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Master thesis in Architecture

Workshop theme: Urban Architecture

**Pyramidal Organization of Collective Housing as an Alternative
to the Mass housing**

Capstone Project: Housing project in Hadjret Ennous (Tipaza)

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Dedication

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Dedication

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With all my gratitude.
thank you.*

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Abstract:

In the context of rapid urbanization in Algeria, especially in the northern and coastal cities where land is becoming increasingly scarce, Public Housing developments have become the norm to accommodate the growing population. However, these mass housing project often prioritize densification and cost efficiency over the social, cultural and mental well-being of residents.

This thesis investigates how affordable and replicable mass housing models can be developed without sacrificing quality of life, cultural relevance and psychological comfort. This research is driven by the question of how can we integrate the Mediterranean lifestyle particularly the private outdoor space into large scale low-cost housing?

The proposed solution is Pyramidal Organization, a housing concept that reimagines spatial hierarchy by prioritizing open to air private space. In contrast to typical AADL housing where terraces only account to 1 to 5% of the total area, this project treats open to sky spaces as essential, not residual. Resulting a 25% to 35% terrace occupancy percentage.

This architectural approach seeks to balance replicability with adaptability, allowing for mass production without erasing local identity and traditional lifestyle. In doing so, the thesis offers an alternative vision for the future of Algerian social housing, one where economic constraint is respected while still affirming the importance of human centered design.

Key themes (words): Collective housing, terraced houses, stepped architecture, pyramidal organization, outdoor space.

Résumé :

Dans le contexte d'une urbanisation rapide en Algérie, particulièrement dans le nord et les villes du littoral où le foncier se raréfie. Les projets de développement public sont devenus la norme pour accueillir cette population croissante. Cependant, ces projets privilégient la densification et la rentabilité plus que le bien-être des résidents et l'aspect social et culturel. Ce mémoire s'interroge comment peut-on développer des modèles de l'habitat de masse qui sont abordables et reproductibles sans compromettre la qualité de vie, la pertinence culturelle et le confort mental. La recherche est guidée par la question : Comment intégrer le mode de vie méditerranéen en particulier l'espace extérieur privé dans les projets de grande échelle et à bas coût ?

La solution proposée est l'Organisation Pyramidale, un concept d'habitat qui repense la hiérarchie en privilégiant les espaces privés ouverts à l'air. Contrairement à l'AADL, où les terrasses ne représentent que 1 à 5% de la surface totale. Ce projet considère les espaces ouverts au ciel comme essentiels et non pas comme des résidus. Ainsi, la terrasse occupe entre 25% à 35% de la superficie totale de chaque unité.

Cette approche architecturale vise à concilier la reproductibilité et l'adaptabilité, permettant la production de l'habitat de masse sans l'éradication de l'identité locale et le mode de vie traditionnel. Ce travail propose une vision alternative pour le futur de l'habitat social algérien. Un avenir où les contraintes économiques sont respectées sans sacrifier l'importance d'une conception centrée sur l'humain.

Mot clés : Habitat Collectif, maisons terrasse, organisation pyramidale, architecture en gradins, espace extérieur.

ملخص:

في ظل التسارع العمراني الذي تشهده الجزائر، خاصة في المدن الشمالية والساحلية حيث يشحّ العقار، أصبحت مشاريع السكن العمومي هي القاعدة لتلبية احتياجات النمو الديموغرافي. غير أن هذه المشاريع غالبًا ما تُعطي الأولوية للكثافة السكانية المردودية الاقتصادية على حساب راحة السكان والجوانب الاجتماعية والثقافية للسكن.

تتناول هذه المذكرة إشكالية تطوير نماذج سكن جماعي تكون في متناول الجميع وقابلة للتكرار، دون التضحية بجودة الحياة، والهوية الثقافية، والراحة النفسية. وتستند هذه الدراسة إلى التساؤل التالي: كيف يمكن إدماج نمط العيش المتوسطي، لا سيما الفضاء الخارجي الخاص، ضمن مشاريع سكنية جماعية منخفضة التكلفة وعلى نطاق واسع؟

الحل المقترح يتمثل في التنظيم الهرمي، وهو مفهوم سكني يعيد النظر في التسلسل الهرمي للمساحات من خلال إعطاء الأولوية للفضاءات الخاصة المفتوحة على السماء. على عكس نماذج سكن AADL حيث لا تمثل الشرفات سوى 1 إلى 5% من المساحة الإجمالية، يعامل هذا المشروع الفضاءات الخارجية كعناصر أساسية، مما يسمح بزيادة نسبة مساحة الشرف لتتراوح ما بين 25% و35% من المساحة الكلية للوحدة السكنية.

تسعى هذه المقاربة المعمارية إلى تحقيق توازن بين قابلية التكرار والتكيف، بما يسمح بإنتاج سكن اجتماعي على نطاق واسع دون طمس الهوية المحلية أو أسلوب العيش التقليدي. وتقدم هذه المذكرة رؤية بديلة لمستقبل السكن الاجتماعي في الجزائر، مستقبل تُحترم فيه القيود الاقتصادية دون إغفال أهمية التصميم الذي يضع الإنسان في صلب اهتماماته.

كلمات مفتاحية: السكن الاجتماعي، منازل بشرفات، التنظيم الهرمي، العمارة المتدرجة، المساحة الخارجية.

Workshop Objectives:

Urban architecture focuses on the design, planning, and development of urban spaces, cities, neighborhoods, and public areas. A discipline blends architecture, urban planning, landscape design, and engineering to create urban environments that are functional, aesthetic, and sustainable.

Urban architecture is above all functional. Its goal is to shape spaces and buildings that satisfy residents' needs by ensuring efficient infrastructure, accessibility, smooth circulation of people and vehicles, and the availability of essential services.

It must also mirror the cultural and historical identity of the city or neighborhood, often expressed through the preservation of historic monuments, the integration of public art, and respect for local architectural styles.

Sustainability is a fundamental aspect of urban architecture. It is reflected in ecological solutions such as green spaces, using streets and squares as ventilation corridors, efficient resource management, and the selection of durable, environmentally responsible materials.

Aesthetic values and visual quality are crucial. Good urban architecture provides attractive, harmonious environments, mindful of the beauty of buildings, public squares, and parks.

Sound urban planning promotes seamless connectivity between districts through well-designed transport networks, bicycle lanes, and pedestrian pathways. It must also foster social inclusion by creating spaces accessible to everyone, regardless of age, economic status, or physical ability.

Finally, urban spaces must be resilient, able to withstand challenges such as natural disasters (floods, earthquakes), climate change, and increasing demographic pressures.

Prof. M. Benhamouche, 2024.

Table of contents:

Acknowledgments.....	I
<i>Dedication</i>	II
Abstract	V
Résumé :.....	VI
:ملخص... ..	VII
Workshop Objectives:.....	VIII
Chapter 1 - Introductory Chapter.....	1
1 General introduction:	2
2 Research problematic:	3
3 Hypothesis	5
4 Thesis objectives:	5
5 Research Methodology:.....	6
4.1. Research Approach.....	6
4.2. Data Collection and Analysis Techniques.....	7
4.3. Justification of Methodological Choices	7
4.4. Research limitations:	8
5. Thesis structure.....	8
Chapter 2 - Literature Review and Comparative Studies.....	10
Introduction:.....	11
1. Conceptual framework:	11
1.1. From terraced Houses	11
1.1.1. <i>Definition of Terraced Houses</i>	11
1.1.2. <i>Historical context and evolution</i>	11
1.1.3. <i>Different limitations of terraced houses</i>	12
1.2. ... to pyramidal organization	15
1.2.1. <i>Definition of Stepped Architecture:</i>	15
1.2.2. <i>Breaking the linear paradigm: Contrast with terraced housing</i>	16
1.2.3. <i>Key principles of stepped design</i>	16
1.2.4. <i>Architectural Framework of Pyramidal Collective Housing</i>	17
1.2.5. <i>Benefits of pyramidal organization</i>	17
1.3. The outdoor living space as a key component of pyramidal organization	20
1.3.1. <i>Definition and role of outdoor living spaces</i>	20
1.3.2. <i>Diverse Outdoor Spaces Enabled by Pyramidal Geometry</i>	21
1.3.3. <i>Benefits of the outdoor living space</i>	22
1.3.4. <i>Design Principles for Maximizing Usability</i>	22
1.4. Continuum of connection: blending private and public outdoor realms	23

1.4.1.	<i>Gradual Transition from Private to Public Spaces in Stepped Design</i>	23
1.4.2.	<i>Fostering Community Through Outdoor Spatial Hierarchy</i>	24
1.4.3.	<i>Sustainable Outdoor Spaces: Systems and Strategies</i>	24
2.	Case studies of pyramidal organization projects	25
2.1.	Terrassenhaus Berlin.	25
2.1.1.	<i>Project Overview</i>	25
2.1.2.	<i>Location</i>	25
2.1.3.	<i>Plans Analysis</i>	26
2.1.4.	<i>Façade Analysis</i>	26
2.1.5.	<i>Key takeaways from the project</i>	27
2.1.6.	<i>Architecturale key concepts</i>	27
2.2.	Alexandra Road Estate in Camden, London.	27
2.2.1.	<i>Project Overview</i>	27
2.2.2.	<i>Location</i>	28
2.2.3.	<i>Plans Analysis</i>	28
2.2.4.	<i>Façade Analysis</i>	29
2.2.5.	<i>Key takeaways from the project</i>	30
2.2.6.	<i>Architectural key concepts</i>	30
2.3.	Koseze Housing Estate	31
2.3.1.	<i>Project Overview</i>	31
2.3.2.	<i>Location</i>	31
2.3.3.	<i>Plans Analysis</i>	31
2.3.4.	<i>Façade Analysis</i>	32
2.3.5.	<i>Key takeaways from the project</i>	33
2.3.6.	<i>Architecturale key concepts</i>	33
2.4.	Heinz-Nittel-Hof.	33
2.4.1.	<i>Project Overview</i>	33
2.4.2.	<i>Location</i>	34
2.4.3.	<i>Plans analysis</i>	34
2.4.4.	<i>Façade analysis</i>	34
2.4.5.	<i>Key takeaways from the project</i>	35
2.4.6.	<i>Architectural key concepts:</i>	35
2.5.	Analytical Insights and Design Learnings from the Case Studies:	36
	Conclusion:	37
	Chapter 3 - Urban diagnosis and Design Proposal for Hadjret Ennous.	38
	Introduction.	39
1.	An Overview of Hadjret Ennous and Its Historical Development	39

1.1. Geographic location:	39
1.2. City's historical development:	40
2. Physical and natural features of Hadjret Ennous:.....	41
2.1. Topography:.....	41
2.2. Climatic features:.....	42
	p
2.3. Hydrological Features:.....	45
2.4. Local Geological Features:	45
2.5. Flora:.....	46
2.6. Fauna:	46
3. Socio-Economic features of Hadjret Ennous:	47
3.1. Demographic evolution:	47
3.2. School enrollment rate:.....	49
3.3. Employment/Unemployment rates:	50
3.4. Local economy:	50
3.4.1. Commercial sector	50
3.4.2. Agriculture:	50
3.4.3. Tourism:	50
4. Urban analysis of Hadjret Ennous and project site:.....	50
4.1. Land Cover and land Use:.....	50
4.2. The built and the unbuilt areas:.....	51
4.3. Functions and activities:	52
4.4. Road network and accessibility:	53
4.5. Housing typologies:	54
4.6. Zoning height limits:.....	55
4.7. Current State of the Built Environment:	56
4.8. Urban Challenges and Structural Issues in Hadjret Ennous:	56
5. Proposed Urban Interventions:	60
5.1. Decentralization of Public Facilities:.....	60
5.2. Rerouting of National Road NR11:.....	60
5.3. Seasonal Traffic Diversion for Beachgoers:.....	60
5.4. Adjustment of the Coastal Buffer Zone:.....	60
5.5. Preservation of the River Easement Corridor:	60
5.6. Adaptive Reconfiguration of Forest Easement Zones:	61
5.7. Relocation of the Sports Stadium:.....	61
5.8. Redevelopment of the Former Stadium Site:	61
6. The Project of pyramidal housing in Hadjret Ennous :	63

6.1.	<i>Technical sheet</i>	63
6.2.	<i>Organizational Logic</i> :	63
6.3.	<i>Project Genesis</i> :	65
6.4.	<i>Mass Plan</i> :	66
6.5.	<i>Plans and units</i> :	67
6.6.	<i>Site ventilation</i> :	69
6.7.	<i>Sun Path and light Penetration</i> :	69
	Conclusion:	71
	GENERAL CONCLUSION:	73
	Bibliography.....	75
	ANNEXES	78
	ANNEXES.....	79
1.1.	Ground Floor	79
1.2.	First Floor	80
1.3.	Intermediate Floor	81
1.4.	Third & Fourth Floors	82
2.	Structure.....	84
3.	Sections.....	85
4.	Facades	86
4.1	Techniques and Strategies	86
5.	3D views and renders.....	89

Figures List:

