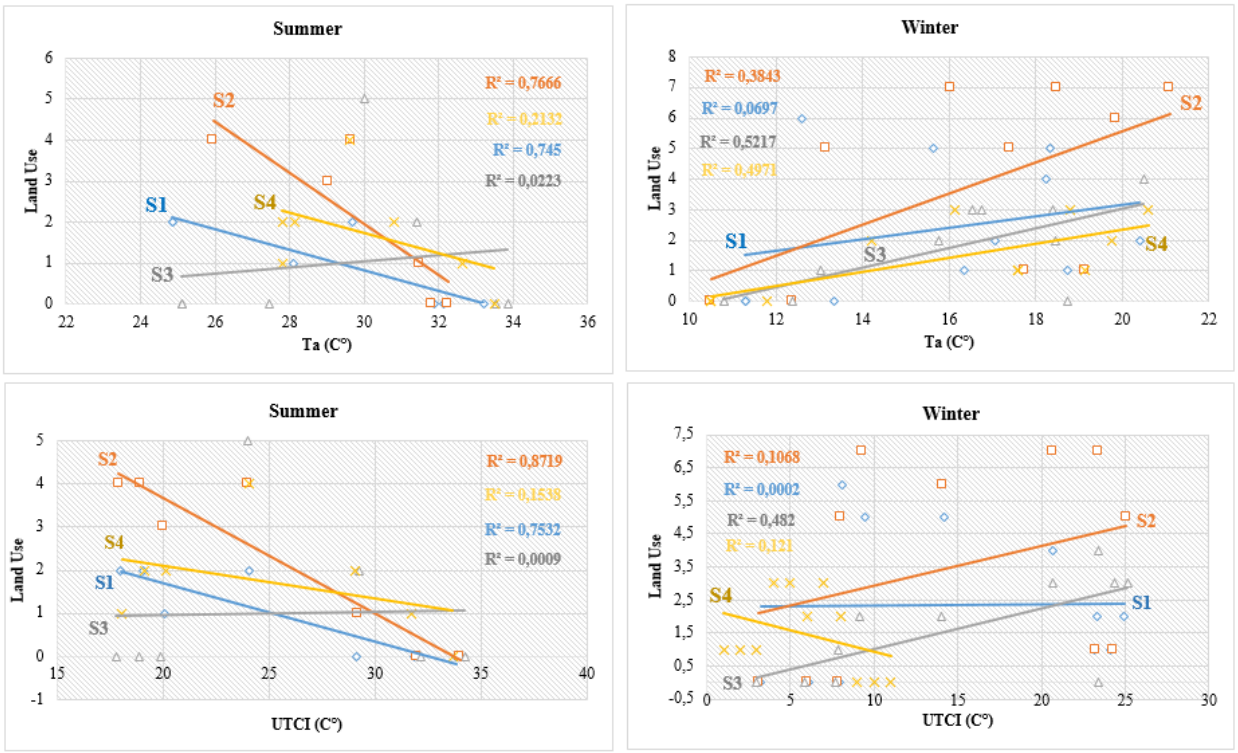


***Figure 8. 21**: Seasonal correlations of land use and OTC in Snoberland (S1–S4). Relationships with Ta and UTCI are shown for summer and winter. Source: Author, 2025.*

Concerning spatial configuration, Figure 8.22 shows a differentiated seasonal pattern in Snoberland. In *summer*, VI shows a moderate positive relationship with mean land use ($R^2 \approx$

0.66), suggesting that children tended to gather more in the visually integrated parts of the park during the restricted afternoon observation period. However, TC shows only a weaker relationship ($R^2 \approx 0.29$), indicating that concentrated movement corridors did not translate as clearly into higher occupation. In *winter*, both configurational relationships become very weak (VI: $R^2 \approx 0.02$; TC: $R^2 \approx 0.06$). This suggests that, under winter conditions, spatial syntax values alone explain little of the variation in use among the four spots. In Snoberland, the internal distribution of children's presence therefore appears to be shaped not only by configuration, but also by other park-specific factors such as vegetation, play provision, enclosure, and controlled access. The analysis thus indicates that spatial configuration plays a partial and seasonally unstable role in Snoberland, especially when compared with the stronger behavioural and environmental attractors of the site.

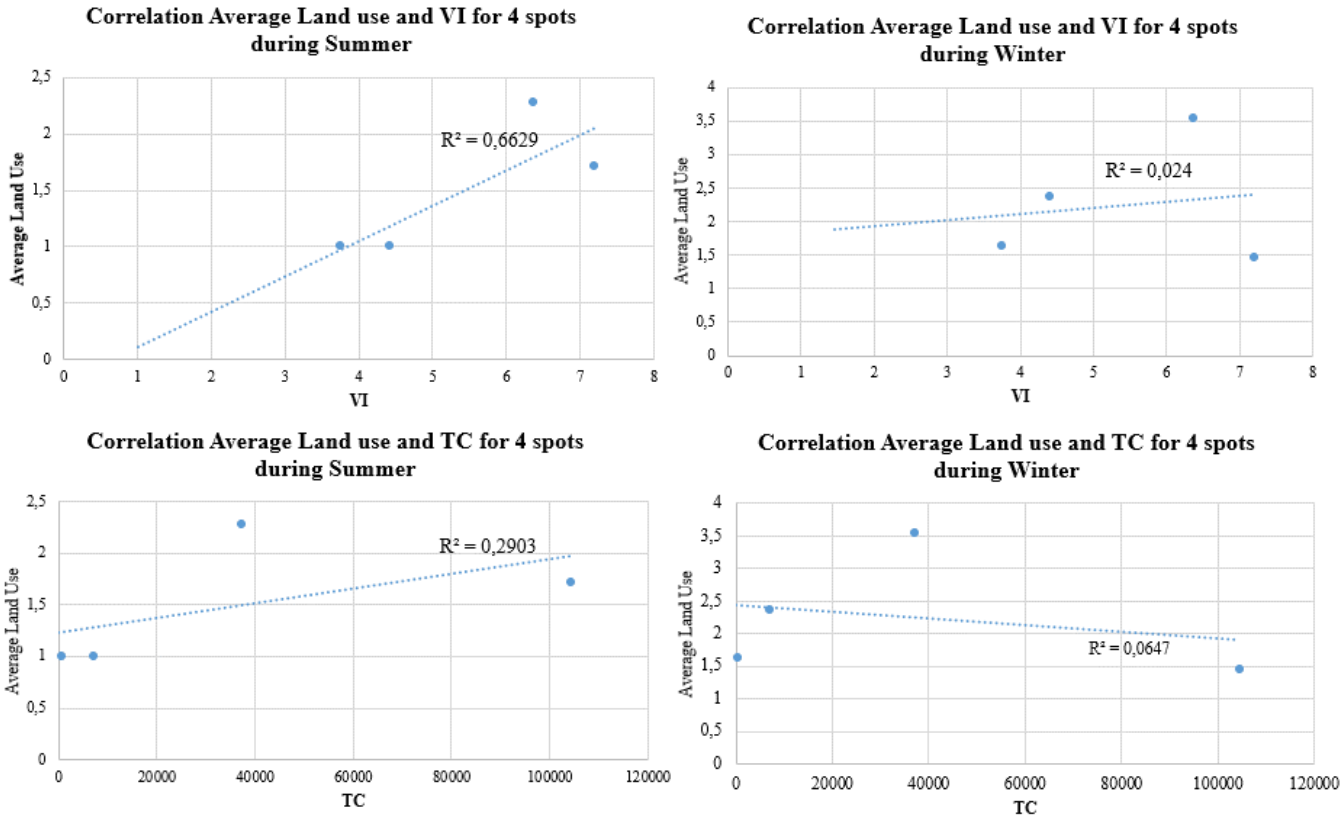


***Figure 8. 22**: Correlations of mean land use and Space Syntax measures in Snoberland (S1–S4). Relationships with VI and TC. Source: Author, 2025.*

5.3. Martyr Plaza

As shown in Figure 8.23, the relationship between children's presence and thermal conditions in Martyr Plaza remains limited and seasonally uneven. In summer, Ta shows clearer and statistically significant associations at S1 ($R^2 = 0.5103$, $p < 0.05$) and S4 ($R^2 = 0.4247$, $p < 0.05$), whereas the relationships remain weak and non-significant at S2 ($R^2 = 0.1554$, $p \geq 0.05$) and S3 ($R^2 = 0.1103$, $p \geq 0.05$). For UTCI, the associations are generally weak in summer, with S1 ($R^2 = 0.0953$, $p \geq 0.05$), S2 ($R^2 = 0.0065$, $p \geq 0.05$), S3 ($R^2 = 0.0022$, $p \geq 0.05$), and S4 ($R^2 = 0.2160$, $p \geq 0.05$), indicating limited explanatory power.

In winter, both thermal indicators remain weak overall. For Ta, the relationships are non-significant at S1 ($R^2 = 0.0089$, $p \geq 0.05$), S2 ($R^2 = 0.0916$, $p \geq 0.05$), S3 ($R^2 = 0.0270$, $p \geq 0.05$), and S4 ($R^2 = 0.0047$, $p \geq 0.05$). A similarly weak pattern appears for UTCI, with S1 ($R^2 = 0.0275$, $p \geq 0.05$), S2 ($R^2 = 0.0434$, $p \geq 0.05$), S3 ($R^2 = 0.0020$, $p \geq 0.05$), and S4 ($R^2 = 0.0065$, $p \geq 0.05$). Overall, these findings suggest that thermal influence in Martyr Plaza is comparatively limited and spatially inconsistent, especially in winter, indicating that children's occupation in this site is likely shaped more strongly by other functional and spatial characteristics than by thermal conditions alone.