Figure 1. Terrassenhaus building	25
Figure 2. National scale – Germany	25
Figure 3. Regional scale – Berlin.....	25
Figure 4. Neighborhood scale – Bottgerstrabe	25
Figure 5. Terrassenhaus plans analysis.....	26
Figure 6. Terrassenhaus section analysis	26
Figure 7. Facades Analysis	26
Figure 8. Alexandra Road Estate	27
Figure 9. Neighborhood scale - Town Of Camden, Alexandra Road Estate.....	28
Figure 10. Regional scale - London Borough of Camden	28
Figure 11. National scale – England	28
Figure 12.Plans Analysis of Alexandra Road Estate	28
Figure 13. Functions of Alexandra Road Estate	29
Figure 14. Facade analysis	29
Figure 15. Koseze Housing Estate	31
Figure 16. National scale – Slovenia	31
Figure 17. Regional scale - Ljubljana	31
Figure 18. Neighborhood scale - Koseze Housing Estate.....	31
Figure 19. Koseze Housing Estate plans analysis.....	32
Figure 20. Koseze Housing Estate facade analysis.....	32
Figure 21. Heinz Nittel-Hof Location	33
Figure 22. National scale – Austria	34
Figure 23. Neighborhood scale - Heinz-Nittel Hof	34
Figure 24. Regional scale - Vienna.....	34
Figure 25. Heinz-Nittel Hof plans analysis	34
Figure 26. Heinz-Nittel Hof facade analysis.....	35
Figure 27. Subdivision plan of FONTAINE DE GENIE	41
Figure 28. Topography map	42
Figure 29. Site topography.....	43
Figure 30. Site section A-A'	43
Figure 31. Site section B-B'	43
Figure 32. Monthly temperature averages	43

Figure 33. Monthly average precipitation in Hadjret Ennous.....	43
Figure 34. Daily wind speed of Hadjret Ennous in October 2020.....	44
Figure 35. Maquis (Petruzzello, 1998)	46
Figure 36. Cistus Populifolius (The Editors, 2018).....	46
Figure 37. Figs (Mayer, 2018).....	46
Figure 38. Population growth (1998-2025) in Hadjret Ennous	48
Figure 39. Gender repartition in Hadjret Ennous.....	49
Figure 40. Age pyramide of Hadjret Ennous	49
Figure 41. Agricultural potential in Hadjret Ennous	50
Figure 42. Hadjret Ennous land cover in %	51
Figure 43. Built/Unbuilt map.....	51
Figure 44. Site context of the built/unbuilt map of Hadjret Ennous	52
Figure 45. Road network map of Hadjret Ennous	53
Figure 46. Site context of the road network map of Hadjret Ennous	54
Figure 47. Site context of the building function map of Hadjret Ennous	53
Figure 48. Building function/activity map of Hadjret Ennous	52
Figure 49. Building typology of Hadjret Ennous.....	54
Figure 50. Site context of the building typology map of Hadjret Ennous	55
Figure 51. Building height map of Hadjret Ennous	55
Figure 52. Site context of the building height map in Hadjret Ennous	56
Figure 53. Building state map of Hadjret Ennous.....	56
Figure 54. Building state map of Hadjret Ennous.....	56
Figure 55. RN11 easement zone in Hadjret Ennous	57
Figure 56. Sea and river easement zone in Hadjret Ennous	57
Figure 57. Building height inconsistency in Hadjret Ennous	58
Figure 58. Building height inconsistency in Hadjret Ennous	58
Figure 59. Urban sprawl towards the forest in Hadjret Ennous	58
Figure 60. Hadjret Ennous diagnostics synthesis map	59
Figure 61. Proposed urban problems solution	62
Figure 62. Project axonometric view	63
Figure 63. Organization Logic.....	64
Figure 64. Wind penetration and flow	69
Figure 65. Sun path and light penetration diagram	70
Figure 66. Project genesis	65

Figure 67. Mass plan	66
Figure 68. Units Diagram	68
Figure 69. Chosen layout plan	67
Figure 70. Structural Diagram	84
Figure 71. Longitudinal Section of the studied unit	85
Figure 72. Transverse section	85
Figure 73. Eastern Facade zoom-in	87
Figure 74. Eastern facade of the studied unit	88
Figure 75. Beach facade 3d render	89
Figure 76. View towards the sea 3d render	89
Figure 77. First person perspective 3d render	90
Figure 78. Public garden 3d render	90
Figure 79. Pedestrian pathway 3d render	91
Figure 80. Axonometric view of the semi-public rooftop garden in 3D	91
Figure 81. First person view of the semi-public rooftop gardens in 3D	92
Figure 82. 3D render of the proposed school program	93
Figure 83. First person view of the administration block	93
Figure 84. First person view of the library and cafeteria	94
Figure 85. First person view of the middle school block	94
Figure 86. Axonometric view of the school in the urban context	95

Tables List :

Table 1. Key takeaways from Terrassenhaus building -----	27
Table 2. Key takeaways from Alexandra Road Estate -----	30
Table 3. Key takeaways from Koseze Housing Estate -----	33
Table 4. Key takeaways from Heinz-Nittel Hof.-----	35
Table 5. Critical reflections on the reviewed/studied projects -----	36
Table 6. Climate characteristics of Hadjret Ennous synthesis table. -----	44
Table 7. Geological features of Hadjret Ennous -----	45
Table8 . Fauna types in Hadjret Ennous -----	46
Table 9. Marine Fauna in Hadjret Ennous -----	47
Table 10. Population Growth over 20 years in Hadjret Ennous-----	48
Table 11. School enrollment rate and facilities needs-----	49
Table 12. Employment situation as of 2022 -----	50
Table 13. Hadjret Ennous urban diagnostic -----	57

CHAPTER 01

Introductory Chapter

1 General introduction:

Urban development along coastlines is a global phenomenon characterized by high population densities and intense economic activity in shoreline zones. This trend—fueled by tourism, industrialization, and residential expansion—poses significant challenges for environmental sustainability, spatial governance, and risk management, including erosion, flooding, and climate vulnerability (Neumann et al., 2015; Nicholls & Cazenave, 2010).

One of the most emblematic manifestations of this phenomenon is balnéarisation, or the transformation of coastal areas into zones primarily dedicated to tourism and leisure. Widely observed in countries such as France and Brazil, this dynamic raises critical issues related to the production of space, environmental degradation, and the evolving relationship between communities and the coastline (Claval, 2005; Capel, 2007; CAPES/COFECUB, 2018). For instance, in France, over 41,000 hectares of urban land are projected to suffer from coastal erosion by 2100, threatening not only homes and infrastructure but also cultural landscapes (ONERC, 2021). Similar pressures are observed across the Global South, notably in Colombia and the Pacific Islands, where unregulated urbanization and mangrove destruction increase ecological fragility (Alongi, 2008; McGranahan et al., 2007).

In Algeria, coastal urbanization has intensified under the influence of demographic growth, centralized economic structures, and escalating housing demand. Coastal regions now concentrate a significant portion of the nation's population and infrastructure (ANAT, 2010). The city of Tipaza, located on the Mediterranean coast, epitomizes these trends. Within it, the neighborhood of Hadjret Ennous offers a particularly acute case, where informal development and standardized public housing projects (such as the AADL program) have disrupted both ecological continuity and cultural identity (Djebar, 2015).

Coastal communities such as Hadjret Ennous are now at a crossroads, grappling with the dual imperatives of modern development and ecological-cultural preservation. The shift from traditional terraced houses—known for fostering strong social ties and climate-adaptive design—towards standardized, repetitive housing blocks has generated negative consequences: fragmentation of community life, weakened climatic resilience, diminished quality of life, and erosion of the region's architectural vernacular.

In response to these challenges, this thesis investigates the potential of the Pyramidal Organization of Collective Housing as a viable, sustainable, and culturally embedded alternative. This modular, tiered urban housing typology aligns with the site's rugged

topography and offers several critical advantages: stepped massing for natural ventilation and daylight access, integration of shared and private terraces, ecological material use, and architectural continuity with the surrounding environment (Fouchier, 2001; Alexander et al., 1977; Gehl, 2010; Ratti et al., 2005).

The overarching goal of this research is to collaboratively prototype a hybrid housing model, tailored specifically to Hadjret Ennous's socio-ecological context. This includes participatory design with local stakeholders—residents, architects, ecologists—to ensure the outcome addresses displacement risks, cultural erosion, and environmental vulnerability. Ultimately, this project aspires to develop a replicable framework for equitable coastal development, where architecture becomes a lever for resilience, inclusivity, and spatial justice.

2 Research problematic:

Most cities shaped by socio-cultural depth and geographic constraints must navigate significant tensions between modernization and continuity. Particularly in coastal regions with rigid topographies—like Hadjret Ennous—the pressures of urbanization and housing shortages have led to development strategies that often contradict local identity and urban form.

Aldo Rossi conceptualized the city as a linguistic structure, emphasizing the role of urban form in preserving collective memory and continuity (*The Architecture of the City*, 1966). Jane Jacobs, similarly, denounced standardized modernist housing for dismantling the “organized complexity” of vibrant neighborhoods (*The Death and Life of Great American Cities*, 1961). Yet, state-imposed programs like the AADL in Algeria tend to replicate foreign, monolithic typologies that ignore the existing spatial, social, and climatic logics of their contexts.

Amid growing urbanization, many cities have turned to vertical densification—mid- to high-rise housing blocks—as a pragmatic response to population pressure and limited land. While this model maximizes land use, it often fails to account for critical socio-spatial dynamics. Private and public outdoor spaces are minimized or poorly planned; architectural uniformity dominates; and cultural adaptability is neglected.

In contrast, traditional terraced housing presents a human-scaled, socially cohesive, and climate-adaptive alternative. It promotes private outdoor living, social interaction, and contextually appropriate aesthetics. However, its low-density, land-intensive nature renders it inefficient in high-demand, spatially constrained contexts like Hadjret Ennous.

This dilemma poses a fundamental question: **Can a hybrid architectural model unify the spatial efficiency of vertical densification with the socio-cultural and climatic benefits of terraced housing?**

In Hadjret Ennous, the conflict between AADL-style collective housing and the traditional terrace house is a spatial and cultural rift. While the former responds to the urgency of housing shortages, it compromises social life, environmental performance, and architectural character. The latter—despite being more attuned to local lifestyles and climate—cannot accommodate the needs of a growing population.

The Pyramidal Housing Model proposes a middle path. By stacking dwellings in a stepped configuration, this typology can combine compactness with spatial generosity. Terraces on multiple levels can accommodate family life, community rituals, and Mediterranean climate conditions. Modular design can promote diversity in housing typologies while maintaining formal unity and topographical adaptation.

This leads to a series of research questions that will guide the present study:

- How can the pyramidal housing model ensure that terraces remain functional and responsive to the familial, cultural, and climatic needs of Hadjret Ennous residents?
- In what ways can passive design principles—such as cross-ventilation, solar orientation, and thermal mass—be integrated into the pyramidal configuration to enhance environmental performance?
- How can this typology adapt to rugged terrain while maintaining architectural continuity and respecting the existing urban morphology of Tipaza?
- Can pyramidal collective housing serve as a replicable model for other Algerian coastal cities facing similar pressures of densification, identity erosion, and ecological vulnerability?

Through these inquiries, this thesis aims to articulate a new architectural paradigm: one that transforms fragile coastal settlements into resilient, inclusive, and culturally meaningful communities.

3 Hypothesis

The research is grounded in the central hypothesis that the pyramidal organization of collective housing can serve as an effective and context-sensitive alternative to both traditional terrace housing and standardized mass housing typologies currently proliferating in Hadjret Ennous. More specifically, the hypothesis posits that:

The pyramidal model is capable of achieving higher residential density than traditional terrace houses while simultaneously preserving, or even enhancing, key socio-spatial benefits—namely, access to functional private and semi-public terraces, opportunities for community interaction, and passive climatic comfort.

It is further hypothesized that this architectural configuration:

- Promotes sustainable land use through vertical stratification, thereby responding efficiently to the site's constrained topography;
- Reinforces social cohesion by facilitating interaction within a hierarchy of public, semi-public, and private spaces;
- Supports cultural continuity by integrating spatial elements aligned with local vernacular traditions;
- Enhances resilience to climate change through passive design strategies such as natural ventilation, solar control, and green integration.

This hypothesis frames the pyramidal housing model not merely as a spatial solution to densification, but as a multidimensional framework capable of addressing the socio-cultural, morphological, and environmental imperatives of coastal cities like Hadjret Ennous.

4 Thesis objectives:

This research aims to critically investigate and propose an innovative residential model for coastal towns, specifically within the socio-ecological context of Hadjret Ennous. The study seeks to bridge the spatial and cultural disjunction between traditional terrace housing and standardized collective developments through the conceptual and architectural exploration of the pyramidal organization of collective housing. Our main objective is to prototype an alternative urban and architectural model that reconciles residential density, socio-spatial quality, and ecological sensitivity, offering a sustainable response to the challenges of

urbanization in coastal Algerian towns. However, the specific objectives of this thesis are outlined as follows:

- To analyze the socio-cultural, environmental, and morphological dynamics of Hadjret Ennous: this involves mapping its topography, demographic trends, and built environment to understand how traditional and modern housing patterns influence community life, spatial usage, and environmental performance.
- To evaluate the spatial and climatic limitations of current terrace and collective housing typologies: this includes assessing their impacts on social cohesion, thermal comfort, land consumption, and vernacular continuity in Mediterranean coastal conditions.
- To formulate and test the architectural viability of the pyramidal collective housing model: emphasis is placed on designing a modular, topography-adapted structure that promotes passive cooling, daylight access, multifunctional terraces, and social interaction through spatial gradation.
- To integrate participatory design methods into the research process: this ensures alignment between the proposed solution and the lived realities, needs, and aspirations of local inhabitants, while reinforcing a bottom-up approach to spatial justice and environmental stewardship.
- To establish design guidelines transferable to similar Algerian coastal settings: the final objective is to synthesize insights into a strategic framework applicable in other high-pressure zones, enabling municipalities and housing agencies to adapt the model based on local variables.

5 Research Methodology:

4.1. Research Approach

The study employs a **mixed-methods strategy**, integrating both **qualitative and quantitative techniques** to ensure a holistic understanding of the research subject. This methodological pluralism enhances the depth and validity of findings by triangulating insights from various sources.

- **Qualitative methods**, including semi-structured interviews, ethnographic on-site observations, and participatory analysis, were instrumental in capturing residents' lived experiences, spatial practices, and perceptions of terrace functionality and collective housing.

- **Quantitative tools**, such as GIS-based spatial analysis and typomorphological metrics, enabled objective measurement of physical attributes—housing densities, terrace sizes, spatial distributions, and solar access patterns—thereby grounding qualitative insights in empirical spatial data.

This dual-pronged methodology is particularly relevant in exploring how architectural configurations—especially pyramidal collective housing—mediate socio-spatial dynamics, environmental integration, and cultural continuity in constrained urban settings like Hadjret Ennous.

4.2.Data Collection and Analysis Techniques

To ensure methodological robustness, the research employed a multi-tiered analytical framework combining spatial, typological, and regulatory assessments.

- **Typomorphological Analysis:** Used to examine the evolution of housing forms, spatial organization, and land-use patterns, this technique provided insights into the historical layering of urban morphology and how contemporary housing forms disrupt or reinforce established spatial logics.
- **GIS and Geospatial Tools:** Utilizing ArcMap 10.8 and ArcScene, the spatial configuration of Hadjret Ennous was digitally modeled. Analysis focused on topography, land use, built densities, and terrace orientations, enabling the identification of potential integration strategies for private outdoor areas within high-density frameworks.
- **Documentary and Regulatory Review:** Urban planning instruments—such as the PDAU (Plan Directeur d'Aménagement et d'Urbanisme), POS (Plan d'Occupation des Sols), and land-use restriction maps—were examined to understand zoning constraints, development potentials, and alignment with national housing policy frameworks.

The combination of these tools facilitated a comparative, layered analysis that embedded architectural exploration within a grounded understanding of planning policy, user behavior, and environmental adaptation.

4.3.Justification of Methodological Choices

The methodology adopted reflects the transdisciplinary nature of the research problem. By intersecting spatial analytics with qualitative inquiry, the study transcends reductive evaluations of form and function to capture the relational dynamics between architectural

design, social behavior, and ecological performance. This methodological orientation aligns with the research objective: to explore how innovative residential typologies, specifically the pyramidal housing model, can mediate between the imperatives of urban densification, social cohesion, cultural continuity, and environmental resilience in coastal Algerian contexts.

4.4. Research limitations:

There was restricted access to some data, like statistics on demographics, some were outdated while others were contradicted on different sources. Additionally, the length of the fieldwork was limited by time restrictions, which made it harder to observe seasonal changes in urban activity.

5. Thesis structure

This thesis follows a structured and pedagogically coherent framework. It is organized into three major chapters, each contributing progressively to the development of the research, from theoretical foundations to applied design solutions:

Chapter 1: General Introduction

This opening chapter sets the conceptual foundation of the study. It introduces the central research theme and outlines the scope and significance of the inquiry. The key research questions, overarching and specific problematics, working hypotheses, and methodological orientations are presented to frame the intellectual trajectory of the work.

Chapter 2: Literature Review and Comparative Case Studies

This chapter provides a critical synthesis of the existing literature relevant to the research topic. It examines core theoretical and architectural concepts such as the terraced housing model, the pyramidal organization of collective housing, and the integration of private outdoor spaces in residential design. To enrich the theoretical discussion with empirical insights, four international case studies were selected based on their innovative typological and spatial approaches: Terrassenhaus – Berlin (Germany), Alexandra Road Estate- London (United Kingdom), Koseze Housing Estate – Ljubljana (Slovenia), Heinz-Nittel-Hof – Vienna (Austria). These projects are analyzed in terms of their morphological configurations, socio-spatial impacts, and relevance to Mediterranean coastal urbanism.

Chapter 3: Urban Diagnosis and Design Proposal for Hadjret Ennous

This final chapter focuses on the applied dimension of the research. It includes a detailed diagnostic analysis of the site of Hadjret Ennous, considering both its natural and anthropic components. The analysis is organized as follows:

1. Natural and Environmental Context: Geographic and environmental setting, historical evolution, climate patterns, biodiversity, and geological vulnerabilities.
2. Socio-Demographic Profile: Population dynamics, gender distribution, age structure, local economic activities, education levels, and employment statistics.

Building on this comprehensive urban reading, the chapter culminates in the articulation of a context-sensitive architectural proposal. The design phase operationalizes the theoretical and empirical findings to prototype a pyramidal collective housing model adapted to the coastal topography and socio-cultural realities of Hadjret Ennous.

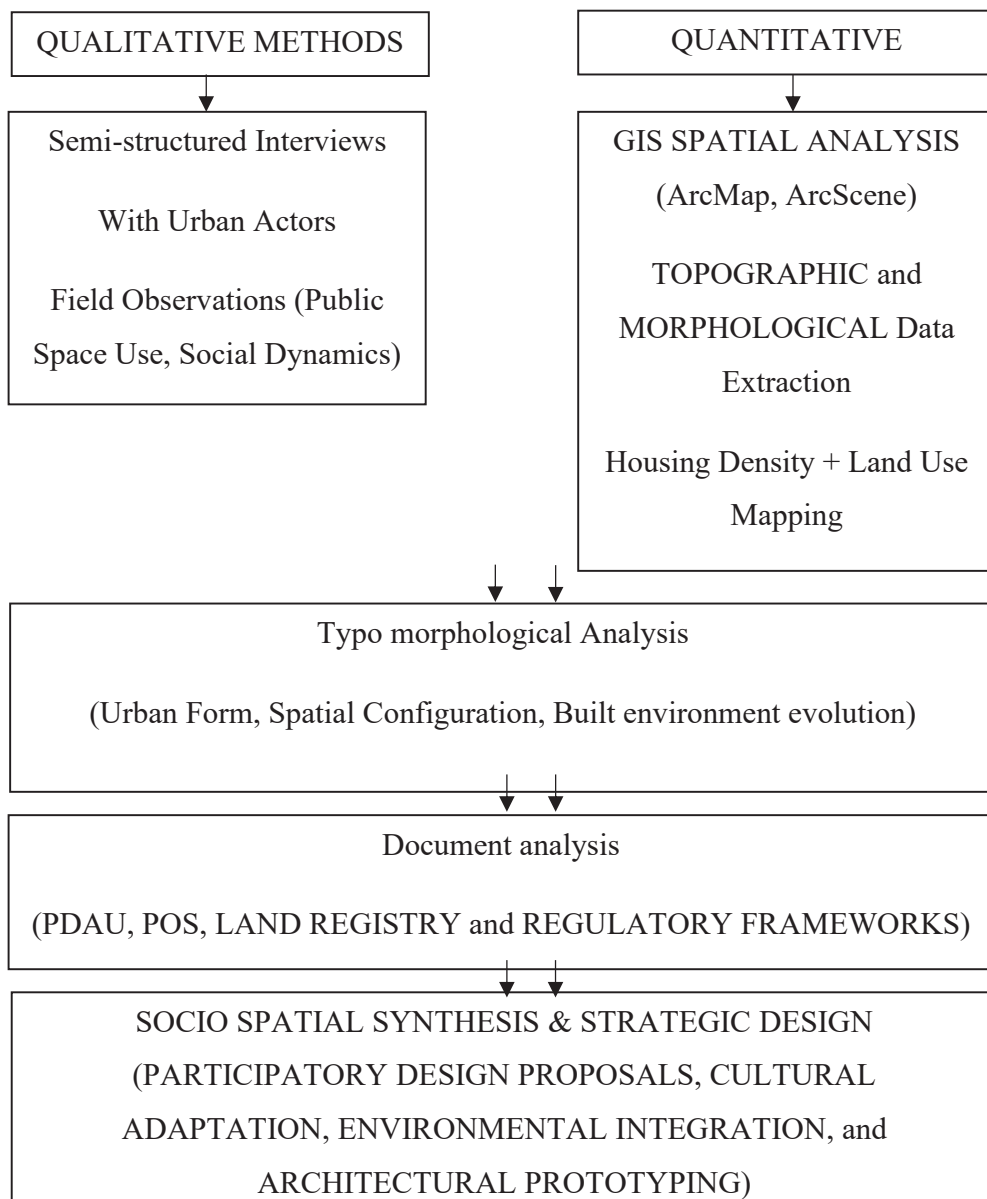


Figure 1: Overall Research Strategy (authors)

CHAPTER 02

Literature Review and Comparative Case Studies

Introduction:

This chapter will provide the theoretical foundation for this research, synthesizing insights from a variety of sources, including books, theses, published articles, and case studies. The chapter commences with an examination of the organization of collective housing in a pyramidal structure, with a view to establishing this approach as a viable alternative to the traditional "Terrace house". The following key concepts will be examined: urban integration through housing types, urban project design and context.

The second section will review case studies relevant to the research topic. The goal is to establish a robust theoretical basis to support the conceptualization of the urban project.

1. Conceptual framework:

1.1. From terraced Houses ...

1.1.1. Definition of Terraced Houses

Terraced housing refers to a residential typology characterized by a linear arrangement of attached houses that have party walls and are typically aligned along a street or courtyard. This typology emphasizes regularity, repetition, and spatial efficiency with each house occupying a narrow, deep plot¹ (Edwards, 1982). Historically, terraced housing evolved to meet pressure from urbanization during 18th- and 19th-century Europe, particularly in urban industrialized areas such as London and Manchester, where high population concentrations meant that laborers needed to be housed in closely spaced, cheap accommodation² (Muthesius, 1982). The linear replication that is contained in the terraced house produces a rigid spatial organization, with density over flexibility. The unit is limited in size to a common footprint, often with little room for architectural innovation or flexibility in accommodating diverse needs from users³ (Hillier & Hanson, 1984).

1.1.2. Historical context and evolution

The spread of terraced housing during the Industrial Revolution was driven by economic pragmatism. For example, London's Georgian and Victorian terraces were designed to maximize land use while accommodating rapid urban migration⁴ (Olsen, 1982). However, this repetition often sacrificed environmental and social quality. Early terraces lacked adequate

¹ John N. Edwards et al, *Housing Type, Stress, and Family Relations*, Oxford university press, (1982).

² Stephan Muthesius, *The English Terraced House*, New Haven: Yale University Press (1982).

³ Bill Hillier & Julianne Hanson, *The Social Logic of Space*, Cambridge University Press (1984).

⁴ Donald J. Olsen, *Town Planning in London: The Eighteenth and Nineteenth Centuries*. Yale University Press. 2nd ed, 1982.

ventilation, daylight, and private outdoor space, issues that persist in many contemporary iterations⁵ (Curl, 2016).

1.1.3. *Different limitations of terraced houses*

Terrace houses may present some limitations therefore reducing their versatility and polyvalence, some of these limitations undermine their overall viability for the users. The following outlines some of the key constraints:

a- Typical layout and spatial limitations:

The traditional terraced house layout is marked by long, narrow plots (often 4–6 meters wide) with shared walls, which impose structural and functional constraints. Key shortcomings include:

- Minimal private outdoor space: Rear gardens or yards are often shallow and overshadowed by adjacent buildings, reducing usability⁶ (Bentley et al., 1985).
- Linear Repetition and Monotony: The uniform façade and repetitive floor plans stifle architectural diversity, contributing to visual and functional homogeneity⁷ (Jacobs, 1961). Hillier and Hanson's *space syntax* theory (1984) critiques such layouts for their "shallow permeability", whereas the spatial configurations often limit movement and interaction⁸. In terraced housing, the linear configuration restricts connectivity and hierarchy between public and private zones, which reduces opportunities for social engagement or adaptable use.

b- Environmental performance limitations

- Restricted Natural Light Penetration: Long, narrow form of old terraced houses restricts front and rear elevations to fenestration and reduces daylight to penetrate to interior rooms. North or south orientation in single aspect is utilized to aggravate the condition to necessitate use of artificial lighting for kitchens, bathrooms, and stairs. (Littlefair, 1991) notes that the terraced housing is not typically consistent with recommended levels of daylight factor (at least 2% for living rooms), particularly in the middle units of long terraces. Such noncompliance does not meet any available level of sustainability⁹, such as

⁵ James Stevens Curl and Susan Wilson, *The Oxford Dictionary of Architecture*, 3rd ed, Oxford university Press, (2016).

⁶ Ian Bentley et al, *Responsiveness Environments: A manual for designers*, Architectural Press (1985).

⁷ Jane Jacobs. *The Death and Life of Great American Cities*. New York: Random House. (1961).

⁸ Bill Hillier & Julianne Hanson, *The Social Logic of Space*, Cambridge University Press (1984).

⁹ Paul Littlefair, P. J. *Site Layout Planning for Daylight and Sunlight*. Bre Press. (1991).

BREEAM daylighting standards (BRE, 2018), in offering equitable exposure to daylight for enhancing occupant health.