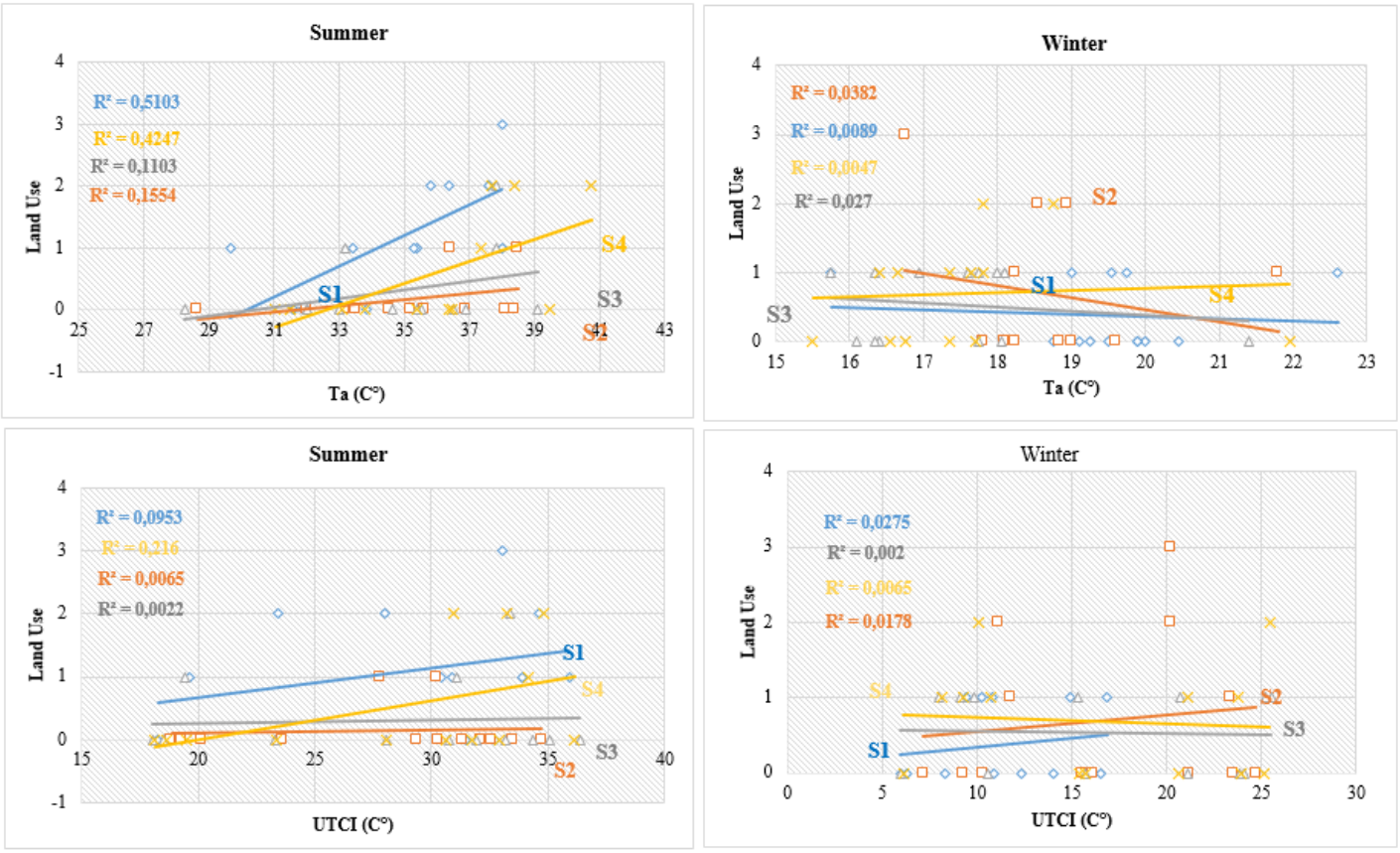


***Figure 8. 23**: Seasonal correlations of land use and OTC in Martyr Plaza (S1–S4). Relationships with Ta and UTCI are shown for summer and winter. Source: Author, 2025.*

Concerning spatial configuration, Figure 8.24 suggests a stronger configurational effect in Martyr Plaza than in the other sites, although this effect varies by season and by index. In *summer*, both VI ($R^2 \approx 0.55$) and especially TC ($R^2 \approx 0.80$) show positive relationships with mean land use, indicating that the more integrated and movement-supportive spots generally attracted more children. In *winter*, however, the relationship changes direction: VI ($R^2 \approx 0.76$) and TC ($R^2 \approx 0.88$) are associated with a negative tendency, meaning that the most frequently occupied spots were not the highest-valued syntactic ones during that season. This suggests that, in winter, children redistributed towards locations offering other advantages, such as comfort, familiarity, or activity support, rather than simply the most central or accessible zones. Martyr Plaza therefore shows that the effect of spatial configuration is not fixed, but may shift according to seasonal thermal context and the functional qualities of the space.

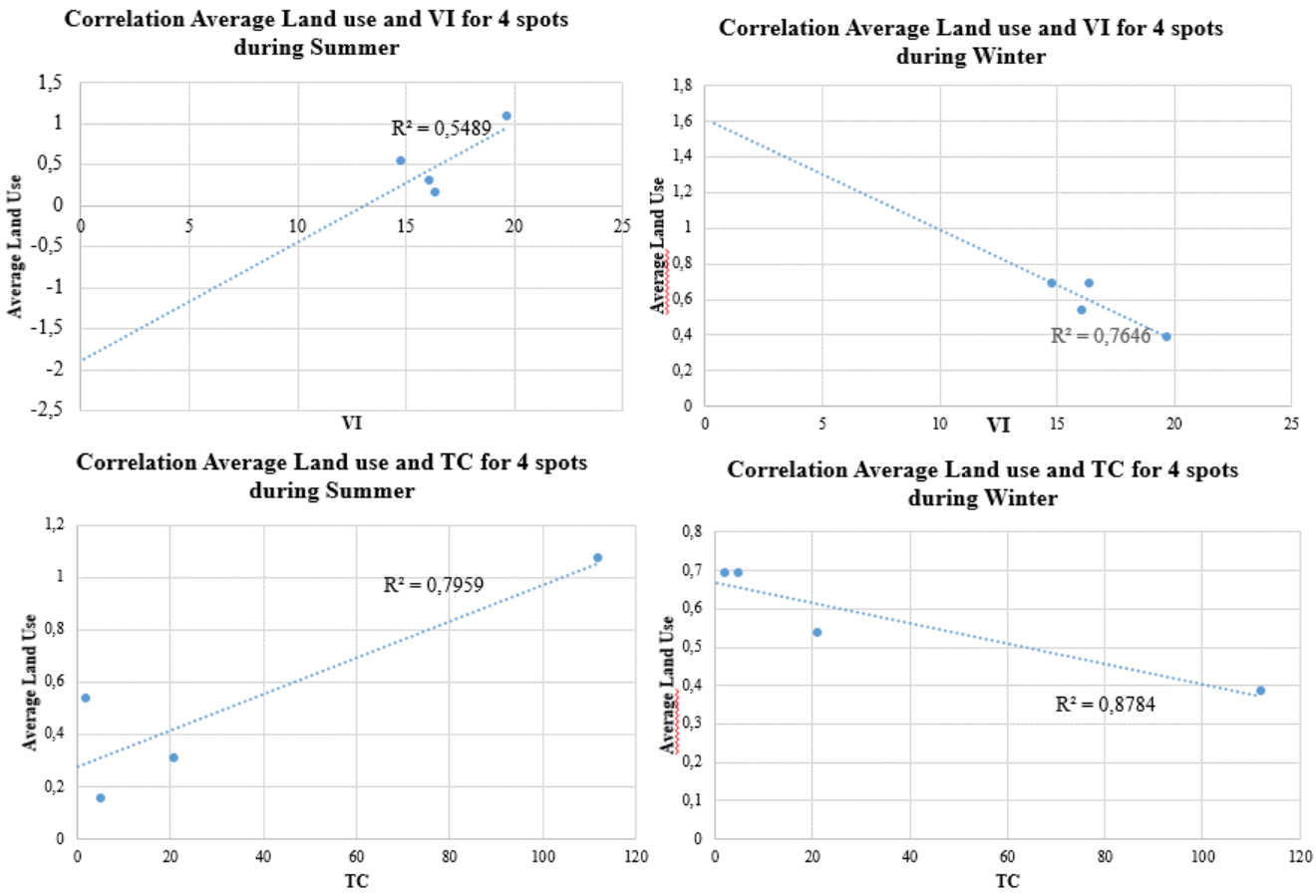


***Figure 8. 24**: Correlations of mean land use and Space Syntax measures in Martyr Plaza (S1–S4). Relationships with VI and TC. Source: Author, 2025.*

Discussion

- The findings indicate that both OTC and spatial configuration shaped CUL in the three outdoor places, although these two dimensions did not influence use in the same way. OTC was more useful for explaining *when* and *where* children used the space, since occupation varied according to seasonal and hourly thermal conditions. By contrast, spatial configuration was more relevant for explaining *where* children tended to concentrate within each site.
- Across the three sites, thermal influence was generally more evident in summer than in winter. During summer, higher thermal stress more frequently coincided with lower levels of land use, especially in the Square and in the most active parts of Snoberland. In winter, the relationships were often weaker, more uneven, and more dependent on the local characteristics of each spot. This suggests that thermal constraints become more visible when outdoor conditions are more restrictive and when children's tolerance margins are reduced.
- The Square showed the clearest contrast between thermal and configurational effects. In this site, thermal influence was more visible in summer, while in winter, *Ta* remained more informative than *UTCI*. Spatially, *TC* corresponded more clearly to children's concentration than *VI*, suggesting that through-movement potential provided a stronger explanation of children's spatial clustering than visibility alone. This indicates that, in the Square, children tended to gather in locations that were not only more accessible in configurational terms, but also more supportive in thermal and functional terms.
- Snoberland demonstrated the strongest summer thermal sensitivity, but a less stable configurational effect. The most active spots were clearly affected by thermal conditions in summer, while in winter the pattern became more differentiated. At the same time, the role of spatial configuration remained partial and seasonally unstable. This suggests that children's land use in Snoberland was shaped not only by syntactic values, but also by the site's specific environmental and functional qualities, including vegetation, play provision, enclosure, and controlled access. In this sense, configurational advantage was present, but it was mediated by the broader attractiveness and organisation of the park.

- Martyr Plaza showed the weakest thermal influence overall, but a comparatively stronger configurational effect in summer.

  Thermal relationships in this site remained limited and spatially inconsistent, especially in winter. By contrast, configurational values were more clearly associated with children's concentration in summer, which suggests that the spatial layout of the plaza played a greater role in structuring use than thermal conditions alone. However, the winter pattern also showed that children did not necessarily gather in the most syntactically favourable locations, indicating that comfort, familiarity, and functional support could redirect occupation away from the most integrated areas.
- Configurational advantage alone was not sufficient to maintain children's occupation when thermal or functional conditions became unfavourable.

  Even when a spot had favourable syntactic values, children did not necessarily remain there if thermal stress was high or if the place lacked supportive environmental and functional qualities. This is an important finding, because it shows that accessibility and integration are relevant, but not self-sufficient, conditions of CUL.
- VI and TC did not contribute equally to explaining children's concentration patterns.

  In several cases, *TC* appeared more strongly associated with children's occupation than *VI,* particularly in the Square and Martyr Plaza during summer. This suggests that movement potential may provide a more useful configurational indicator than visibility alone when analysing children's use of outdoor places. At the same time, this was not consistent across all sites, which indicates that the explanatory value of syntax measures remains context-dependent.
- *These findings reinforce the relevance of GUD as an integrated framework for enhancing CUL.* The study suggests that improving CUL cannot rely solely on better accessibility, stronger visibility, or reduced thermal stress considered in isolation. Rather, it requires an integrated design approach in which thermal moderation, spatial configuration, environmental quality, and child-supportive activity settings are addressed together. In this respect, the combined reading of OTC and spatial configuration provides a more useful basis for child-sensitive urban design than either dimension taken separately.

Conclusion

This chapter examined how spatial configuration shapes CUL in the three outdoor spaces. Drawing on questionnaires, Space Syntax analysis, behavioural maps, children's participatory drawings, and the correlation of spatial-thermal indicators with children's land use, the chapter aimed to understand where children tend to gather and how spatial configuration influences patterns of occupation within the three sites.

Overall, the findings suggest that spatial configuration helps structure the spatial distribution of children's presence, but that its effect is neither uniform nor equally stable across all sites and seasons. In several cases, more integrated, visible, and accessible areas tended to attract more children, yet this relationship was also shaped by safety, play provision, familiarity, supervision, and thermal conditions. The final correlation further showed that favourable spatial configuration alone does not automatically produce use, since unfavourable thermal or functional conditions may still reduce or redirect occupation. This interpretation is supported by the comparative results across the three sites, although the correlation analysis should be read with caution because the thermal regressions remain exploratory and the syntax scatterplots are based on only four spots per site.

The three sites reveal distinct spatial patterns of use. The Square offers open public access but combines only moderate configurational qualities with weak maintenance and limited child-centred provision, which reduces its overall attractiveness. Martyr Plaza benefits from strong configurational openness and movement potential, but its limited play provision constrains its liveability, especially for younger children. Snoberland provides the most attractive and supportive environment in terms of facilities, perceived safety, and play value, although its enclosed, supervised, and fee-paying character makes access more selective and less routine than in the other two sites. The results also show that children's outdoor use is not explained by spatial configuration alone. Questionnaire findings and children's drawings further suggest that the effect of spatial configuration depends on whether the space is experienced as safe, comfortable, and engaging.

Taken together, the results support the second hypothesis of the thesis, which states that higher VI and TC are associated with stronger clustering and movement density mainly when UTCI conditions are thermally favourable. They show that spatial configuration structures where children concentrate, while OTC regulates when these spatial potentials are effectively used. At the same time, the results indicate that configurational measures do not contribute equally,

since TC often corresponded more clearly to children's concentration than VI in some sites and seasons.

GENERAL CONCLUSION

Conclusion

For decades, rapid urbanisation and climate change have placed increasing pressure on the liveability of outdoor urban spaces. In semi-arid contexts such as El Khroub, this pressure is particularly critical for children, whose physiological vulnerability, developmental needs, and dependence on outdoor places make spatial accessibility and thermal usability central to their urban liveability. This thesis set out to investigate how spatial configuration and OTC jointly shape CUL in three outdoor places in El Khroub: the Square, Martyr Plaza, and Snoberland. More specifically, it aimed to examine how configurational properties, represented through VI and TC, interact with thermal conditions, represented mainly through UTCI and Ta, in order to influence children's movement, presence, and patterns of use. In doing so, the research sought to respond to an important gap in the literature, namely the limited number of studies that integrate spatial and thermal dimensions within a child-centred analytical framework, particularly in semi-arid North African cities.

To address this objective, the thesis adopted a hybrid methodology combining theoretical review and empirical field investigation. Across the three case studies, microclimatic measurements, UTCI-based simulation, Space Syntax analysis, behavioural mapping, questionnaires, and children's drawings were triangulated to examine both the physical characteristics of the sites and CUL.

At the theoretical level, the thesis has shown that CUL cannot be understood through adult-centred or single-variable approaches. It depends on the interaction of spatial, environmental, developmental, and social conditions. Within this framework, OTC is treated as a dynamic spatiotemporal factor explaining when and where children use outdoor space, while spatial configuration is treated as a relatively stable spatial factor explaining where they concentrate. This distinction constitutes the main conceptual contribution of the thesis, as it brings OTC and spatial configuration into a shared child-centred framework.

At the empirical level, the findings suggest that spatial configuration and OTC both matter, but not in the same way. Spatial configuration indices provide a spatial framework that helps explain where children are more likely to gather, although this effect varies according to site, season, and the specific configurational measure considered. By contrast, OTC parameters have a more direct influence on when and to what extent outdoor places are used, since thermally

unfavourable conditions can reduce or suppress occupation even in locations that are spatially well integrated or accessible. In this sense, the findings support the interpretation that spatial structure and thermal conditions operate together, with configuration shaping spatial potential and OTC mediating its practical realisation across time.

The comparison among the three case studies reinforces this interpretation. The Square was found to be highly accessible and publicly open, but weakened by degraded infrastructure, limited maintenance, and marked seasonal thermal stress. Martyr Plaza displayed strong configurational qualities in terms of visibility and movement potential, yet its limited recreational provision and exposure to harsh thermal conditions constrained its overall support for children's outdoor use. Snoberland offered the most supportive physical and microclimatic environment, with more diversified facilities and more favourable moderation of thermal stress, although its fee-paying and supervised character introduced a different form of selectivity in access and routine use. These differences show that CUL is shaped not by a single factor, but by the combined effects of accessibility, equipment, thermal conditions, and forms of access or control. The thesis also shows that children's outdoor use cannot be reduced to physical form alone. Seasonal rhythms, time of day, supervision patterns, and site function all influenced behaviour. The questionnaire results suggest that children and caregivers form two related but distinct perceptual perspectives on the same outdoor environments, since adults did not necessarily perceive thermal and spatial conditions in the same way as children. These qualitative findings strengthen the argument that child-centred evaluation of urban space must go beyond formal design qualities and account for the experiential and emotional dimensions of outdoor use.

In relation to the research questions, the main research question is addressed by showing that GUD can enhance CUL when spatial configuration and OTC are considered together. Children's liveability depends not only on visibility, accessibility, and connectivity, but also on whether thermal conditions allow these spatial potentials to be used comfortably. Regarding the first secondary question, the integrated analysis of VI, TC, UTCI, and Ta shows that VI and TC help explain where children concentrate, while UTCI and Ta help explain when their presence increases, decreases, or is redirected. Regarding the second secondary question, the seasonal comparison shows that OTC mediates the influence of spatial configuration in both summer and winter: spatial configuration provides a relatively stable framework of potential use, while thermal conditions determine when this potential becomes effective. Regarding the third secondary question, eight GUD principles are proposed (detailed in Recommendations):

climate-responsive passive design, thermal zoning, child-scale microclimatic design, configurationally informed placement of activities, material-based thermal mitigation, ventilation-oriented landscape, seasonal adaptability, and governance/maintenance/inclusive access — together translating the empirical results into climate-responsive and child-sensitive design principles for thermally comfortable and spatially accessible outdoor places.

The findings also allow the two hypotheses of the thesis to be evaluated. The first hypothesis, which states that children's occupation density and duration of stay decrease when UTCI values move away from thermally acceptable ranges, is confirmed mainly through Chapter VII. The second hypothesis, which states that higher VI and TC are associated with stronger clustering and movement density, mainly when UTCI conditions are thermally favourable, is supported mainly through Chapter VIII. Together, these findings show that spatial configuration structures where children concentrate, while OTC regulates when these spatial potentials are effectively used.

On this basis, the thesis makes four main contributions. First, it offers a conceptual contribution by linking CUL, spatial configuration, OTC, and GUD within a single analytical framework. Second, it makes a methodological contribution through the combination of environmental measurement, spatial analysis, behavioural observation, and participatory child-centred methods. Third, it provides an empirical contribution by generating evidence from a semi-arid Algerian context that remains underrepresented in the literature. Fourth, it makes a practical contribution by showing that child-friendly outdoor design in such contexts requires attention to both spatial legibility and thermal moderation.

From a planning and design perspective, the thesis indicates that improving CUL in semi-arid environments requires more than simply providing open space. Outdoor places must also be designed and managed in ways that reduce thermal stress, extend the periods of comfortable use, and provide conditions that support safe, engaging, and inclusive occupation by children. This implies the need for better integration of shading, vegetation, materials, layout, accessibility, and play opportunities within public-space design. It also suggests that climate-responsive and child-sensitive design should be treated as a core urban priority rather than as an optional enhancement.

Finally, this thesis should be read as an exploratory but grounded contribution to understanding how children use and experience outdoor urban spaces in El Khroub. It does not claim to resolve all dimensions of CUL, nor to establish a universally applicable causal model. Rather, it shows

that the interaction between spatial configuration and thermal conditions is an important and insufficiently studied dimension of child-friendly cities, and that addressing this interaction can help inform more responsive forms of GUD in semi-arid cities. In this sense, the research provides a basis for future studies that may extend the framework to other climatic contexts, larger samples, additional sensory variables, and longer observation periods.

Recommendations

In accordance with the objectives and conceptual framework of this thesis, the recommendations are formulated through the principles of GUD. In this research, GUD is not treated as a general environmental ambition, but as the principal design and planning framework through which OTC and spatial configuration can be improved to enhance CUL in semi-arid urban contexts. At the same time, the empirical findings of this study show that these principles cannot be applied in a uniform manner. Their implementation must remain sensitive to the distinct spatial, thermal, and functional conditions observed in the three investigated outdoor places.

1. GUD-based recommendations for enhancing CUL

1.1. Climate-responsive passive design

The first recommendation is to treat GUD as a framework for organising outdoor space in relation to children's bodily, perceptual, and behavioural needs. In semi-arid urban contexts, design should not be limited to aesthetic greening or the simple addition of shaded devices. Rather, outdoor places should be conceived as *adaptive environmental systems* in which the arrangement of vegetation, built form, surfaces, circulation paths, and activity nodes collectively shapes children's comfort, safety, and willingness to remain in space. Such a perspective is consistent with the findings of this thesis, which show that thermal conditions strongly affect children's presence and duration of stay, while spatial configuration helps explain where they tend to concentrate within the same site.

1.2. Thermal zoning rather than uniform shading

A second recommendation is to replace the logic of uniform thermal treatment with a strategy of *thermal zoning*. Instead of assuming that all parts of an outdoor place require the same environmental response, GUD interventions should differentiate between zones of active play, passage, pause, supervision, and seasonal occupation. In practical terms, this means creating a gradient of thermal conditions: cooler and more protected zones for summer stay and social

interaction, semi-shaded transition zones for circulation, and selectively sun-exposed areas that remain attractive during cooler periods. In this way, the design of outdoor space becomes seasonally responsive rather than climatically one-dimensional. The contribution of this recommendation lies not in proposing shade as a generic solution, but in organising environmental comfort according to children's actual patterns of use and temporal occupation.

1.3. Child-scale microclimatic design

A third recommendation is that GUD should be applied at the child's scale, not only at the general urban scale. Since this study evaluates children's thermal exposure and spatial behaviour directly, it suggests that design decisions should respond to the environmental conditions children actually experience in their *height range, movement zones, play areas, and resting spaces*. Child-friendly microclimatic design**,** therefore**,** requires more than overhead protection. It also involves the careful positioning of vegetation, the moderation of radiant heat from surrounding surfaces, the design of resting edges for caregivers, and the creation of spaces where children can alternate between exposed and protected conditions according to their activities and thermal perceptions. This approach strengthens the child-centred contribution of GUD and distinguishes it from standard environmental design aimed primarily at adult users**.**

1.4. Configurationally informed placement of activities

A fourth recommendation is that GUD interventions should be spatially strategic. The findings of this thesis suggest that the effectiveness of child-friendly design depends not only on what is introduced into space, but also on where it is placed in relation to visibility, accessibility, and movement potential. Child-oriented functions should therefore be distributed according to the interaction between OTC and spatial configuration. Active play areas should be located where configurational advantages coincide with thermally tolerable conditions. Caregiver seating should be positioned in places that allow surveillance without reducing children's autonomy. Resting and gathering points should be placed where thermal relief and visual accessibility reinforce one another. In this sense, GUD should be understood as a framework for the spatial organisation of comfort, not merely for environmental enrichment. This is one of the principal ways in which the present thesis contributes beyond standard recommendations**,** such as adding trees or pergolas**.**

1.5. Material-based thermal mitigation and child-sensitive ground design

A fifth recommendation is to give greater importance to the thermal and tactile performance of urban surfaces. Outdoor places designed for children should not rely exclusively on overhead

cooling strategies, since the ground plane itself strongly shapes comfort, movement, and play. GUD principles should therefore include the use of low-heat-retention, safe, durable, and child-sensitive materials capable of reducing heat storage, improving walkability, and limiting discomfort or injury. Surface design should support a diversity of child activities while also responding to climatic realities. This means avoiding large expanses of exposed heat-radiating mineral paving in zones of prolonged stay, while promoting mixed surface systems that combine environmental performance with functional suitability. Such an approach expands GUD from greening alone to a more comprehensive rethinking of the thermal behaviour of the urban ground.

1.6. Ventilation-oriented landscape and spatial design

A sixth recommendation is that GUD interventions should preserve and enhance air movement rather than relying only on shading devices. In semi-arid conditions, ventilation can play a key role in increasing outdoor comfort when integrated properly with spatial design and vegetation. Accordingly, GUD should avoid creating visually green but climatically stagnant spaces. Instead, planting schemes, built edges, and spatial layouts should be arranged to maintain or guide beneficial air movement through children's activity zones. Vegetation density, enclosure, and the placement of structures should therefore be calibrated so that cooling is achieved through a combination of shade, evapotranspiration, and airflow. This recommendation reflects a more advanced understanding of thermal design and reinforces the argument that liveable child-oriented spaces depend on the coordination of multiple environmental factors rather than on single devices.

1.7. Seasonal adaptability and flexible occupation

A seventh recommendation is to design outdoor places as seasonally adaptive environments rather than fixed-use spaces. The findings of this thesis show that the same place may become attractive or underused depending on the time of day, season, and prevailing thermal conditions. GUD should therefore support flexible occupation by allowing children to shift between protected, open, shaded, and sunlit zones. The design of public spaces in El Khroub should not seek a single neutral condition, but rather provide a spectrum of environmental possibilities that respond to seasonal variability. This perspective is particularly important in semi-arid contexts, where summer overheating and winter exposure require different yet spatially integrated responses. By emphasising adaptability rather than uniformity, this recommendation strengthens the long-term usefulness of child-oriented urban spaces.