- **Poor Ventilation and Air Quality:** Inability to achieve cross ventilation in single-aspect homes retains stale air and moisture, which poses mold growth and respiratory disease risks. Terraced house's front and back windows system creates a "tunnel effect" whereby ventilation is restricted in linear paths without circulating effectively (CHSE, 2015). Research conducted by Gupta and Gregg (2016) set that UK inner city mid-terrace houses contained 30% higher humidity than comparable semi-detached homes, which they found was due to systemic ventilation faults¹⁰.
- **Urban Heat Island (UHI) Intensification:** The solid, compact masonry external covering of the terraced dwelling house is responsible for increasing UHI impact through solar heating and retention. (Oke, 1982) refers to the street appearance of the terraced house as "urban canyons," in which abrupt vertical partitions between the buildings retain heat and restrict night-time cooling¹¹. London's Islington, a traditional terraced area, had 5–7°C higher summer temperatures than similar green spaces in comparison (Greater London Authority, 2021). Heat stress creates cooling energy demands that undermine climate resilience.

c- Social Limitations

- **Privacy Deficits in Outdoor Spaces:** Terraced house back gardens are typically narrow (3–4 meters wide) and bordered by high walls or fences, creating claustrophobic under-used spaces (Bentley et al. 1985), such "defensible space" designs as privileging surveillance at the expense of usability, as residents tend to find such areas insecure or vulnerable. The lack of acoustic privacy from party walls also discourages outdoor activity, as indicated by a survey of Manchester's Victorian terraces¹² (Ravetz, 2001).
- **Constrained Community Interaction:** The rigid linearity of terraced streets deters neighbourly and social encounters. (Jacobs, 1961) argues that healthy city neighborhoods require "eyes on the street" and mixing of use, but consistency of terraced housing prevents spatial differentiation¹³. Pavement-accessible front doors without in-between spaces (e.g., porches or front gardens) reduce possible neighbor contact opportunities¹⁴ (Gehl, 2010).

¹⁰ Gupta, R., & Gregg, M. Building and Environment. Science Direct Journal (2012).

¹¹ Oke T.R. The Energetic Basis of the Urban Heat Island. Quarterly Journal of the Royal Meteorological Society. (1982).

¹² Alison Ravetz, A. *Council Housing and Culture: The History of a Social Experiment*. Taylor and Francis. (2001).

¹³ ¹³ Jane Jacobs. *The Death and Life of Great American Cities*. (1961),

¹⁴ Jan Gehl, J. *Cities for People*. Island Press. (2010).

Among Bristol's terrace areas, one study determined 68% of respondents had fewer than five pleasant contacts with neighbors per month, correlated with low subjective social cohesion scores (Power, 2008).

- **Inflexibility for Demographic Diversity:** The standardized terrace house floor plans are also not adaptable to evolving needs in family groups, e.g., multigenerational or aging in place. Their absence of adaptable spaces (e.g., ground-floor bedrooms or accessible entrances) isolates aged and disabled home dwellers, evidenced by a UK Housing Survey¹⁵ (DCLG, 2017). Parents with children also face issues when repurposing narrow, multi-story layouts as a workplace for those distant and an entertainment area¹⁶ (Carmona, 2009).

d- Limitations of the Outdoor Spaces in Terraced houses:

- **Narrow and shaded backyards:** The elongated, narrow layout of the rear gardens cast too much shadow, particularly in mid-terrace houses. Littlefair (1991) indicates that inner terraced sites have only 30–50% of daylight for detached housing, limiting their functionality for gardening or recreation. This issue is compounded by overshadowing from adjacent buildings, violating guidelines for "usable outdoor space" outlined in the UK's *Manual for Streets* (DfT, 2007), which recommends a minimum of 5 meters width for functional private gardens.
- **Lack of usable front yard space:** Terraced dwellings do not tend to have front gardens or are reduced to shallow "transition zones" filled with rubbish bins and vehicles. Jacobs (1961) criticizes such a configuration for eliminating the separation of public from private space, exposing people to the sound of the street, and lowering the potential for informal social interaction. A study of Bristol's Victorian terraces found that 82% of residents avoided using front yards due to privacy concerns.
- **Homogeneity of outdoor spaces:** The repetitive layout of terraced gardens represses ecological and aesthetic diversity. Standardized outdoor spaces, according to Rowe and Koetter (1978), fail to accommodate varied user needs, such as children's play space, urban agriculture, or quiet sanctuaries. Research by Thompson (2002) found that 67% of the occupants of terraced housing used the word "monotonous" to describe their gardens, citing identical fencing, paving, and planting schemes between zones.¹⁷

¹⁵ Office, S. *The Stationery Office Annual Catalogue*. (2017).

¹⁶ Carmona, M. Design Coding and the Creative, Market and Regulatory Tyrannies of Practice. *Urban Studies*. (2009).

¹⁷ Thompson, C.A. Managing the Work-Life Balancing Act: An Introductory Exercise. (2002).

- **Inflexibility to changing needs:** Terraced gardens lack adaptability to demographic shifts, such as aging populations or growing families. The narrow, linear form complicates modifications like installing accessible pathways or expanding living spaces outdoors. Carmona (2009) highlights that fewer than 15% of UK terraced homes have gardens adaptable for wheelchair access¹⁸, based on data from the *English Housing Survey* (DCLG, 2017). Similarly, the lack of horizontal space restricts the integration of sustainable technologies, such as rainwater harvesting systems or solar panels¹⁹ (Gupta & Gregg, 2016).

1.2. ... to pyramidal organization

1.2.1. Definition of Stepped Architecture:

Stepped architecture, or "cascading" or "terraced" design, is a spatial arrangement in which building volumes are stacked in ascending or descending levels to create a series of interconnected platforms or terraces. Unlike linear repetition of traditional terraced housing, stepped architecture employs a three-dimensional, non-linear geometry to disrupt rigid urban patterns, fostering visual dynamism and functional diversity²⁰ (Frampton, 2020). The typology is characterized by:

- **Vertical layering:** The structures ascend in staggered tiers, often along topographic contours or engineered slopes²¹ (Alexander et al., 1977).
- **Setbacks and overhangs:** The upper floors recede back from the building footprint, creating shaded exterior spaces and reducing solar gain²² (Baker, 2019).
- **Interconnected terraces:** Each level contains private or semi-private outdoor areas while maintaining a visual and physical exposure to communal spaces²³ (Blundell Jones, 2016).

Stepped architecture was an answer to the limitations of planar urban forms, and the ziggurats of Mesopotamia and the cliff dwellings of Mesa Verde were early implementations. It has now been revitalized for modern contexts to address problems of density, sustainability, and social harmony in communal housing²⁴ (Safdie, 1997).

¹⁸ Carmona, M. *Design Coding and the Creative*, (2009),

¹⁹ Gupta, R., & Gregg, M. *Building and Environment*.

²⁰ Kenneth Frampton. *Modern Architecture: A Critical History*, Thames & Hudson. (2020).

²¹ Christopher Alexander et al. *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, (1977).

²² Baker N et al. *Daylight Design of Buildings: A Handbook for Architects and Engineers*. James & James (1999).

²³ Peter Blundell Jones, *Architecture and Ritual: How Buildings Shape Society*; Bloomsbury Academic (2016).

²⁴ Safdie, M., & Kohn, W. *The City After the Automobile*. (1997).

1.2.2. *Breaking the linear paradigm: Contrast with terraced housing*

Stepped architecture contrasts with traditional terraced houses that depend on horizontal repetition to limit space and social opportunities. Stepped architecture subverts linearity by vertical articulation to allow:

- **Enhanced light and ventilation:** Experts agree that the staggered form lets light seep and penetrate deeper into lower floors and allows cross-ventilation from more than one façade.
- **Reduced monotony:** Irregular massing creates varied sightlines and architectural interest, countering the visual homogeneity of terraced rows²⁵ (Jacobs, 1961).
- **Topographic integration:** Stepped architecture integrates itself on sloped sites, minimizing excavation and despoliation of landscape—a radical contrast to force linear design on flat plots²⁶ (Lynch, 1960).

For example, Habitat 67 (Montreal, 1967) by Moshe Safdie demonstrated that high density (125 dwellings per hectare) could be achieved using stepped modular units without loss of light, privacy, or outdoor space.

1.2.3. *Key principles of stepped design*

- a- Cascading terraces: Each level of a stepped building serves as a private terrace for the one above and a roof for the one below. This double role optimizes outdoor space use, such as in “Housing in Rue des Suisses” (Paris, 2001), where 80% of the units have terraces over 15 m²²⁷ (Koolhaas, 2002).
- b- Spatial hierarchy and connectivity: Stepped architecture offers a gradient of public-to-private spaces:
 - Street level: Public courtyards or retail spaces.
 - Mid-levels: Semi-private terraces and collective walkways.
 - Upper levels: Private terraces with panoramic views over the city²⁸ (Gehl, 2010).

This hierarchy fosters informal social contact, such as in Barcelona's Walden 7 (1975), in which 60% of the population reported daily neighborly contact²⁹ (Bohigas, 1985).

- c- Environmental responsiveness: The stepped shape optimizes sun exposure south-facing terraces in the Northern Hemisphere receive winter sunlight, and overhangs shade

²⁵ Jane Jacobs. *The Death and Life of Great American Cities*. (1961).

²⁶ Lynch, K. *The Image of The City*. THE MIT press. (1960).

²⁷ Koolhaas, R. *JunkSpace*. (2002).

²⁸ Gehl, J. *Cities for People*. Island Press. (2010).

²⁹ Oriol Bohigas, *Reconstrucció de Barcelona*. Edicions 62, (1985)

summer light³⁰ (Olgyay, 1963). Studies on Freiburg stepped housing in Germany documented a reduction of 25% in the need for heat from linear blocks.

1.2.4. Architectural Framework of Pyramidal Collective Housing

Pyramidal collective housing refers to a stepped or ziggurat-like configuration where building mass ascends in receding tiers, creating multiple horizontal planes for outdoor spaces. This form diverges from traditional high-rises by prioritizing three-dimensional spatial diversity over vertical compaction³¹ (Frampton, 2020). Key characteristics include:

- **Tiered Terraces:** Each floor plate steps back from the one below, generating private outdoor areas for upper units while sheltering lower levels³² (Alexander et al., 1977).
- **Central Atria:** Vertical voids within the pyramid enhance cross-ventilation and daylight penetration to inner units³³ (Baker, 2019).
- **Sloped Facades:** Angled surfaces optimize solar exposure for terraces and green walls³⁴ (Olgyay, 1963).

1.2.5. Benefits of pyramidal organization

Pyramidal organization offers many benefits across multiple dimensions; the following are the main advantages:

a- Environmental benefits

These are the some of the environmental benefits of the pyramidal organisation:

- ✓ Maximizing natural light penetration

Stepped architecture multi-level configuration ensures equity in daylighting distribution by reducing overshadowing between units. Compared to linear terraced housing, in which interior units suffer reduced solar access, stepped configurations angle façades to capture sunlight on multiple orientations.

- **Solar geometry optimization:** Staggered setbacks allow lower tiers to capture sunlight unhindered by neighboring buildings. Olgyay (1963) emphasizes that stepped forms in

³⁰ Olgyay, V. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*. Princeton University Press, (1963).

³¹ Kenneth Frampton. *MODERN ARCHITECTURE: a critical history*. Thames & Hudson. (2020).

³² Christopher Alexander et al. *A Pattern Language: Towns, Buildings, Construction*, (1977).

³³ Baker, N. et al *Daylight Design of Buildings: A Handbook for Architects and Engineers*. James & James (1999).

³⁴ Olgyay, V. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, (1963).

mid-latitude climates (e.g., Europe) can receive 20–30% more annual daylight autonomy than flat-roofed blocks³⁵.

- **Glare reduction:** Overhangs and terraces diffuse direct sunlight, reducing glare without sacrificing illuminance levels. A study of Habitat 67 (Montreal) found that 90% of units met the Illuminating Engineering Society (IES) standard of 300 lux for habitable rooms in winter.
 - **Reflective surfaces:** Reflective Surfaces: Light-colored materials on terraces improve amplify daylight penetration. The BRE Daylighting Guide suggests albedo values >0.6 for stepped buildings to maximize light reflection into lower floors³⁶ (Littlefair, 1991).
- ✓ Improved natural ventilation

The staggered massing and varied heights of stepped architecture disrupt wind flows, establishing pressure gradients that drive cross-ventilation.

- **Wind channeling:** Stepped profiles also act as aerodynamic ducts, boosting air speed between levels. As per CIBSE Guide A (2015), these designs can achieve air-change rates of 4–6 ACH (air changes per hour), which is more than the 1–2 ACH of terraced housing.
- **Stack ventilation:** Vertical voids and atria in stepped buildings make use of temperature gradients to pull warm air upwards, as in BedZED (London), where stepped blocks cut mechanical ventilation requirements by 50% ³⁷ (Dunster, 2008).
- **Microclimate regulation:** The Freiburg Vauban district of Germany employs stepped housing to funnel cool breezes from adjacent forests, it is reported that it reduces indoor temperatures by 3–4°C during summer.

b- Social benefits

Pyramidal organization demonstrates a strong emphasis and provides deep care towards the social aspect resulting in the improvement of quality of life as a whole.

- ✓ Social connectivity: creating communal spaces through stepped design

³⁵ Olgyay, V. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, (1963).

³⁶ Paul Littlefair, P. J. *Site Layout Planning for Daylight and Sunlight*. (1991).

³⁷ Dunster, B. *The ZEDbook: Solutions for a Shrinking World* (1st ed.). Taylor & Francis. (2008).

Stepped architecture redesigns the connection between private and communal outdoor spaces by spatially intertwining them on various levels. Unlike terraced housing, which encapsulates rear gardens, stepped arrangements create a gradient of accessibility:

- **Private terraces:** Each dwelling opens onto a private outdoor platform, usually elevated for privacy. Alexander et al. (1977) describe these as "transitional zones" negotiating indoor privacy and public interaction³⁸.
- **Semi-private walkways:** Stair and bridge connections between tiers are inhabited as informal meeting areas. Gehl (2010) describes how these "soft edges" facilitate casual interactions without intruding on residential privacy³⁹.
- **Communal roof gardens:** Shared green roofs on top of stepped blocks, like those in Siedlung Halen (Bern), provide collective areas for garden use, recreation, or celebration⁴⁰ (Blundell Jones, 2016). This overlap approach guarantees that 70–80% of stepped development residents and 30–40% of residents in terraced housing use private and shared outdoor space frequently⁴¹ (Carmona, 2009).