1.8. Governance, maintenance, and inclusive access as components of GUD

Finally, the results of this study indicate that GUD should not be reduced to physical design alone. The effectiveness of child-friendly outdoor spaces also depends on maintenance routines, social inclusiveness, and governance capacity. Degraded paving, poorly maintained planting, intrusive uses, and selective access can all undermine the environmental and spatial qualities of a site, even when its physical design is relatively strong. For this reason, GUD should incorporate regular repair, vegetation management, cleanliness protocols, control of conflicting uses, and inclusive policies that treat children as legitimate everyday users of public space. Participatory processes that consider the views of children and caregivers should also be encouraged, since they help align environmental design with lived experience. This confirms that GUD is both a design framework and a mode of urban management.

2. Site-specific application of GUD principles

The empirical findings further suggest that the application of GUD should differ according to the diagnosed condition of each site.

2.1. The Square

For the Square, GUD should operate primarily as a strategy of *recovery and requalification*. The site requires the restoration of basic public-space quality before more advanced child-oriented enhancement can be fully effective. Here, the priority is not simply to add isolated green elements, but to reorganise the site through safer and thermally moderated ground conditions, stronger pedestrian protection, child-supportive microclimatic pockets, and the rehabilitation of its visual and functional quality. The Square, therefore, calls for a form of GUD that combines environmental improvement with spatial repair and the reassertion of child-compatible everyday use.

2.2. Martyr Plaza

For Martyr Plaza, GUD should function as a strategy of *thermal enrichment and functional activation*. Since the plaza already benefits from openness and strong movement potential, the main task is to convert these configurational advantages into conditions that better support children’s occupation. This requires targeted thermal zoning, greater environmental diversity, and the introduction of child-oriented functions in zones where movement, visibility, and comfort can reinforce one another. In this case, GUD should not radically transform the open

character of the plaza, but rather increase its capacity to support lingering, gathering, and child-friendly use under more thermally favourable conditions.

2.3. Snoberland

Snoberland presents the strongest combination of environmental quality, play provision, and thermal support among the three case studies. However, this advantage must be interpreted critically, since it is associated with an enclosed, supervised, and fee-paying site structure that restricts routine and equitable access. The site, therefore, cannot be advanced as a straightforward model of public child-friendly urban design. Rather, it reveals a tension that is central to GUD itself: environmental and recreational quality may be high, yet inclusiveness may remain limited when access is socially selective. The contribution of Snoberland to this thesis is thus diagnostic rather than normative. It makes it possible to identify design qualities that could be translated into more inclusive public-space practice, such as vegetation, diversified play opportunities, and thermal moderation, while also underscoring the necessity of equitable access as a condition of genuine CUL.

Final synthesis

Taken together, these recommendations show that the contribution of this thesis does not lie in proposing universally familiar devices such as shade or pergolas in isolation. Rather, its contribution lies in demonstrating how GUD can be operationalised as a child-centred, evidence-based, and site-specific framework linking OTC, spatial configuration, and observed patterns of occupation. The originality of the proposed approach is therefore not object-based, but relational and strategic: it identifies *which type of intervention is needed, where it should be located, under what thermal and spatial conditions it should be applied, and how it can better support CUL in semi-arid urban public spaces.*

Strengths and Originality

The thesis advances two original contributions:

- First, at the **international level**, it proposes, operationalises, and empirically tests an integrated framework in which spatial configuration is treated as a relatively static spatial factor and OTC as a dynamic spatiotemporal factor that gates the activation of configurational potential for children's outdoor occupation. The existing literature has handled these two dimensions separately. Child-specific studies focus on OTC alone. Studies that combine Space Syntax with OTC remain confined to general adult or

campus populations. Previous studies confirms this fragmentation at regional level, identifying the underrepresentation of behavioural and cultural adaptation, and the dominance of micro-scale, single-variable analyses, as two of five persistent shortcomings in OTC research across the Middle East and North Africa. The framework developed in this thesis addresses both gaps by bringing children, spatial configuration, and OTC together in a unified analytical and empirical structure.

- Second, at the **national level**, the thesis offers the first outdoor child-specific OTC study conducted in Algeria. Algerian OTC research has examined hot-arid and Mediterranean adult contexts, and the only prior study to address children's thermal conditions in Algeria examined indoor school environments for autistic children. The present thesis therefore inaugurates outdoor, child-specific OTC research within the Algerian context, and links it for the first time to spatial configuration analysis through a hybrid behavioural protocol. It also extends configurational scholarship on Algerian outdoor space, which has so far concentrated on adult movement and historical morphology, into child-sensitive territory.

Limitations and Constraints

While the methodological framework developed for this study provides a robust approach to evaluating CUL, it is necessary to acknowledge several inherent limitations that contextualise the interpretation of the findings and delineate avenues for future research.

- Firstly, although the data collection campaign deliberately encompassed two distinct seasonal periods (summer and winter) to capture critical climatic variations, it ultimately represents a temporal snapshot. This cross-sectional approach may not fully account for longer-term behavioural adaptations, transitional seasonal patterns (such as spring and autumn), or the impacts of extreme, anomalous weather events driven by climate change.
- Secondly, the geographical scope of the empirical investigation is confined to three specific outdoor places within the semi-arid context of El Khroub. While these sites were rigorously selected to ensure representative spatial and microclimatic diversity within the local urban fabric, this focus inherently limits the broader spatial generalisability of the findings. Replicating this integrated methodology across diverse climatic zones and distinct socio-cultural contexts would significantly enhance the overarching understanding of spatial-thermal interactions.

- Thirdly, the demographic parameters of the study are strictly focused on children aged 6 to 12. While this explicitly addresses a major gap in urban liveability research, it inherently excludes other vulnerable populations, such as the elderly, toddlers, or individuals with reduced mobility, who possess distinct thermal sensitivities and spatial needs. Expanding the methodological framework to encompass intergenerational perspectives remains a vital objective for comprehensive urban design assessments.
- Fourthly, although the combination of Space Syntax and systematic behavioural mapping provided valuable spatial insights, the static nature of syntactic models cannot fully capture the dynamic adaptive strategies children may use in response to thermal stress, such as shifting routes, changing activity duration, or relocating to more comfortable micro-spaces. In addition, the present study focused primarily on thermal conditions and selected spatial configuration indices, without fully integrating other environmental and social dimensions, such as visual comfort, acoustic comfort, air quality, and lighting quality. Future research could therefore strengthen the framework by incorporating longitudinal spatial tracking, wearable environmental sensors, dynamic agent-based modelling, and broader multisensory indicators.
- Fifthly, the questionnaire and drawing-based components were based on children and caregivers who were present during the fieldwork periods. This presence-based sampling was appropriate for capturing real users of the selected outdoor places, but it does not represent all children living in El Khroub. Children who rarely use these spaces, or who are prevented from using them because of parental restrictions, distance, disability, safety concerns or socio-economic constraints, may therefore be underrepresented. Future studies could complement on-site surveys with school-based or household-based surveys in order to include both users and non-users of outdoor places.

Research insights and perspectives

The findings obtained in this research provide critical insights into the socio-spatial and climatic barriers affecting children in the Algerian context. This work establishes a framework for urban designers and policymakers to address the marginalisation of children in the public realm. To build upon this foundation, further research may address the following perspectives:

- Demonstrate the international transferability of the spatial–thermal framework by extending its application across radically different climatic, morphological, and cultural

contexts, building on the supplementary Seoul case (see Appendix D. p A-4) as a precedent for cross-climatic replication and contributing to a globally comparable evidence base on child-responsive GUD.

- Expand the integrated spatial-thermal methodology to different climatic zones across Algeria, including coastal Mediterranean cities and hyper-arid Saharan regions, to test the adaptability of the proposed GUD strategies.
- Incorporate longitudinal digital tracking methodologies, such as GPS mapping and wearable thermal sensors, to capture continuous, real-time data on children's independent mobility and physiological responses.
- Investigate the combined effects of spatial configuration, thermal comfort, and acoustic comfort on children's cognitive development and play behaviours.
- Apply the developed analytical framework to educational environments, specifically evaluating how the spatial and thermal configuration of schoolyards impacts children's well-being and academic performance.
- Explore the thermal performance of various innovative, locally sourced ecological materials and their specific impact on reducing the Tmrt at a child's physical height.

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APPENDICES

Appendix A: Questionnaires for Outdoor Places

Children's Questionnaire for Outdoor Places

Purpose: This questionnaire aims to evaluate children's urban liveability in outdoor places. All responses are used for scientific purposes only, while preserving participants' privacy.

Site	_____	**Date**	_____
Child's first name	_____	**Time**	_____
Child's family name	_____	**Gender**	☐ Female ☐ Male
Age	_____	**School level**	_____

Section 1. Use and Preferences

Question	Response
Do you live near this site?	☐ Yes ☐ No
How often do you visit this site?	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely
Who accompanies you to this place?	_____
What do you like to do in the place?	_____ _____ _____
What attracts you to this place?	☐ Location ☐ Weather ☐ Safety ☐ Play equipment ☐ Layout / planning

Section 2. Perceptions of Outdoor Thermal Comfort

Question	Response
How do you feel right now?	☐ Hot ☐ Cold ☐ Neutral
Where is your favourite area in this place?	_____ _____
Why is it your favourite place?	_____ _____ _____ _____
What do you usually wear when you come to this place?	☐ Light clothing (T-shirt, shorts) ☐ Medium clothing (long sleeves, trousers) ☐ Heavy clothing (jacket) ☐ Accessories (hat, sunglasses)

Section 3. Safety and Play

Question	Response
How do you feel when you play in the place?	_____ _____
What is your favourite game or activity in the place?	_____ _____
Do you feel afraid or in danger in the place?	☐ Yes ☐ No
Have you ever been bothered or exposed to danger in this place?	_____ _____ _____ _____

Section 4. Spatial Configuration

Question	Response
How easy is it for you to reach your favourite places in the place?	☐ Very easy ☐ Easy ☐ Neutral ☐ Difficult ☐ Very difficult
Is it easy for you to move around in the place?	☐ Yes, very easy ☐ Yes, but sometimes difficult ☐ No, it is difficult
Can you see your friends easily when you play in the place?	☐ Yes, always ☐ Yes, most of the time ☐ Sometimes ☐ No, rarely
Are there any places where you feel hidden or out of sight? If yes, please say where.	☐ Yes ☐ No _____

Section 5. General Satisfaction and Suggestions

Can you draw your dream place on the next page?
_____ _____ _____ _____

Parents' / Caregivers' Questionnaire

Dear Sir / Madam, this questionnaire has been designed to investigate children's experience in outdoor places. All responses will be used for scientific purposes only, with full respect for participants' privacy.

Respondent Information

Child's surname	.....	**Child's first name**	.....
Site	.....	**Date**	.....
Time	.....	**Gender**	□ Female □ Male
Age	.....	**School level**	.....

Section 1. Use and Preferences

1. Do you live near this place?

□ Yes

□ No

2. What is the main reason that brings you here with your child?

_____

_____

_____

_____

3. How often do you visit the place with your children?

□ Daily

□ Weekly

□ Monthly

□ Rarely

4. At what time of day do you usually come with your children?

□ Morning

□ Afternoon

□ Evening

□ Night

5. Which activities do your children enjoy most in the place?

_____

_____

_____

_____

Section 2. Perceptions of Outdoor Thermal Comfort

6. How comfortable is the temperature in the place?

□ Very comfortable

□ Comfortable

□ Neutral

□ Uncomfortable

□ Very uncomfortable

7. How does the weather affect your decision to bring your child to the place?

□ Not at all

□ Slightly

□ Moderately

□ Greatly

□ Severely

8. How do you usually dress your child when visiting this place?

□ Light clothing (e.g., T-shirts, shorts)

□ Medium clothing (e.g., long sleeves, trousers)

□ Heavy clothing (e.g., jackets)

□ Accessories (e.g., hats, sunglasses)

9. Are there enough shaded areas in the place?

□ Yes

□ No

10. If no, please specify which areas need more shade.

_____

_____

_____

_____

Section 3. Safety and Accessibility

11. Do you feel safe allowing your child to visit this place alone?

□ Yes, definitely

□ Yes, but under certain conditions (please specify below)

□ No, not at all (please specify the reason below)

_____

_____

_____

_____

12. Do you have any safety concerns about the place?

□ Yes

□ No

13. If yes, please specify the reason.

_____

_____

_____

_____

14. Can you see your child easily while they are playing in the place?

□ Yes, always

□ Yes, most of the time

□ Sometimes

□ No, rarely

Section 4. Overall Satisfaction and Suggestions

15. How satisfied are you with the overall design and facilities of the place?

□ Very satisfied

□ Satisfied

□ Neutral

□ Dissatisfied

□ Very dissatisfied

16. What improvements would you like to see in the place to enhance your child's experience?

_____

_____

_____

_____

_____

_____

Thank you for your participation.

Appendix B: Visual Sequences of the Observation Spots (S1–S4) per Site and Season

Visual sequences document the photographed conditions at each observation spot across morning, afternoon, and evening time periods, for both summer and winter investigation campaigns.

Site: The Square | Season: Summer | Date: [20/07/2024]

Morning	Afternoon	Evening
S1 	S1 	S1 
S2 	S2 	S2 
S3 	S3 	S3 
S4 	S4 	S4 

Site: The Square | Season: Winter | Date: [22/12/2024]



Site: Martyr Plaza | Season: Summer | Date: [24/07/2024]

Morning	Afternoon	Evening
S1 	S1 	S1 
S2 	S2 	S2 
S3 	S3 	S3 
S4 	S4 	S4 

Site: Martyr Plaza | Season: Winter | Date: [26/12/2024]

Morning	Afternoon	Evening
S1 	S1 	S1 
S2 	S2 	S2 
S3 	S3 	S3 
S4 	S4 	S4 

Site: Snoberland | Season: Summer | Date: [23/07/2024]

Afternoon	Evening
S1	**S1**
	
S2	**S2**
	
S3	**S3**
	
S4	**S4**
	

Site: Snoberland | Season: Winter | Date: [30/12/2024]

Morning	Afternoon	Evening
S1 	S1 	S1 
S2 	S2 	S2 
S3 	S3 	S3 
S4 	S4 	S4 

Appendix C: Microclimatic measurements recorded at the three study sites

SNOBERLAND DAY 1: SUMMER (Day 1: July 22, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
3 – 4 pm	31.4	32.8	33.8	33.4	40.1	37.3	36.6	37.2	0.4	0.4	0.6	1.7
4 – 5 pm	32.7	32.2	33.9	32.7	37.9	37.8	37.4	39	0.0	1.0	0.2	2.4
5 - 6 pm	31.9	31.0	31.1	29.9	39.1	41.4	40.0	42.2	0.0	3.0	1.0	0.8
6 – 7 pm	30.4	30.3	30.5	30.3	43.1	44.7	43.4	45.2	0.4	0.0	0.4	1.4
7 - 8 pm	29.2	30.3	27.5	27	50.1	48.6	54.3	50.1	0.4	1.7	1.2	1.0
8 - 9 pm	24.2	24.8	24.3	27.5	63.4	60.3	62.5	54.0	1.3	0.3	0.5	0.3

SNOBERLAND DAY 2: SUMMER (Day 2: July 23, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
3 – 4 pm	32.9	30.8	33.3	33.6	38.8	42.5	39.2	39.2	0.8	0.3	0.9	0.0
4 – 5 pm	33.7	32.3	33.8	32.6	38.5	39.1	38.5	40.0	0.4	0.5	0.8	1.0
5 - 6 pm	31.9	32.0	31.7	31.7	43.1	42.1	42.2	44.4	0.3	0.0	1.7	1.2
6 – 7 pm	29.0	29.0	29.5	28.9	44.5	44.8	44.8	45.1	0.1	0.3	0.0	0.5
7 - 8 pm	27.0	27.8	27.4	29.3	50.1	47.2	48.1	44.7	0.0	0.1	1.3	0.5
8 - 9 pm	25.5	27.1	25.9	28.1	50.4	46.1	49.5	45.4	0.3	0.1	0.0	0.0

SNOBERLAND DAY 1: WINTER (Day 1: December 30, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
11 – 12 am	19.7	20.1	19.8	19.7	46.8	44.0	48.4	42.8	0.0	0.1	0.0	0.1
12 – 1 pm	16.8	17.9	16.8	17.6	51.0	47.3	49.2	47.9	0.0	0.0	0.0	0.0
1 - 2 pm	16.3	16.5	16.6	17.2	51.6	50.8	50.9	49.7	0.1	0.0	0.0	0.0
2 – 3 pm	22.7	22.4	22.4	21.9	40.0	40.8	38.2	40.3	0.0	0.0	0.4	0.0
3 – 4 pm	18.2	18.8	18.6	19.1	44.5	46.7	45.6	47.1	0.0	0.0	0.0	0.0
4 – 5 pm	18.6	20.4	19.4	20.0	44.7	42.4	43.7	44.0	0.0	0.0	0.0	0.0
5 - 6 pm	16.5	16.1	16.0	16.1	49.2	51.7	49.4	51.0	0.0	0.0	0.0	0.0
6 – 7 pm	13.4	14.0	13.8	14.7	59.0	57.5	57.9	56.2	0.0	0.0	0.0	0.0
7 - 8 pm	13.0	12.3	12.4	11.8	61.7	64.4	64.0	65.5	0.0	0.0	0.0	0.0
8 - 9 pm	11.3	10.5	10.8	10.5	64.3	66.7	66.6	66.4	0.0	0.0	0.0	0.0

SNOBER LAND DAY 2: WINTER (Day 2: December 31, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
11 – 12 pm	17.8	18.2	17.7	18.6	46.8	48.4	49.1	49.1	0.0	0.0	0.0	0.0
12 – 1 pm	15.9	17.6	16.7	17.6	54.4	51.1	52.5	51.3	0.3	0.0	0.0	0.0
1 - 2 pm	17.8	18.3	16.5	18.0	46.2	48.3	50.0	45.5	0.4	0.0	0.0	0.0
2 – 3 pm	18.1	19.8	18.6	19.3	46.1	44.3	47.6	45.3	0.1	0.1	0.0	0.0
3 – 4 pm	18.3	18.2	18.2	18.5	46.0	44.5	44.7	43.5	0.3	0.0	0.0	0.0
4 – 5 pm	18.1	19.3	17.5	19.5	43.3	42.6	43.5	42.7	0.0	0.4	1.0	0.5
5 - 6 pm	14.8	16.0	15.5	16.2	51.7	49.7	49.9	50.0	0.0	0.0	0.0	0.0
6 – 7 pm	11.8	12.3	12.3	13.7	62.4	60.5	61.3	55.5	0.1	0.0	0.0	0.0
7 - 8 pm	13.7	12.5	12.4	11.8	57.2	61.6	61.4	62.0	0.0	0.0	0.0	0.0
8 - 9 pm	11.3	10.5	10.8	10.5	64.3	66.7	66.6	66.4	0.0	0.0	0.0	0.0

MARTYR PLAZA DAY 1: SUMMER (Day 1: July 24, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 am	29.5	28.7	29.2	30.5	39.0	42.5	39.1	38.0	0.3	0.0	0.3	0.4
10 – 11 am	31.4	33.6	32.8	33.5	35.7	35.5	34.2	36.9	0.3	0.1	0.4	0.0
11 am – 12 pm	33.7	33.5	33.5	35.0	33.9	34.6	34.3	33.0	0.0	0.5	0.0	0.1
12 – 1 pm	34.8	33.5	33.5	34.7	31.6	32.6	34.5	30.6	0.4	0.5	0.0	0.5
1 - 2 pm	34.5	36.4	37.3	38.4	32.7	30.5	29.0	27.5	0.0	0.3	0.3	0.2
2 – 3 pm	35.7	35.5	36.8	39.3	32.4	29.5	29.2	25.6	0.2	0.4	0.1	0.3
3 – 4 pm	36.0	36.4	36.4	37.0	31.8	30.1	29.4	28.6	0.5	0.4	0.8	0.6
4 – 5 pm	39.8	39.5	38.3	38.8	28.3	28.2	28.2	28.1	0.1	0.3	1.4	0.6
5 - 6 pm	36.5	36.1	36.5	36.5	30.2	30.4	29.1	30.4	0.5	0.6	0.5	1.5
6 – 7 pm	32.7	33.5	33.1	33.8	37.3	36.2	36.3	35.9	0.4	0.1	0.9	0.8
7 - 8 pm	30.6	32.2	31.4	32.7	43.1	40.8	42.1	40.4	0.0	0.4	0.4	0.9
8 - 9 pm	31.1	30.3	29.9	29.3	44.2	44.8	45.6	47.1	0.0	0.3	0.0	0.0

MARTYR PLAZA DAY 2: SUMMER (Day 2: July 25, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 pm	29.8	28.6	27.3	31.6	39.5	43.5	48.0	39.2	0.6	0.4	0.0	0.0
10 – 11 pm	32.3	32.8	33.2	34.1	35.7	35.1	35.2	32.6	0.0	0.5	0.0	0.0
11 – 12 pm	34.0	35.6	35.8	37.9	31.5	31.2	29.1	28.0	0.1	0.1	0.4	0.3
12 – 1 pm	36.0	36.9	37.6	40.0	28.4	28.3	26.4	24.7	0.4	0.1	0.5	0.9
1 - 2 pm	36.1	37.4	36.5	40.5	29.4	27.6	27.2	25.4	0.0	0.1	1.2	1.2
2 – 3 pm	39.5	41.3	41.4	42.2	26.1	25.2	24.5	23.6	0.0	0.1	0.0	1.1
3 – 4 pm	40.0	39.8	39.3	38.4	26.1	25.6	26.5	26.1	0.4	0.7	0.8	0.5
4 – 5 pm	36.2	37.5	37.4	38.0	29.2	28.4	27.4	27.2	0.3	0.3	0.3	0.0
5 - 6 pm	36.2	36.7	36.5	36.2	28.7	28.8	29.7	29.0	0.0	0.2	0.4	0.3
6 – 7 pm	35.8	35.6	35.4	35.4	28.9	29.0	29.0	29.1	0.0	0.0	0.4	0.7

7 - 8 pm	33.4	33.5	33.2	33.1	34.7	34.6	35.5	34.5	0.0	0.1	0.2	0.4
8 - 9 pm	31.6	32.0	32.0	31.5	37.5	37.5	37.5	37.6	0.6	0.4	0.0	0.5

MARTYR PLAZA DAY 1: WINTER (Day 1: December 26, 2024)