✓ Communal terraces and gardens as a social catalyst

Stepped architecture's terraced nature naturally creates shared landscapes that promote social cohesion:

- **Vertical plazas:** Tiered gardens serve as micro-neighborhoods, illustrated in Walden 7 (Barcelona), where weekly community markets and festivals are held in 18 interlocking courtyard⁴² (Bohigas 1985).
- **Intergenerational zones:** Sloped gardens with seating groups and playgrounds provide for various age groups. A study of Park Hill (Sheffield) found that 63% of residents used communal terraces daily, citing intergenerational bonding as a key benefit⁴³ (Ravetz, 2001).
- **Urban agriculture:** Stepped rooftops in Quinta Monroy (Chile) support community farming, reducing social isolation by 40% among participants (Aravena, 2016).

³⁸ Christopher Alexander et al. *A Pattern Language: Towns, Buildings, Construction*. (1977).

³⁹ Gehl, J. *Cities for People*. (2010).

⁴⁰ Peter Blundell Jones, *Architecture and Ritual: How Buildings Shape Society*; Bloomsbury Academic (2016).

⁴¹ Carmona, M. *Design Coding and the Creative*, (2009).

⁴² Oriol Bohigas, *Reconstrucció de Barcelona*. (1985).

⁴³ Alison Ravetz, A. *Council Housing and Culture: The History of a Social Experiment*. (2001).

- ✓ Visual connectivity and social interaction

The stepped architecture's non-linear geometry enhances visibility between units and communal space, encouraging "passive surveillance" and neighborly trust:

- **Diagonal sightlines:** Angled facades allow residents to overlook shared space without direct exposure, aligning with Jacobs' (1961) concept of "eyes on the street". In Housing in Rue des Suisses (Paris), 75% of residents perceived greater safety because of this visual permeability⁴⁴ (Koolhaas, 2002).
- **Social staircases:** Erskine has reported that Exposed stairwells and ramps in projects like Byker Wall (Newcastle) enhance chances of encounters, with 55% of residents meeting friends through these pathways.
- **Theater of activity:** Tiered balconies facing central atria, as in Gallarate Quarter (Milan), create a sense of communal spectacle, enhancing social engagement by 30%⁴⁵ (Rossi, 1982).

1.3. The outdoor living space as a key component of pyramidal organization

1.3.1. Definition and role of outdoor living spaces

The outdoor living space can be defined as a designed or a natural environment adjacent to a residential unit, it facilitates daily activities, social interactions and engaging with the nature. It ranges from privately owned terraces or balconies to public gardens and communal rooftops. It has a significant role in improving physical and psychological health, also strengthening social cohesion⁴⁶ (Kaplan & Kaplan, 1989). Research demonstrates that access to outdoor spaces significantly enhances mental well-being. Ulrich's seminal study (1984) found that hospital patients with views of nature recovered 8.5% faster than those without, underscoring the therapeutic value of natural environments⁴⁷. In residential contexts, outdoor areas reduce stress biomarkers, such as cortisol levels, by 15–20%⁴⁸ (Bowler et al., 2010).

⁴⁴ Koolhaas, R. JunkSpace. (2002).

⁴⁵ Aldo Rossi, Peter Eisenman (Introduction by), The architecture of the city, The MIT Press, (1983).

⁴⁶ Kaplan, R., & Kaplan, S. *The experience of nature: A psychological perspective*. Cambridge University Press. (1989).

⁴⁷ Ulrich RS. View through a window may influence recovery from surgery. *Science*. (1984)

⁴⁸ Bowler, D.E., Buyung-Ali, L.M., Knight, T.M. *et al.* A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health* **10**, (2010).

1.3.2. Diverse Outdoor Spaces Enabled by Pyramidal Geometry

- **Private Terraces:** Each dwelling in pyramidal housing typically accesses a private terrace proportional to its floor area. These spaces serve as extensions of indoor living areas, enabling activities like gardening, dining, and relaxation. Terraces are staggered to ensure visual privacy while maintaining sightlines to communal areas, aligning with Alexander's *Pattern 147: Outdoor Room*⁴⁹ (Alexander et al., 1977). Overhangs and trellises on south-facing terraces (in Northern Hemisphere contexts) provide summer shading while allowing winter sun penetration, reducing cooling loads by 15–20%⁵⁰ (Santamouris, 2014). In *Habitat 67* (Montreal), 85% of units feature private terraces averaging 20 m², with residents reporting 30% higher satisfaction compared to balcony-less apartments.
- **Communal Gardens:** Mid-level courtyards and plazas embedded within the pyramidal structure foster community interaction. Central gardens located at every 3–4 floors act as “neighborhood nodes,” reducing vertical segregation. Gehl (2010) observed a 40% increase in casual interactions in such configurations compared to conventional towers⁵¹. Tiered planting beds in *Bosco Verticale* (Milan) support 800 trees and 4,500 shrubs, attracting 20+ bird species and improving air quality by 15%⁵² (Arup, 2015). The *Pyramid Housing Complex* (Eindhoven) integrates communal herb gardens on its 5th and 10th tiers, with 60% of residents participating in weekly gardening sessions (Dobbelsteen and tillie, 2012).
- **Rooftop Gardens:** The pyramid's apex often features expansive green roofs that serve dual ecological and social purposes. Vegetated roofs absorb 60–70% of rainfall, reducing urban runoff⁵³ (Oberndorfer et al., 2007). Rooftop farms in *Quinta Monroy* (Chile) increased community cohesion by 35%, with produce sales funding local amenities⁵⁴ (Aravena, 2016). *Hammarby Sjöstad* (Stockholm) uses pyramidal rooftops for solar panels and recreational decks, Reports suggest that 25% reduction in energy demand was achieved.

⁴⁹ Christopher Alexander et al. *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, (1977).

⁵⁰ Santamouris, M. *Cooling the cities. A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments*. *Solar Energy*, 103, 682–703 (2014).

⁵¹ Gehl, J. *Cities for People*. (2010).

⁵² Arup. (2015). *Bosco Verticale – Milan*.

⁵³ Erica Oberndorfer et al, *Green Roofs as Urban Ecosystems: ecological structures, functions, and services*, (2007).

⁵⁴ Aravena, A. *Reporting from the Front: 15th International Architecture Exhibition*. Marsilio Editori. (2016)

1.3.3. *Benefits of the outdoor living space*

The outdoor living space offers a range of benefits that enhances the communal dimension and fostering the social cohesion, some are addressed in following:

a- Enhancing Community and Social Interaction

Outdoor living spaces act as social catalysts by fostering spontaneous encounters and collective activities:

- **Communal Terraces:** Tiered platforms in pyramidal housing, such as *Habitat 67* (Montreal), create micro-communities. Safdie reported that 70% of residents engaged in weekly social activities on shared terraces, compared to 30% in conventional apartments.
- **Co-Designed Gardens:** Participatory design of outdoor spaces, as seen in *Quinta Monroy* (Chile), increased community trust by 40%⁵⁵ (Aravena, 2016).
- **Playable Landscapes:** Multi-level play areas in *Siedlung Halen* (Bern) encouraged cross-generational interaction, with 65% of parents citing improved neighbor relationships⁵⁶ (Blundell Jones, 2016).

Gehl (2010) argues that such spaces embody the "soft edges" of urban design, where semi-private zones mediate between individual privacy and collective engagement⁵⁷.

1.3.4. *Design Principles for Maximizing Usability*

The design principles in the following are intended to maximize functional zoning, biophilic integration such as plants and water and the final aspect is materiality and durability in order to combat natural features and to ensure maximum usability across all seasons.

a- Functional Zoning:

- **Activity-Specific Areas:** Divide terraces into zones for dining (hardscape), gardening (planters), and lounging (softscape), as advocated by Francis (1987).
- **Universal Access:** Ramps and elevators connecting tiers ensure inclusivity, meeting *ADA Standards* for slope (1:12) and width (1.5 m).

b- Biophilic Integration:

⁵⁵ Aravena, A. Reporting from the Front: 15th International Architecture Exhibition. Marsilio Editori. (2016).

⁵⁶ Peter Blundell Jones, *Architecture and Ritual: How Buildings Shape Society*, (2016).

⁵⁷ Jan Gehl, *J. Cities for People*. Island Press. (2010).

- **Sensory Planting:** Incorporate aromatic herbs (lavender, rosemary) and tactile foliage (grasses, ferns) to engage multiple senses⁵⁸ (Kellert, 2018).
- **Water Features:** Reflective pools or cascading streams on communal decks lower ambient temperatures by 2–3°C⁵⁹ (Hathway et al, 2012).

c- Materiality and Durability:

- **Permeable Surfaces:** Gravel paths and porous pavers reduce heat absorption and prevent flooding, as implemented in *Eco-Link@Bidadari* (Singapore) (URA, 2022).
- **Weather-Resistant Furnishings:** Powder-coated steel benches and teak decking withstand climatic stress, extending usability across seasons⁶⁰ (Carmona, 2009).

1.4. Continuum of connection: blending private and public outdoor realms

1.4.1. Gradual Transition from Private to Public Spaces in Stepped Design

Pyramidal collective housing employs tiered geometries to create a seamless spatial gradient from intimate private areas to vibrant communal zones. This continuum is achieved through:

- **Zoned Terraces:** Private terraces at upper levels transition to semi-private walkways and shared gardens at mid-levels, culminating in public plazas at ground level. Alexander et al. (1977) describe this as *Pattern 114: Hierarchy of Open Space*, where spatial layers mediate between solitude and socialization⁶¹.
- **Visual Connectivity:** Angled façades and staggered balconies allow residents to observe communal activities without sacrificing privacy, fostering passive engagement⁶² (Gehl, 2010). In *Habitat 67* (Montreal), 75% of residents reported feeling connected to neighbors through such sightlines.
- **Threshold Elements:** Pergolas, trellises, and low walls demarcate transitions, as seen in *Siedlung Halen* (Bern), where 80% of residents identified these features as key to balancing privacy and community⁶³ (Blundell Jones, 2016).

⁵⁸ Kellert, S.R. *Nature by Design: The Practice of Biophilic Design*. Yale University Press. (2018).

⁵⁹ Hathway, E. A., & Sharples, S. (2012). The interaction of rivers and urban form in mitigating the urban heat island effect: A UK case study. *Building and Environment*, 58, 14–22.

⁶⁰ Carmona, M. *Design Coding and the Creative*, (2009).

⁶¹ Christopher Alexander et al. *A Pattern Language: Towns, Buildings, Construction*. (1977).

⁶² Gehl, J. *Cities for People*. Island Press. (2010).

⁶³ Peter Blundell Jones, *Architecture and Ritual: How Buildings Shape Society*, (2016).

1.4.2. Fostering Community Through Outdoor Spatial Hierarchy

Outdoor spaces in pyramidal housing act as social incubators by structuring interaction at varying scales:

- **Private Terraces:** Serve as personal retreats, reducing stress by 25% through biophilic elements like potted plants and water features⁶⁴ (Ulrich, 1984).
- **Semi-Private Walkways:** Stepped pathways in *Walden 7* (Barcelona) increased chance encounters by 40%, with 60% of friendships originating in these zones⁶⁵ (Bohigas, 1985).
- **Communal Gardens:** Central courtyards in *Quinta Monroy* (Chile) host weekly communal meals, boosting trust among residents by 35%⁶⁶ (Aravena, 2016).
- **Public Plazas:** Ground-level markets and amphitheaters, as in *Hammarby Sjöstad* (Stockholm), attract 200+ visitors daily, enhancing neighborhood vibrancy (Grahm et al., 2010).

This hierarchy aligns with Jacobs' (1961) advocacy for "eyes on the street" and Calthorpe's (1993) "pedestrian pockets," ensuring safety and sociability.

1.4.3. Sustainable Outdoor Spaces: Systems and Strategies

- **Greywater Recycling:** Terraced gardens in pyramidal housing integrate greywater systems that filter and reuse water from sinks and showers for irrigation. *Bosco Verticale* (Milan) recycles 25,000 liters of greywater annually, reducing potable water use by 30%⁶⁷ (Boeri, 2015). Such systems align with *BREEAM* benchmarks for water efficiency (BRE, 2018).
- **Rainwater Harvesting:** Sloped roofs channel rainwater into underground cisterns for non-potable uses. Some studies say that the Pyramid of Drottninghög (Helsingborg) captures 90% of annual rainfall, saving 1.2 million liters yearly.
- **Native Plant Integration:** "Local flora reduces irrigation needs by 50% and supports regional biodiversity." *Eco-Link@Bidadari* (Singapore) uses native species to attract pollinators, increasing butterfly populations by 150% (URA, 2022).

⁶⁴ Ulrich RS. View through a window may influence recovery from surgery. *Science*. (1984).

⁶⁵ Oriol Bohigas, *Reconstrucció de Barcelona*. (1985).

⁶⁶ Aravena, A. (2016). *Reporting from the Front: 15th International Architecture Exhibition*. Marsilio Editori.

⁶⁷ Boeri, S. (2015). *Bosco Verticale: A manifesto for sustainable living*.

- **Material Sustainability** Permeable paving and reclaimed wood decking minimize environmental impact. *Hammarby Sjöstad*'s communal decks utilize 80% recycled materials, lowering embodied carbon by 40% (Grahn et al., 2010).