Hours	**Ta**				**RH**				**AV**			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 am	18.0	16.2	13.8	13.9	49.1	50.3	60.5	59.6	0.0	0.0	0.4	0.0
10 – 11 am	16.2	16.1	15.6	15.1	57.8	55.2	55.4	55.2	0.0	0.0	0.0	0.0
11am – 12 pm	14.6	14.7	13.7	15.1	56.8	58.7	58.6	55.3	0.0	0.0	0.2	0.1
12 – 1 pm	17.4	16.5	16.1	15.9	56.4	54.1	57.6	57.1	0.0	0.0	0.1	0.0
1 - 2 pm	17.5	16.5	15.9	16.0	57.1	56.9	58.7	58.1	0.0	0.0	0.0	0.3
2 – 3 pm	16.0	14.9	13.0	13.9	61.0	61.9	63.6	67.0	0.0	0.0	0.2	0.0
3 – 4 pm	19.4	19.1	16.6	15.6	58.8	54.6	58.0	59.6	0.0	0.0	0.1	0.3
4 – 5 pm	20.2	18.4	15.4	15.7	54.3	54.0	60.4	63.1	0.0	0.5	0.0	0.0
5 - 6 pm	19.8	19.0	15.8	16.3	54.0	55.7	58.9	59.0	0.0	0.0	0.0	0.1
6 – 7 pm	20.1	20.0	19.2	18.9	56.7	54.1	50.1	52.0	0.0	0.0	0.0	0.0
7 - 8 pm	20.6	18.5	17.2	17.7	48.4	54.6	52.8	51.0	0.0	0.0	0.0	0.1
8 - 9 pm	19.8	18.2	17.0	16.6	54.0	51.0	53.2	54.3	0.0	0.0	0.0	0.4

MARTYR PLAZA DAY 2: WINTER (Day 2: December 27, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 pm	20.5	20.0	19.0	17.1	49.8	48.0	46.8	49.5	0.0	0.0	0.0	0.2
10 – 11 pm	15.3	17.4	15.9	18.4	54.2	51.5	52.2	53.6	0.4	0.0	0.2	0.0
11 – 12 pm	23.6	22.4	22.5	22.4	39.0	42.0	43.1	41.4	0.0	0.0	0.0	0.2
12 – 1 pm	27.8	27.1	26.7	28.0	37.1	36.7	38.7	35.0	0.0	0.0	0.0	0.0
1 - 2 pm	20.7	19.1	18.0	19.3	44.6	45.2	46.4	44.5	0.1	0.1	0.1	0.5
2 – 3 pm	24.0	23.1	19.7	19.4	40.3	40.0	45.9	45.3	0.0	0.0	0.7	0.7
3 – 4 pm	21.5	20.1	19.5	19.7	46.0	47.4	45.1	46.2	0.0	0.0	0.1	0.2
4 – 5 pm	18.8	17.8	17.3	17.4	48.2	49.3	50.7	50.4	0.0	0.0	0.2	0.0
5 - 6 pm	17.7	17.5	16.4	16.5	55.0	60.7	54.4	55.2	0.0	0.0	0.0	0.0
6 – 7 pm	19.0	17.9	16.8	16.7	52.0	51.9	52.6	53.4	0.0	0.0	0.0	0.0
7 - 8 pm	18.9	18.8	18.0	17.9	56.4	51.7	52.0	54.4	0.0	0.0	0.0	0.0
8 - 9 pm	20.0	19.5	18.5	18.1	50.2	49.7	50.5	53.4	0.0	0.0	0.1	0.0

THE SQUARE DAY 1: SUMMER (Day 1: July 20, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 am	30.0	33.0	34.0	34.0	38.6	28.6	26.4	26.2	0.0	0.6	0.0	0.0
10 – 11 am	37.3	39.7	41.6	41.1	23.1	22.8	20.5	21.7	0.0	0.0	0.2	0.0
11am – 12 pm	37.4	41.6	42.5	42.2	25.5	21.6	21.0	21.3	0.0	0.1	0.0	0.1
12 – 1 pm	37.2	40.1	42.0	41.4	24.6	23.7	21.6	20.5	0.3	0.0	0.0	0.0
1 - 2 pm	38.7	40.1	42.6	42.0	25.1	22.5	23.2	21.8	0.0	0.0	0.0	0.0
2 – 3 pm	39.1	40.3	41.5	42.1	23.0	22.4	22.4	20.8	0.0	0.1	0.0	0.6
3 – 4 pm	39.7	42.1	42.2	42.3	21.5	21.9	21.0	22.5	0.5	1.0	0.0	1.5
4 – 5 pm	40.6	41.8	41.8	41.9	27.0	23.2	21.9	22.0	0.0	0.5	0.3	0.2
5 - 6 pm	38.7	40.3	40.3	39.9	25.3	27.1	25.4	24.5	0.0	0.0	0.0	0.3
6 – 7 pm	38.2	38.9	38.9	39.4	26.7	26.9	26.5	26.2	0.3	0.0	0.5	0.0
7 - 8 pm	35.4	35.4	35.4	34.9	32.0	34.7	22.1	32.9	0.0	0.0	0.3	0.0
8 - 9 pm	34.1	33.8	33.8	33.6	34.0	34.1	34.4	33.0	0.0	0.0	0.0	0.2

THE SQUARE DAY 2: SUMMER (Day 2: July 21, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 pm	31.7	33.2	35.7	37.4	35.5	32.3	33.1	34.3	0.4	0.0	0.0	0.0
10 – 11 pm	38.2	38.4	39.3	39.7	27.4	25.0	27.8	25.3	0.0	0.6	0.0	0.0
11 – 12 pm	38.4	40.0	41.6	41.7	22.9	21.8	21.2	20.6	0.6	0.5	0.0	1.9
12 – 1 pm	41.3	41.9	44.2	43.6	22.3	19.7	20.1	19.2	1.5	1.1	0.2	0.4
1 - 2 pm	43.8	44.1	46.0	45.0	20.7	18.8	19.5	18.6	0.5	1.8	0.9	0.4
2 – 3 pm	40.0	41.5	41.6	39.4	21.7	21.1	22.4	22.6	0.5	1.1	0.8	0.4
3 – 4 pm	42.1	42.0	42.5	42.8	21.4	20.8	21.1	23.5	0.6	1.4	0.0	0.3
4 – 5 pm	39.5	40.5	41.4	41.3	26.0	25.4	25.8	26.3	0.4	0.5	0.3	0.4

5 - 6 pm	37.8	38.3	38.1	38.0	28.5	28.6	27.8	28.7	0.0	0.0	0.4	0.3
6 – 7 pm	35.2	35.9	35.7	35.5	30.4	30.8	30.6	31.0	0.2	1.9	0.5	0.0
7 - 8 pm	33.1	32.7	32.7	32.7	33.6	33.7	32.9	33.1	0.0	0.2	0.8	0.1
8 - 9 pm	31.2	30.8	31.1	30.9	33.4	36.6	33.7	34.8	0.8	0.0	0.3	0.9

THE SQUARE DAY 1: WINTER (Day 1: December 22, 2024)

Hours	**Ta**				**RH**				**AV**			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 am	16.4	16.4	15.4	18.2	45.3	45.0	48.6	41.1	0.0	0.0	0.0	0.0
10 – 11 am	17.6	17.5	17.8	15.4	51.1	46.2	46.8	51.1	0.0	0.0	0.0	0.0
11 – 12 am	18.1	16.8	17.8	16.9	48.7	49.0	46.1	48.5	0.5	0.0	0.0	0.0
12 – 1 pm	19.2	18.8	20.0	19.8	43.5	43.1	41.5	41.3	1.1	0.3	0.0	0.1
1 - 2 pm	20.8	20.0	20.3	21.1	43.6	40.2	41.7	38.4	0.7	1.1	0.0	0.4
2 – 3 pm	24.6	25.0	25.8	25.6	36.0	31.1	33.9	31.3	0.0	0.1	0.0	0.4
3 – 4 pm	20.5	21.1	21.2	20.3	37.5	37.3	35.7	36.9	0.0	0.0	0.5	0.1
4 – 5 pm	18.0	18.3	19.0	18.6	42.3	41.6	39.6	39.9	0.0	0.1	0.0	0.1
5 - 6 pm	16.3	16.8	17.9	16.6	43.2	43.9	43.5	44.8	0.0	0.0	0.0	0.1
6 – 7 pm	17.6	17.8	19.3	16.4	41.4	40.9	43.3	43.5	0.1	0.0	0.0	0.3
7 - 8 pm	18.7	19.3	19.7	17.3	40.6	39.6	44.7	39.3	0.0	0.0	0.0	0.1
8 - 9 pm	16.1	16.2	16.7	14.6	41.6	42.6	42.7	43.2	0.2	0.0	0.3	0.9

THE SQUARE DAY 2: WINTER (Day 1: December 23, 2024)

Hours	Ta				RH				AV			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
9 – 10 pm	15.9	15.2	18.0	15.1	68.6	72.9	62.8	60.5	0.0	0.0	0.6	1.0
10 – 11 pm	14.7	15.8	16.2	13.4	53.8	53.5	52.4	56.2	0.8	0.1	0.0	0.2
11 – 12 pm	15.8	16.3	16.5	16.1	52.0	50.7	51.0	51.5	0.1	1.2	0.5	0.1
12 – 1 pm	14.2	14.0	16.7	12.8	55.7	54.3	51.7	57.4	0.8	1.7	0.1	1.1
1 - 2 pm	10.3	9.7	11.1	8.7	64.4	63.8	60.9	67.6	0.3	0.0	0.2	0.3
2 – 3 pm	13.0	14.0	15.1	15.0	55.0	52.4	51.6	54.2	0.9	1.7	0.7	0.1
3 – 4 pm	15.3	16.2	17.3	13.4	58.6	57.7	52.8	62.4	0.0	0.0	0.0	0.1
4 – 5 pm	14.7	15.3	16.3	13.2	54.0	54.1	52.5	57.7	1.5	0.0	0.0	0.8
5 - 6 pm	12.1	12.0	14.7	12.0	62.3	60.8	57.7	64.1	0.5	0.1	0.0	0.0
6 – 7 pm	15.5	15.0	17.1	13.0	57.5	56.9	53.5	58.9	0.6	0.3	0.3	0.6
7 - 8 pm	15.6	15.6	17.3	14.2	53.3	53.6	46.4	58.0	0.1	0.6	0.6	0.0
8 - 9 pm	11.9	12.2	12.4	10.8	69.0	64.6	66.7	68.7	0.0	0.4	0.1	0.3
6 – 7 pm	19.0	17.9	16.8	16.7	52.0	51.9	52.6	53.4	0.0	0.0	0.0	0.0
7 - 8 pm	18.9	18.8	18.0	17.9	56.4	51.7	52.0	54.4	0.0	0.0	0.0	0.0
8 - 9 pm	20.0	19.5	18.5	18.1	50.2	49.7	50.5	53.4	0.0	0.0	0.1	0.0

Appendix D: Supplementary Field Investigation: Children's Behaviour in Outdoor Spaces (Seoul, South Korea)

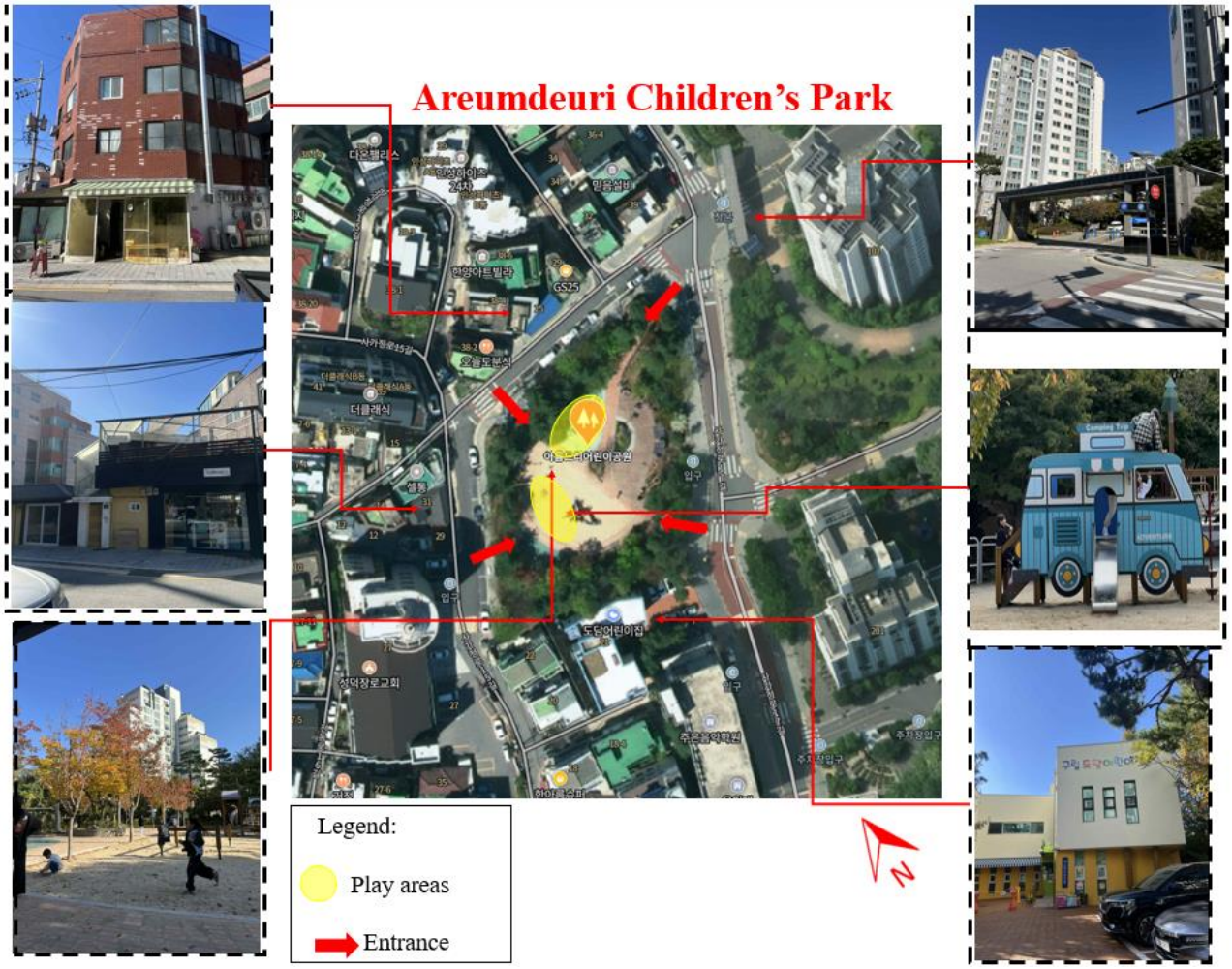
Context

This appendix presents a supplementary field investigation conducted during a research training visit to Seoul, South Korea, from October 22nd to November 8th, 2025, under the supervision of Professor Sun-Young Rieh. This work is independent of the main thesis and is not part of the core empirical investigation conducted in El Khroub. However, it applied a similar observational and spatial methodology, and its findings offer a complementary perspective on the relationship between spatial configuration and children's use of outdoor spaces in a contrasting urban and climatic context.

Study area and site selection

The investigation was conducted in Dongdaemun-gu, an inner-eastern district of Seoul, characterised by dense residential development shaped through successive land readjustment projects. Over recent decades, Seoul has confronted significant challenges in the provision and maintenance of outdoor public spaces, many of which are leftover areas or cut off by busy roads, restricting movement, visibility, and informal gathering. Four outdoor spaces were selected, all designed primarily for children's use:

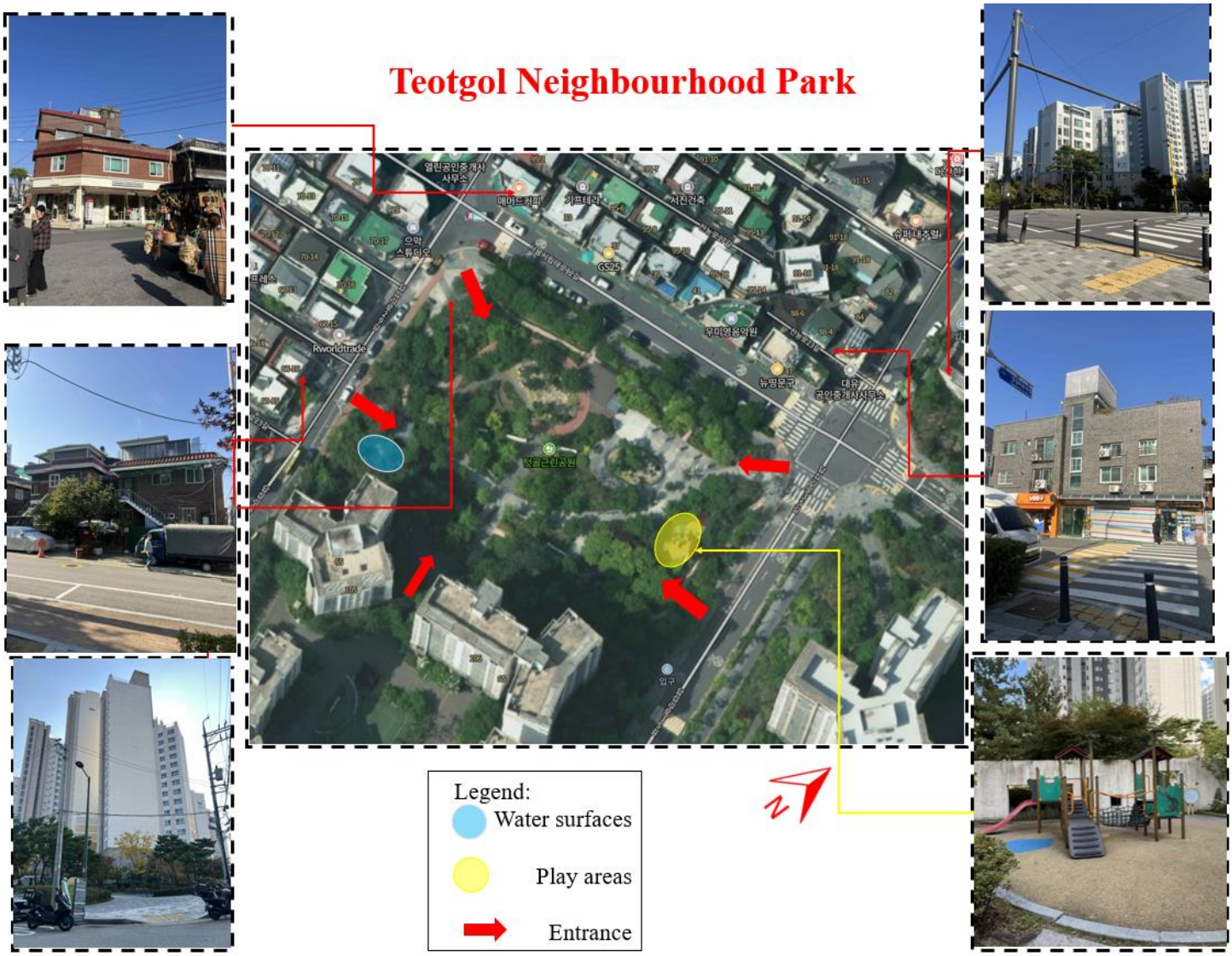
Site 1 — *Areumdeuri Children's Park*: Covering 2,480.75 m², the site has an irregular lozenge shape defined by trees and vegetation structuring four main circulation paths, play areas, urban furniture, and green spaces. It is framed by houses to the north, a nursery school to the south, the RAEMEN residential complex to the east, and a church to the west.



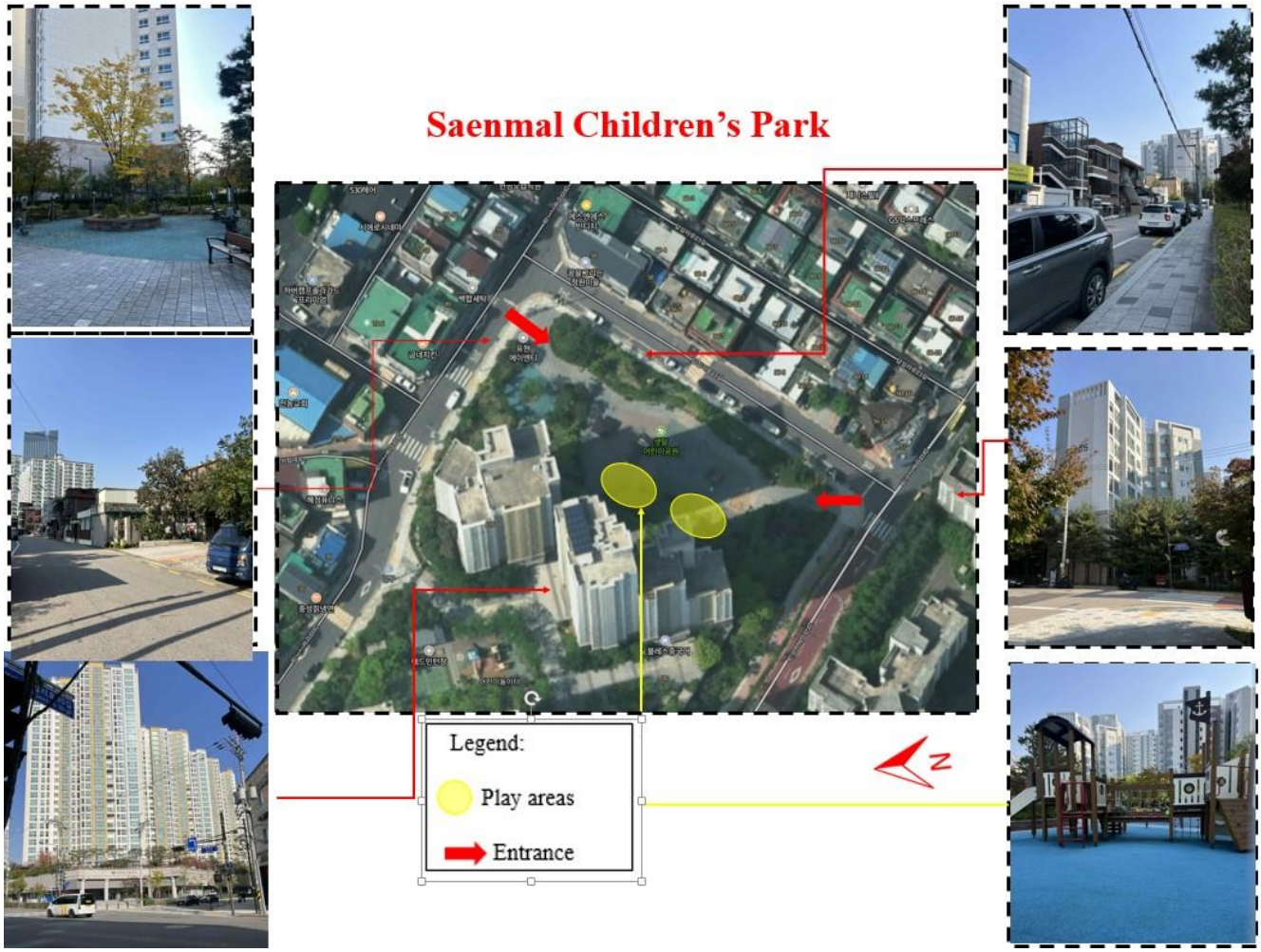
- Site 2 — *Jeongok Village Par*k: Covering 2,188.48 m², the site has a regular rectangular shape with a main entrance and two secondary access points, children's play areas, pergolas, benches, sports equipment, and green spaces. It is surrounded by residential houses without dedicated private playgrounds.



Site 3 — *Teotgol Neighbourhood Park*: The largest site at 5,836.43 m², designed as a space where children can freely experience the forest. It includes four access points, toddler play zones, outdoor sports equipment, pergolas, and extensive landscaped vegetation. It is bordered by the RAEMEN residential complex to the south and east, which contains its own play spaces.