2. Case studies of pyramidal organization projects

2.1. Terrassenhaus Berlin.

2.1.1. Project Overview

Name: Terrassenhaus Berlin.
 Location: Berlin, Germany.
 Vocation: Mixed Use/Residential
 Architects: Brandlhuber, Emde, Burlon,
 Muck Petzet.
 Owner: Olivia Reynolds, Elke Fala
 Date: 2018
 Surface: 3396 m²



Figure 1. Terrassenhaus building (Archdaily)

2.1.2. Location



Figure 2. National scale – Germany (Google Maps)

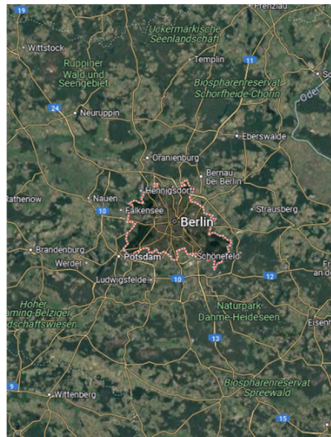


Figure 3. Regional scale – Berlin (Google Maps)

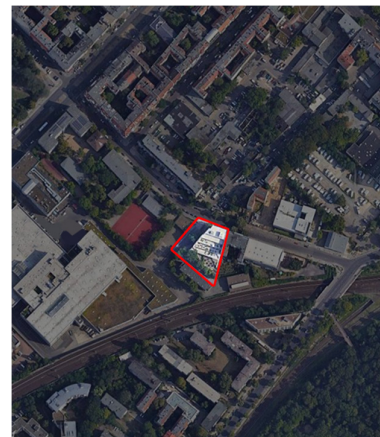


Figure 4. Neighborhood scale – Bottgerstrabe (Google Maps)

2.1.3. Plans Analysis

Each higher floor reduces in area allowing for a 6m terrace, the program changes according to available area per floor.



Figure 2. Terrassenhaus plans analysis

The lowest and highest floor is intended for public use (a gallery and a shared roof) while the rest is private, the private floors share a public walking area that connects the stairs.

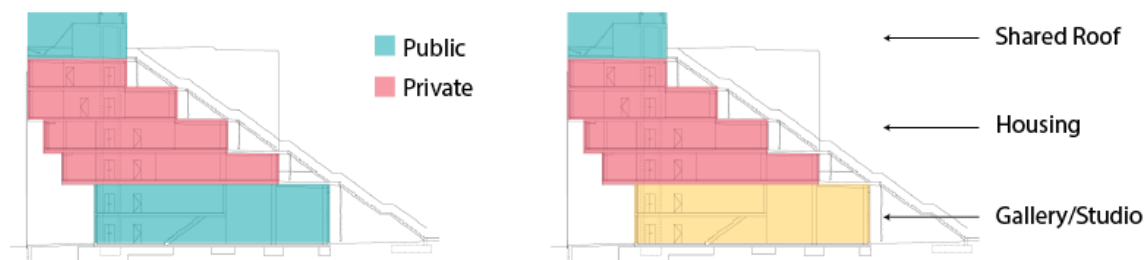


Figure 3. Terrassenhaus section analysis

2.1.4. Façade Analysis



Figure 4. Facades Analysis

The facades feature a stepped concrete form (Red), with large windows (Green) opening to terraces and to the street, enhancing natural light and connectivity with the outdoors. External staircases (Yellow) integrate into the design and maximizing the design concept of the stepped form. The detailing of the facades is minimal, with clean lines and an emphasis on function over ornamentation.

2.1.5. Key takeaways from the project

Table 1. Key takeaways from Terrassenhaus building

Advantages	Disadvantages
Versatility: The building houses a mix of residential, office, atelier, and gallery spaces, reflecting the need for multifunctional buildings in dense urban environments. This helps meet the needs of diverse users in a single location, reducing the need for additional infrastructure.	Potential for Overcrowding: The communal spaces, while promoting social interaction, could potentially lead to overcrowding in the shared areas.
Community-Oriented Design: encouraging social interaction and a sense of community. Contrasting traditional apartment layouts, which often isolate individuals.	Privacy Concerns: The external staircases and shared terraces can result in reduced privacy for residents. The proximity of neighbors on these terraces might lead to potential noise issues or a lack of personal space, which can be a downside for some.

2.1.6. Architectural key concepts

Spatial and Social Design: Each floor steps back to create a semi-public covered square, and the terraces have a semi-public character. The design aims to blur the lines between work and living, exploring the boundary between public and private. The garden has a village-like character, intended to contrast modern materials with an urban setting.

Adaptability and Versatility: The building's design, characterized by mono-materiality and versatile interiors, provides adaptable spaces for various future uses

Functional mixity: Successful integration of functional mixity resides in connecting residential and commercial elements.

2.2. Alexandra Road Estate in Camden, London

2.2.1. Project Overview

Name: **Alexandra Road Estate.**
Location: **Camden, North London, England.**
Vocation: **Mixed Use**
Architects: **Neave Brown,
Camden Council's Architects**
Owner: **Gouvernement**
Date: **1978**
N° of Units: **520**



Figure 5. Alexandra Road Estate (Archdaily)

2.2.2. Location



Figure 7. National scale – England (Google Maps)

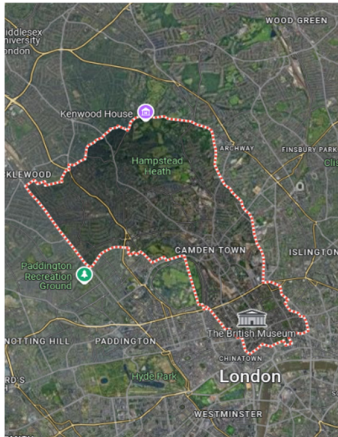


Figure 8. Regional scale - London Borough of Camden (Google Maps)



Figure 9. Neighborhood scale - Town Of Camden, Alexandra Road Estate (Google Maps)

2.2.3. Plans Analysis

520 flats varying from 1, 2, 3 or 4 bedrooms. The duplexes have bedrooms on the ground floor and a storage or a living room, while the upper floor contains the kitchen and dinner room with a terrace. Architect emphasizes on having a balcony for each bedroom/living room.

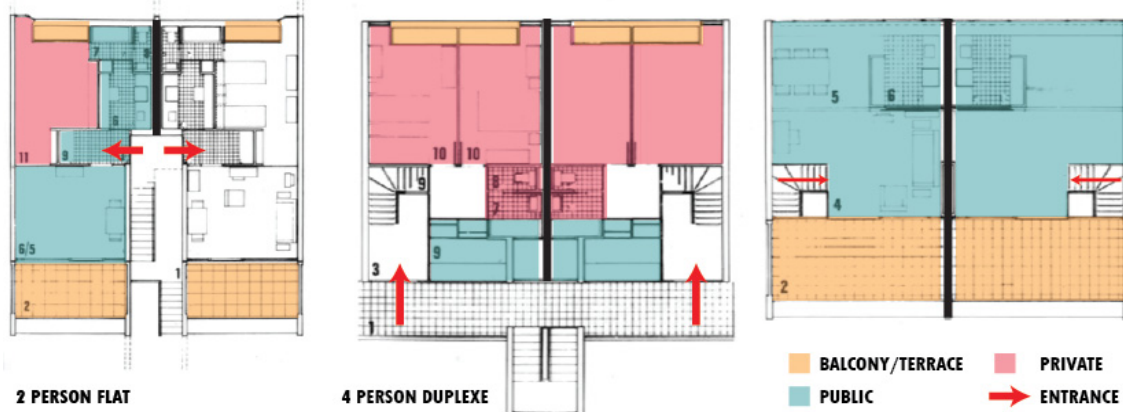


Figure 10. Plans Analysis of Alexandra Road Estate (based on Steixner, G. & Welzig, M. (2020). *Luxury for All: Milestones in European Stepped Terrace Housing.*)

Different functions of the project:

The Alexandra Road Estate combines housing with key community functions, including a school, youth club, and green public spaces. Its design promotes pedestrian circulation and social interaction, making it a model of integrated urban living.

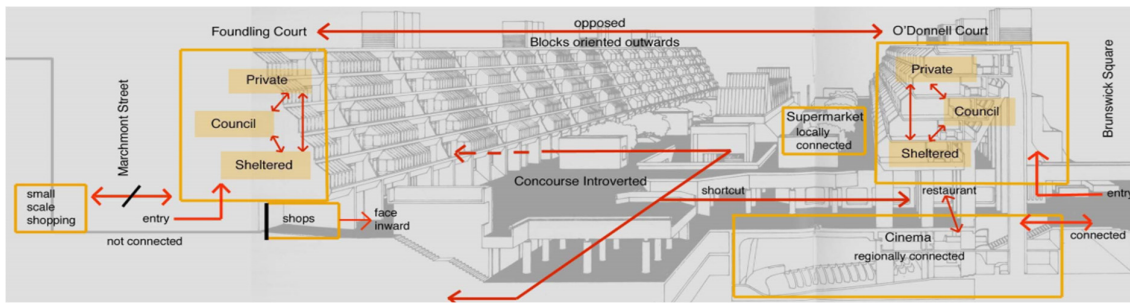


Figure 11. Functions of Alexandra Road Estate

2.2.4. Façade Analysis

The facades of the Alexandra Road Estate are defined by their Brutalist design, with raw concrete as the primary material. The use of textured concrete, strong horizontal and vertical lines, and staggered terraces. Large windows and narrow openings allow for natural light and ventilation. The design prioritizes functionality, with exposed structural elements like staircases. (See Figure. 13)

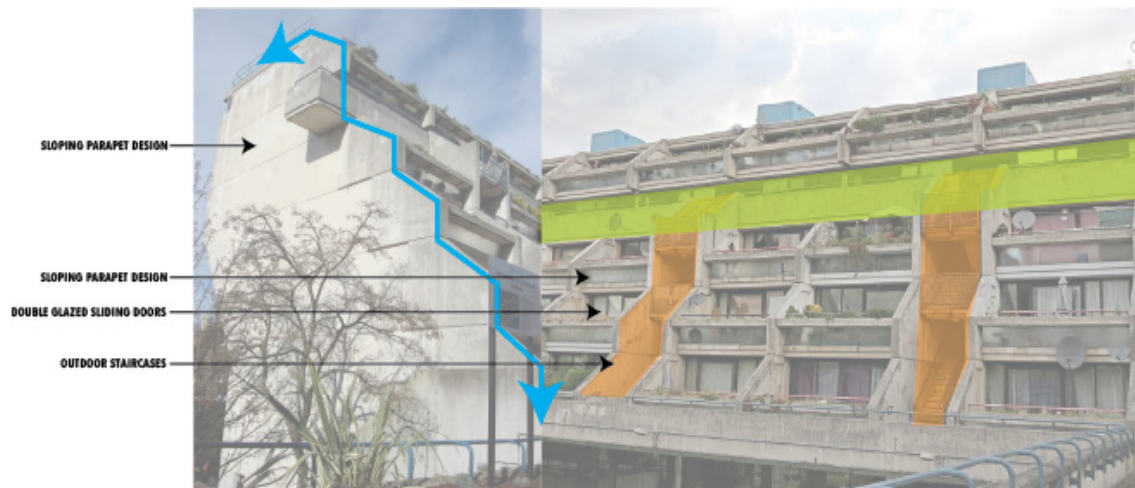


Figure 62. Façade analysis (based on. Magazyn WhiteMAD)

2.2.5. Key takeaways from the project

Table 2. Key takeaways from Alexandra Road Estate

Advantages	Disadvantages
Human Scale: Despite the scale and density of the development, the estate was designed with a strong emphasis on human scale. The layout, with its stepped terraces, reduces the impact of large, imposing buildings. The terraces and walkways are designed to create an intimate atmosphere that feels welcoming and approachable.	Poor Integration with Surrounding Urban Fabric: The estate's bold, individualistic design does not always integrate seamlessly with the surrounding architecture, making it stand out rather starkly against the existing buildings. Some critics argue that the estate disrupts the neighborhood's overall cohesion, rather than blending harmoniously with the surrounding urban environment.
Individual Privacy: The design provides privacy through its careful layout of spaces, with maisonettes and flats arranged so that each has a sense of separation from neighbors, ensuring personal space and reducing noise.	Access and Circulation Issues: The complex layout, with its elevated walkways and separate pedestrian routes, can make navigation challenging, particularly for those with mobility issues, the elderly, or families with young children.

2.2.6. Architectural key concepts

- **Layout:** The buildings are arranged in a series of interconnected blocks, with stepped terraces that follow the natural contours of the site. The estate is divided into a mix of public and private spaces, with pedestrian walkways that help foster social interaction among residents.
- **Design Philosophy:** The estate was designed with a focus on providing a high quality of life for working-class families. It emphasizes a strong sense of community through its layout, prioritizing shared spaces and a communal atmosphere.
- **Flexibility and Adaptability:** The design was created with future adaptability in mind. The layout allows for potential expansion, modifications, or changes in the use of the spaces to suit evolving community needs. The flexibility of the units also allows for different family sizes and configurations.

2.3. Koseze Housing Estate

2.3.1. Project Overview

Name: **Koseze Housing Estate.**
Location: **Ljubljana, Slovenia.**
Vocation: **Mixed Use/Residential**
Architects: **Viktor Pust**
Clients : **SGP Zidar Kočevje, Ingrad Celje**
Date: **1974-1981**
Site Area: **119,000 m²**
Built Area: **38,000 m²**
N° of units: **1548**

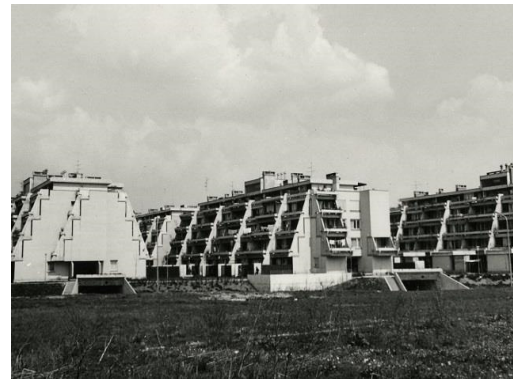


Figure 73. Koseze Housing Estate (source)

2.3.2. Location



Figure 10. National scale – Slovenia (Google Maps)



Figure 105. Regional scale - Ljubljana (Google Maps)



Figure 106. Neighborhood scale - Koseze Housing Estate (Google Maps)

2.3.3. Plans Analysis

Pedestrians and cars are separated by a basement street below the block units with garages on either side. There is also a one-way parking corridor below the complex with parking bays on both sides. The blocks have two prominent entries in each of them with apartments facing the east and west directions. Apartment designs are economic and rational. Green atriums surrounded by semi-transparent wooden fences are seen around ground floor apartments. Apartments on the upper floors have terraces designed by planters of exposed concrete and iron railing. The apartments range in size from studios to four rooms.

The four blocks have approximately twenty ground floor units opening onto the central pedestrian area of the settlement with mixed use such as shops, bars, kindergarten, pharmacy, post office, bank, etc.

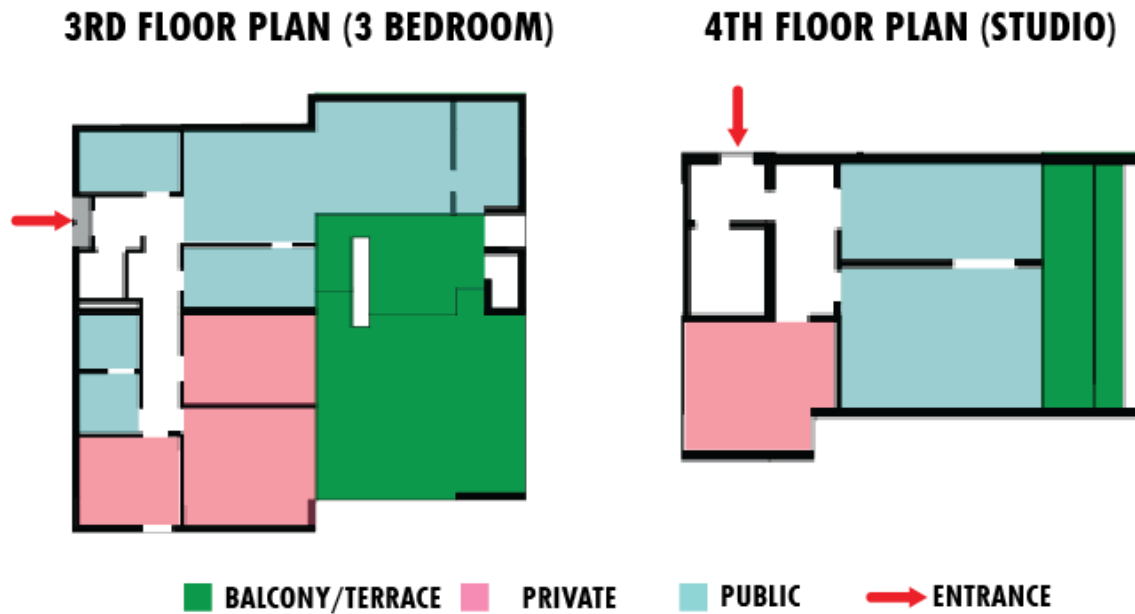


Figure 117. Koseze Housing Estate plans analysis (Authors based on Gerhard Steixner, Maria Welzig)

2.3.4. Façade Analysis

The facades of the Koseze blocks have been refurbished in recent years to meet new EU energy efficiency laws, residents modified their terraces each to his preference, some converted their open terraces into covered winter gardens. Also, the colors chosen for some blocks are bright and acrylic, contrary to the original all white giving a strongly uneven appearance to the complex. (See Figure. 19)

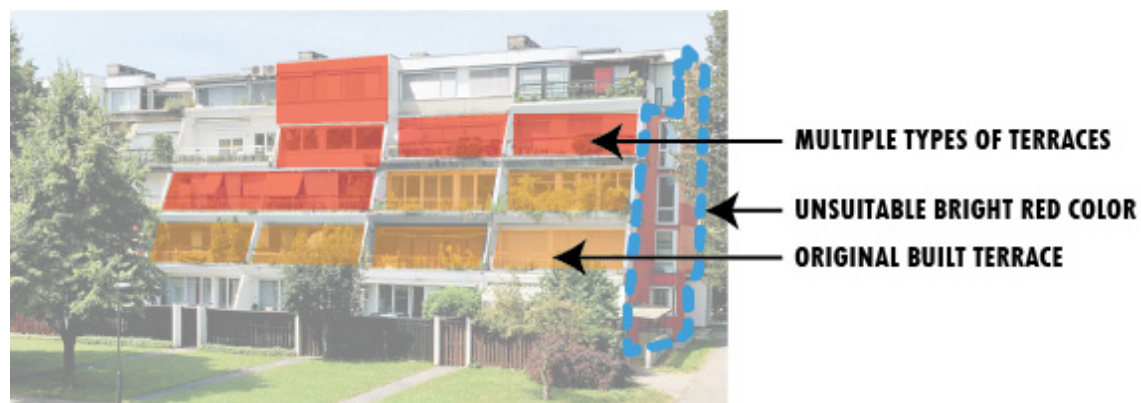


Figure 128. Koseze Housing Estate facade analysis (Authors based on Gerhard Steixner, Maria Welzig)

2.3.5. Key takeaways from the project

Table 3. Key takeaways from Koseze Housing Estate

Advantages	Disadvantages
Absence of social segregation: The settlement was originally built for the middle class. However, the high level of greenspace, good logistics near the neighborhood and plentitude of playgrounds allowed the project to house all different classes.	Increased Density Beyond Original Plans: The number of apartments nearly doubled from the original plan, leading to several issues. For instance, what was once abundance of parking spaces became a shortage, forcing residents to resort to makeshift solutions to park their cars.
Abundance of parking spaces: Pedestrians and cars are separated by an underground street beneath the block units with garages on either side. A one-way parking corridor beneath the complex also has parking spaces on both sides.	Lack of regulation and control: After the refurbishment and rehabilitation of the facades, each resident painted his own façade with a different color than their neighbors, which led to uneven appearance to the complex.

2.3.6. Architectural key concepts

Rational apartment layouts: Apartments are described as rational and economic, typically double-oriented (east-west) for good light and ventilation.

Pedestrian-friendly layout: Pedestrian and vehicular traffic are separated (cars largely underground) making the neighborhood green, traffic-free, and safer.

2.4. Heinz-Nittel-Hof

2.4.1. Project Overview

Name: **Heinz-Nittel-Hof.**
Location: **Vienna, Austria.**
Vocation: **Mixed Use/Residential**
Architects: **Harry Glück & Partner**
Clients : **City of Vienna**
Date: **1979-1983**
Site Area: **150,000 m²**
Built Area: **34,500 m²**
N° of units: **1422**



Figure 139. Heinz Nittel-Hof Location (Gerhard Steixner, Maria Welzig)

2.4.2. Location

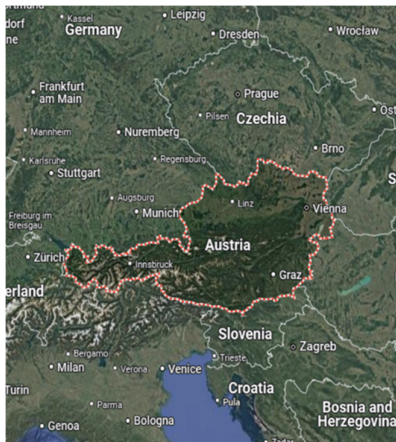


Figure 16. National scale – Austria (Google Maps)

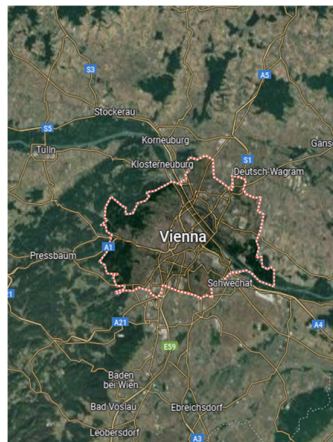


Figure 161. Regional scale - Vienna (Google Maps)



Figure 162. Neighborhood scale - Heinz-Nittel Hof (Google Maps)

2.4.3. Plans analysis

The project contains 10 blocks that house 1000 appartements. It is a modular, four-part, low-lying shape that opens up with terraces from west to east for over a kilometer. 150 parking spots on two levels. With a block depth of 18 meters and a cross-wall grid of 5.8 meters, the majority of appartments are through-units, which can be either single-story appartments or, less frequently, maisonettes. This allows for roomy layouts of up to 100 m² for a three-room appartment.

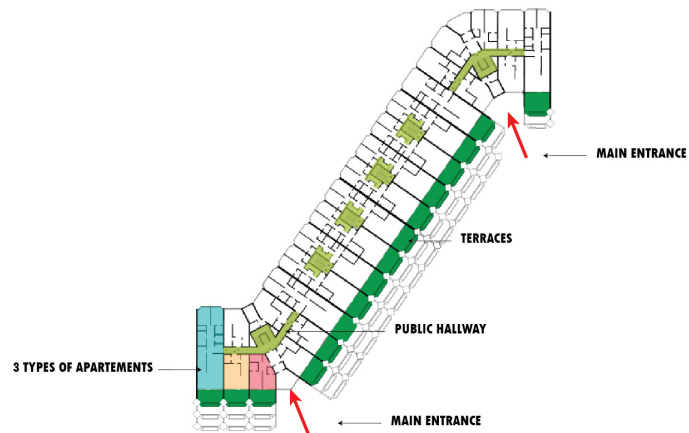


Figure 173. Heinz-Nittel Hof plans analysis (by authors based on (Steixner & Welzig, 2020))

2.4.4. Façade analysis

Although the building's mass and form are influenced by **Brutalist** tendencies, **Late Modernist** features like open terraces soften the design and gave it a human scale. The use of vegetation ensure privacy. External insulation, consisting of trapezoidal sheet metal panels positioned vertically and covered in light beige.

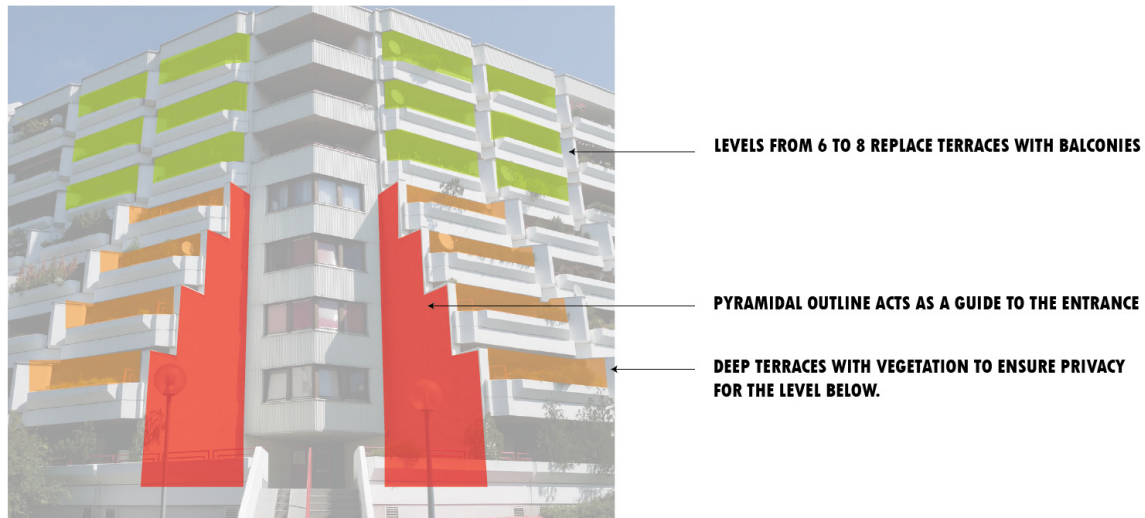


Figure 184. Heinz-Nittel Hof facade analysis (by authors based on File:Heinz-Nittel-Hof 2.jpg - Wikimedia Commons, 2011)

2.4.5. Key takeaways from the project

Table 4. Key takeaways from Heinz-Nittel Hof.

Advantages	Disadvantages
Compactness of the structures: achieved by deep block depths, yielding an extremely advantageous surface to volume ratio. This significantly enhances the buildings' energy performance in addition to being pertinent to construction and maintenance expenses.	Safety and Social Order Concerns: Some residents have expressed fear of certain areas, especially in the evenings, due to groups of youths or hearsay about violence. Broader complaints mention pollution, crime, and cultural tensions.
Extreme block depths: The design allowed for roomy three-room residences up to 100 square meters in size, which is something unheard off in the city of Vienna. This was achieved with a block depth of 18 meters and a cross wall spacing of 5.8 meters.	Scale and Potential Anonymity: The very large size of the complex might lead to feelings of anonymity for some residents.

2.4.6. Architectural key concepts:

Communal green spaces: Every appartement is oriented towards a communal pedestrian green space creating a park like micro-climate.

Traffic free environment: Tranquility and safety are enhanced by using underground parking spaces.

2.5. Analytical Insights and Design Learnings from the Case Studies:

After reviewing and analyzing the four selected projects, critical reflections were taken into consideration in order to apply or to avoid in the final project. In this table we summarize these points based on previous information.