Site 4 — *Saenmal Children's Park*: Covering 2,724.65 m², with a regular rectangular layout and two main access points leading to play areas, drinking fountains, a pergola, and sports equipment. It is surrounded by houses, stores, and two residential complexes, each containing its own play areas.



Methodology applied

The methodology mirrors the observational framework applied in the main thesis investigation. It combined qualitative and quantitative approaches as follows:

- Behavioural mapping: Systematic observation of children's activities across the four sites, conducted over 3 days per site (including one weekend day), with observations recorded every 10 minutes from 12.00 pm to 6.00 pm.
- Questionnaire surveys: Structured questionnaires administered to both children and caregivers, covering usage patterns, TSV, PVV, and PAV.
- Space Syntax analysis: Derivation of VI values from VGA maps and TC values from Axial Maps using DepthmapX software.
- Combined approach: Overlapping of behavioural maps with Space Syntax outputs to compare children's actual use of space with spatial configuration potentialities

Main results

- **Behavioural patterns**

Overall, the highest levels of children's activity across all four sites were recorded between 2.00 and 3.00 pm, coinciding with school dismissal hours. The lowest activity was consistently observed between 12.00 and 1.00 pm. Areumdeuri Children's Park recorded the highest overall frequency of children's presence, while Teotgol Neighbourhood Park recorded the lowest, with several observation periods showing zero activity despite its large size and forest character.

Site	Peak Activity	Lowest Activity	Overall Use
Areumdeuri Children's Park	2–3 pm (41 children)	5–6 pm	Highest
Jeongok Village Park	2–3 pm (38 children)	5–6 pm	High
Teotgol Neighbourhood Park	2–5 pm (7 children max)	12–2 pm (0 children)	Lowest
Saenmal Children's Park	3–4 pm (66 children)	12–1 pm	Moderate

- **Space Syntax results**

VI values ranged from a maximum of 64.44 to a minimum of 4.28, with an average of 29.22. TC values ranged from 949 to 0, with an average of 127.12. Saenmal Children's Park and Jeongok Village Park emerged as the most integrated and highest-choice spaces, while Teotgol Neighbourhood Park showed the lowest integration and choice values, reflecting spatial isolation and limited connectivity.

- **Survey results**

Children at Areumdeuri and Jeongok reported TSV ranging between neutral and cool, consistent with the autumn investigation period. PAV was rated as easy by the majority of respondents at Areumdeuri (14 children) and Jeongok (10 children). PVV was rated as "always" or "most of the time" at Areumdeuri and Jeongok, while no responses were collected at Teotgol and Saenmal due to the near-absence of children.

Concluding Remark

The Seoul investigation provides a decisive contrastive validation of the central theoretical distinction of this thesis: the differentiation between temporal factors, *when* children use outdoor space, and spatial factors, *where* they concentrate within it. This contrast is rendered all the more scientifically meaningful by the climatic opposition between the two study contexts: Seoul operates under a humid continental climate (Köppen: Dwa), characterised by four distinct seasons and mild temperate autumns, while El Khroub operates under a hot-summer Mediterranean climate (Köppen: Csa) with semi-arid tendencies. It is characterised by extreme summer heat stress and cold winter conditions. This climatic contrast is not incidental; it is the very condition that allows the two investigations to function as complementary poles of a single analytical argument.

It is important to note that no microclimatic measurements or OTC parameters were recorded during the Seoul investigation. The thermal context is therefore inferred from the climatic characteristics of the season: the investigation was conducted in autumn 2025 (October–November), a period during which Seoul's humid continental climate typically produces mild, temperate outdoor conditions with average temperatures ranging between 10–18°C. Under such seasonal conditions, extreme thermal stress, whether heat or cold, is unlikely to constitute a primary barrier to outdoor activity. This inference is further supported by the questionnaire responses collected at the four sites, where children and caregivers reported thermal sensation votes ranging between neutral and cool, and where the impact of weather on site use was rated as slight to non-significant by caregivers. In the absence of instrumental OTC data, these subjective responses constitute the available evidence that thermal conditions were not a limiting factor during the investigation period.

Spatial configuration, as measured through VI and TC via Space Syntax, is by definition a static spatial parameter: it does not change across the day, across seasons, or across weather conditions. The VGA and Axial maps of the four Seoul sites remained identical whether observed on a sunny weekday, a cloudy weekend, or a cold afternoon. Spatial configuration can only ever answer the question of *where*, which zones are more visible, more connected, more accessible. It cannot, by its own nature, answer the question of *when*.

Under these conditions, a thermally mild season, no recorded OTC stress, and school timetables governing *when*, the variability in children's spatial engagement across the four sites was explained not by thermal discomfort but by functional attractors: the quality, diversity, and

exclusivity of play equipment. Areumdeuri attracted the highest number of children due to its unique play elements, including trampolines, and a diverse spatial layout not replicated by surrounding residential complexes. Teotgol, despite its large size and greatest spatial extent, was consistently avoided by children over six years old due to toddler-oriented equipment and strong competition from private playgrounds within adjacent residential complexes. When OTC is not a stressor, *where* children go is governed by spatial configuration and functional attractors, while *when* they appear is governed by social and institutional rhythms alone.

This is precisely where the contrast with El Khroub becomes scientifically decisive. In the semi-arid context of this thesis, OTC is not a neutral background condition, it is a dynamic spatiotemporal parameter varying simultaneously in space (across observation spots S1–S4, depending on shading, surface materials, and morphological configuration) and in time (across hours of the day and across summer and winter seasons). During summer, UTCI values at exposed spots during midday exceeded thermal stress thresholds, collapsing children's presence entirely, regardless of spatial integration or functional equipment. During winter, cold stress produced an equivalent temporal suppression of activity. OTC governed *when*, and in doing so, overrode the predictive power of spatial configuration during thermally extreme periods.

The Seoul investigation therefore functions as an implicit control condition: by operating in a thermally mild season without OTC measurement as a variable, it isolates the *where* dimension and reveals that spatial configuration and functional attractors alone produce moderate, context-dependent engagement. El Khroub reintroduces OTC as a dynamic temporal force, demonstrating its primacy over static spatial parameters under thermal stress conditions. Together, both investigations confirm the core hypothesis of this thesis, that OTC, as a dynamic spatiotemporal parameter, exerts a greater influence on children's temporal use of outdoor space than spatial configuration does, and that child-responsive urban design must account for both the static geometry of space and the dynamic thermal conditions that determine whether that geometry can ever truly be activate

Appendix E: Outdoor activity and microclimate recording tables

Typical week of Winter/summer of El Khroub Constantine : Date ../..../....

DAY 1 : Outdoor place name (...)

Investigation spots		S1	S2	S3	S4	Number of children alone		Number of accompanied children		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
DAY TIME	HOURS	Visual sequence				Girl	Boy	Girl	Boy	Value of Ta (C°)				Value of RH (%)				Value of AV (m/s)			
Morning	9am to 10 am																				
	10am to 11 am																				
	11am to 12 pm																				
Afternoon	12 pm to 1 pm																				
	1 pm to 2 pm																				
	2 pm to 3 pm																				
	3 pm to 4 pm																				
	4 pm to 5 pm																				
Evening	5 pm to 6 pm																				
	6 pm to 7 pm																				
	7pm to 8 pm																				
	8 pm to 9 pm																				

Typical week of Winter/summer of El Khroub Constantine : Date ../..../....

DAY 2 : Outdoor place name (...)

Investigation spots		S1	S2	S3	S4	Number of children alone		Number of accompanied children		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
DAY TIME	HOURS	Visual sequence				Girl	Boy	Girl	Boy	Value of Ta (C°)				Value of RH (%)				Value of AV (m/s)			
Morning	9am to 10 am																				
	10am to 11 am																				
	11am to 12 pm																				
Afternoon	12 pm to 1 pm																				
	1 pm to 2 pm																				
	2 pm to 3 pm																				
	3 pm to 4 pm																				
	4 pm to 5 pm																				
Evening	5 pm to 6 pm																				
	6 pm to 7 pm																				
	7pm to 8 pm																				
	8 pm to 9 pm																				

Appendix F: Article Publication

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An overview of enhancing children's urban liveability in Algeria: A holistic approach to well-being☆

Abir Labdani *, Soufiane Fezzai, Lazhar Gherzouli

Applied Civil Engineering Laboratory (LGCA), Department of Architecture, University of Echahid Cheikh Larbi Tebessi, Road of Constantine, 12022, Tebessa, Algeria

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ABSTRACT

Despite the growing body of literature on Children's Urban Liveability (CUL) in recent years, most studies remain fragmented, focusing on individual themes such as safety, education, or public spaces, without addressing how these aspects interconnect. Moreover, existing comprehensive CUL frameworks are largely developed in high-income countries, with little consideration of their relevance or adaptability to rapidly urbanising contexts in the Global South. In Algeria, no integrative or context-sensitive model currently exists to inform urban policy and planning. To address these theoretical and practical gaps, this study introduces the Integrated Child-Centric Urban Liveability Model (ICCULM). The model reconceptualises CUL as the dynamic interplay of five interrelated dimensions: the physical environment, education, public spaces, health and safety, and governance. Using a PRISMA-informed systematic review of 18 published studies (2014–2024), we synthesised international perspectives and assessed their applicability to the Algerian context. Our findings highlight the persistent exclusion of children from urban planning in Algeria, revealing that their rights and needs are absent from the political agenda. In light of these shortcomings, we recommend that child impact assessments be made mandatory and that participatory planning mechanisms be embedded in policy frameworks. This paper contributes to CUL theory by positioning children at the centre of liveability debates and sustainable urban development strategies. It also outlines pathways for translating these theoretical shifts into practice, towards building inclusive and sustainable cities by, for, and with children, where children's well-being serves as a benchmark for good urban living.

1. Introduction

Researching sustainable cities is challenging due to the complexity of urban development and the diversity of programmes addressing its key issues. Policy debates often focus on specialist agendas such as age-friendly, resilient, compact, or slow cities (Brown et al., 2019a). Yet, as Lennard and Lennard (1992, 2000) argue, placing children at the centre of urban planning offers a unifying lens for enhancing liveability. A city designed to meet children's developmental, social, and safety needs inevitably raises the quality of life (QoL) for all. Evidence shows that policies and designs supporting children also benefit the elderly, people with disabilities, and wider populations, fostering more inclusive and equitable cities (Ramírez-Saiz et al., 2025). Child-oriented urban design offers profound benefits that extend well beyond children, enhancing the QoL for all residents. As urban theorist Enrique Peñalosa noted, "*If we can build a successful city for children, we will have a successful city for all people.*" (Peñalosa, 2007). Case studies from cities like Copenhagen, Amsterdam, and Bogotá illustrate these benefits. Copenhagen's Superkilen Park, for example, has transformed a previously divided neighbourhood into a vibrant, inclusive public space that serves residents of all ages and backgrounds. Such initiatives demonstrate that child-oriented design principles can lead to measurable improvements in safety, social cohesion, and public health outcomes across all age groups. Children can be seen as an indicator species for urban health: when cities work for children, they work for everyone (Lennard & Lennard, 1992). Rapid urbanisation is reshaping the spaces where children live, with global urban populations projected to reach 8 billion by 2050 (Williams et al., 2017; Zhang et al., 2023). This growth intensifies pressure on infrastructure, services, and ecosystems, underscoring the importance of urban liveability (UL) across physical, social, economic, and environmental domains (Badland & Pearce, 2019; Brown et al., 2019b; Paul & Sen, 2020). From a salutogenic perspective, the

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* Corresponding author at: Department of Architecture, University of Echahid Cheikh Larbi Tebessi, Road of Constantine, 12022, Tebessa, Algeria.
E-mail addresses: abir.labdani@univ-tebessa.dz (A. Labdani), soufiane.fezzai@univ-tebessa.dz (S. Fezzai), lazhar.gherzouli@univ-tebessa.dz (L. Gherzouli).

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