Table 5. Critical reflections on the reviewed/studied projects

<i>WHAT TO APPLY</i>	<i>WHAT TO AVOID</i>
Design for the community: Community oriented designs tend to help people feel that they belong to the neighborhood.	Negligence of parking spaces: Parking spaces are as important as the buildings, also helps in improving quality of life for residents.
Focus on individual privacy: Orient the interior design to have more personal privacy, where residents won't feel exposed.	Accessibility constraints: Buildings and spaces should be easily accessible, particularly for those with mobility issues, the elderly, or families with young children.
Versatility: integration of functional mixity and conception of versatile spaces for multi-use.	Overcrowding and randomness: Functions shouldn't be mixed randomly, design the buildings to transition smoothly from public to private areas.

Conclusion:

This chapter has critically examined the limitations of traditional terraced housing and presented stepped (pyramidal) architecture as a viable alternative that addresses its spatial, environmental, and social shortcomings. Terraced housing, while historically efficient in accommodating urban density, suffers from rigid linearity, poor daylight and ventilation, lack of adaptable outdoor spaces, and limited social interaction. These constraints highlight the need for a more responsive architectural typology in contemporary urban design.

Stepped architecture emerges as a solution by reconfiguring residential structures into three-dimensional, tiered forms. Its key advantages include:

Enhanced Environmental Performance: Staggered designs improve natural light penetration, cross-ventilation, and microclimate regulation, reducing energy demands and urban heat island effects.

Social Connectivity: The spatial hierarchy of private terraces, semi-private walkways, and communal gardens fosters neighborly interaction while maintaining privacy.

Flexibility and Adaptability: Unlike the monotonous repetition of terraced housing, stepped architecture accommodates diverse user needs, from multigenerational living to sustainable retrofitting.

Furthermore, the integration of outdoor living spaces—ranging from private balconies to shared rooftop gardens demonstrates how pyramidal organization enhances both individual well-being and community cohesion. Case studies such as Habitat 67 and Bosco Vertical illustrate the successful application of these principles, proving that high-density housing need not sacrifice environmental quality or social vitality.

While terraced housing served as a pragmatic response to historical urbanization pressures, its inherent limitations render it insufficient for contemporary urban challenges. Stepped architecture offers a more sustainable, socially engaging, and adaptable alternative, aligning with modern demands for resilient, human-centered design. Future research should explore scalable implementations of pyramidal housing in diverse urban contexts, ensuring its viability as a model for equitable and sustainable living.

CHAPTER 03

Urban Diagnosis and Design Proposal for Hadjret Ennous

Introduction

Hadjret Ennous is a town and municipality in Tipaza Province in northern Algeria. The name "Hadjret Ennous" translates to "Half Rock" or "Spirit's Fountain" in local dialect, referring to the distinctive rock formations found in the area. This coastal settlement is part of the broader Mediterranean region, characterized by its unique climate, geography, and geological features. Located approximately 70 kilometers west of Algiers, Hadjret Ennous is positioned along the Mediterranean coastline. The region is known for its natural beauty, historical significance, and as the site of a major power plant facility (Hadjret Ennous power plant). This chapter outlines the main natural, physical, social, and urban characteristics of Hadjret Ennous. It deals with the geography, climate, ecology, and history of the site, along with demographic and employment data. Urban analysis focuses on land use, street pattern, housing typology, and buildings state, leading to a diagnosis map of the city's main issues. The chapter summarises with proposed urban interventions and introduces our pyramidal housing project.

1. An Overview of Hadjret Ennous and Its Historical Development

1.1. Geographic location:

The wilaya of Tipaza is located in northern Algeria, on the Mediterranean coast.

- It belongs to the Tell region, known for its coastal relief and fertile plains.
- It is located around **70 km west of Algiers**, reinforcing its strategic and economic importance.

Territorially, the wilaya of Tipaza is located in northern Algeria, on the Mediterranean coast.

- **To the north:** It is bordered by the Mediterranean Sea.
- **To the east:** It borders the wilaya of Algiers.
- **West:** Bounded by the wilayas of Chlef and Aïn Defla.
- **To the south:** It shares its borders with the wilaya of Aïn Defla.

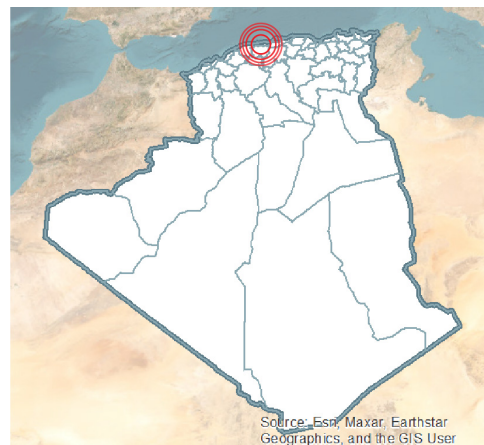


Figure 195: location of the wilaya of Tipaza

Regionally, the municipality of Hadjret Ennos, in the wilaya of Tipaza, is strategically located close to the Mediterranean coast.

- **North:** Bordered by the Mediterranean Sea.
- **South:** Bounded by the rural commune of Sidi Semiane.
- **To the east:** the commune of Sidi Ghiles.
- **To the west:** Neighboring the Messelmoun commune

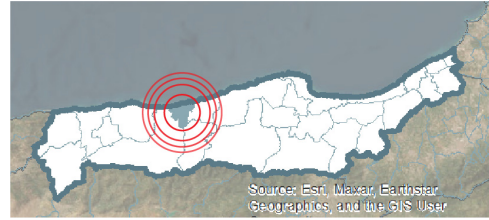


Figure 206: Location of Hadjret Ennos in the wilaya of Tipza

1.2. City's historical development:

Demographically, the indigenous people of HAJERET ENNOUS come from two distinct tribes: the first being the FEKKY BENI-AMEUR, and the second, the DJAOUT ATH-OUAGHLIS. As for its current name, the origin of the Hadjret Ennos can be traced back to four main periods as illustrated in figure 27:



Figure 217: historical evolution of Hadjret Ennos (Authors)

Pre-Roman: The archaeological record of Hadjret Ennos, while not extensively detailed in the provided material, offers glimpses into its past. A significant landmark is a 10-meter high monolith located in Hadjret Ennos, which is believed to predate the Roman era. The existence of such a structure suggests that the area held importance for earlier populations, potentially serving as a site of cultural or religious significance.

Imperial Roman era: During the Roman Imperial period, the area was recognized as a source of granite within the Roman province of Mauretania Caesariensis. This granite was utilized both locally for construction and potentially exported to other parts of the Roman Empire, placing Hadjret Ennos within the broader economic and logistical networks of that era. There are many remaining vestiges from the Roman era, notably with the exploitation of quarries and

the site of TAMZITA, where an oil mill from that time, dating back to the 1st century AD, can be found.

Turks 1515-1830: According to (Jean-Claude Rosso 2015), it was given the name “**Hadjret Ennous**” meaning "the stone in the middle", a name given by Turkish navigators in reference to the islet located some 50 meters from the central shore. This islet served as a landmark for sailors, marking the equidistance between the Cherchell and Gouraya capes.

French Occupation 1830-1962: It was a village of 58 inhabitants, including 45 Europeans, and belonged to the “Mixed Municipality” of GOURAYA. The territory originated from the large “Douar of SIDI SEMIANE”, established by the imperial decree of June 29, 1870.



Figure 228. Jean Claude Rosso (2015). Subdivision plan of FONTAINE DE GENIE

From its founding under the name “**FONTAINE-du-GÉNIE**” in 1880. According to (Jean-Claude Rosso 2015), it was named after a water source running down the mountain, tapped by the French to supply a fountain used by the colonial military engineers. It was incorporated into the district of the “Mixed Municipality” of CHERCHELL until 1929. At that point, it was separated from the original douar and reclassified as a "section" within the fully-established municipality of NOVI. The occupation led to demographic changes and the development of agricultural activities, as evidenced by the cooperative winery. The construction of the military fountain served as a key piece of infrastructure during this time.

Post-independence: the area reverted to its original name “**Hadjret Ennous**”, and has undergone substantial industrialization with the construction of the major power plant in 2009. This development has likely led to demographic shifts.

2. Physical and natural features of Hadjret Ennous:

2.1. Topography:

Hadjret Ennous is characterized by its coastal location and varied topography (see Figure 28) that includes:

- **Coastline:** Mediterranean coastal areas with rocky formations
- **Elevation:** Generally low elevation (average 25m above sea level)
- **Relief:** Significant variations in elevation within a short distance, with the maximum elevation change of approximately 241 meters within 3.2 KM of the town center
- **Nearby mountains:** Proximity to Mount Chenoua (905m elevation)

The city features gently undulating terrain, with elevations ranging from sea level to 65 meters. Coastal plains rise gradually, shaping a landscape ideal for scenic terraced neighborhoods.

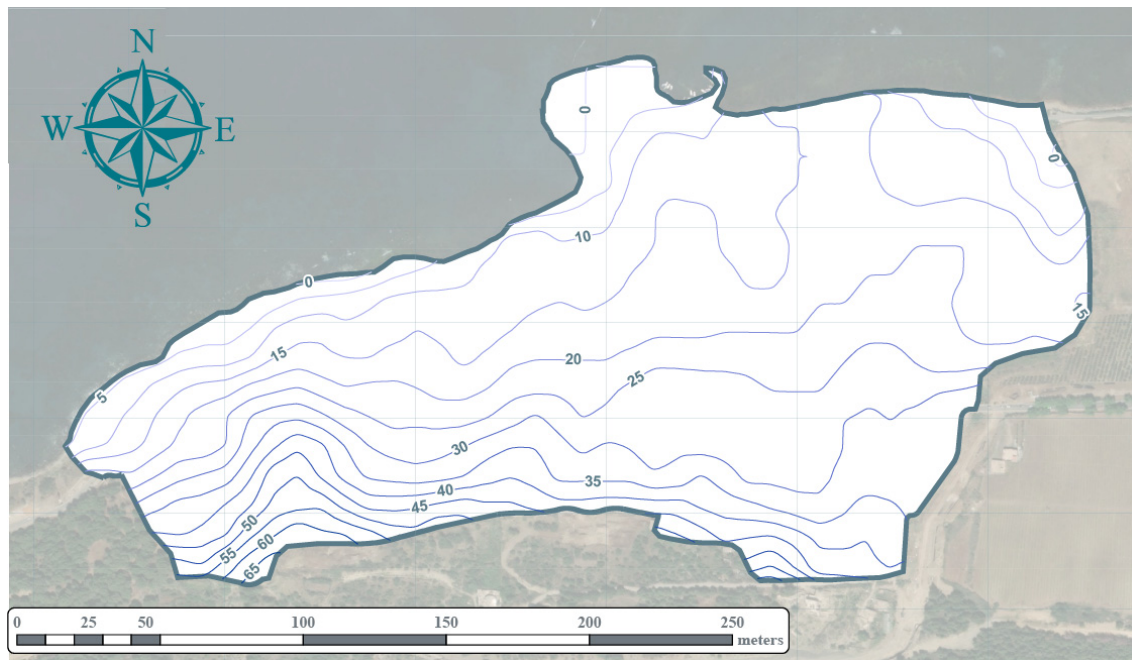


Figure 239. Topography of Hadret Ennous (Authors via ArcMap 10.8)

The chosen site for our project has a soft gradient, increasing from 5 meters in the north to 15 meters along the southern limits. The slope, being natural, provides for the chance of stepped building bases so that each building enjoys unobstructed views out to sea and enhances privacy for the terraces.

2.2. Climatic features:

Hadjret Ennous experiences a Mediterranean climate (Köppen climate classification: **Csa**), characterized by hot, dry summers and mild, wet winters. This climate regime is typical of the northern coastal regions of Algeria.

2.2.1. Temperature:

The annual average temperature is approximately 19.2°C. Summers are hot with average highs reaching 31.8°C in August, while winters are mild with average lows around 11°C in January.

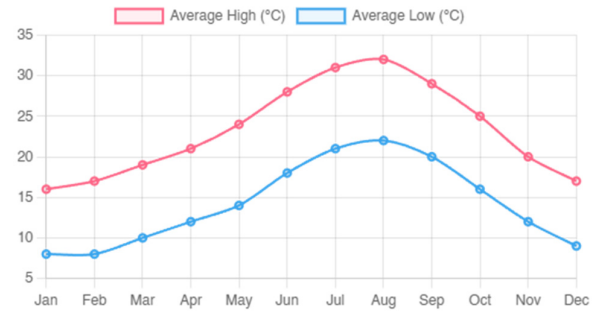


Figure 242. Monthly temperature averages (Hadjerat Ennous, Tipaza, DZ Climate Zone, Monthly Averages, Historical Weather Data, 2015)

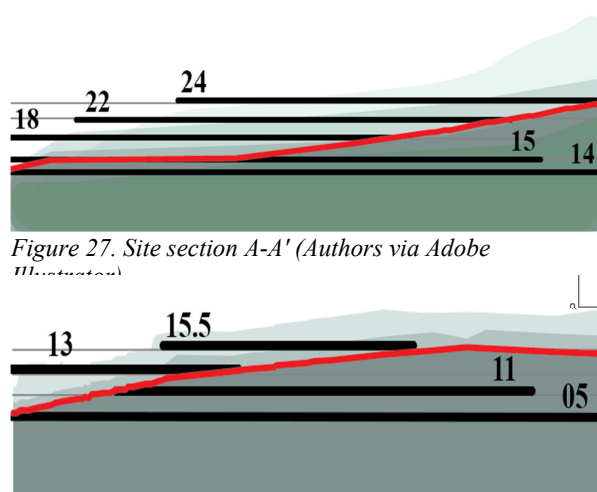


Figure 27. Site section A-A' (Authors via Adobe Illustrator)

Figure 27. Site section B-B' (Authors via Adobe Illustrator)

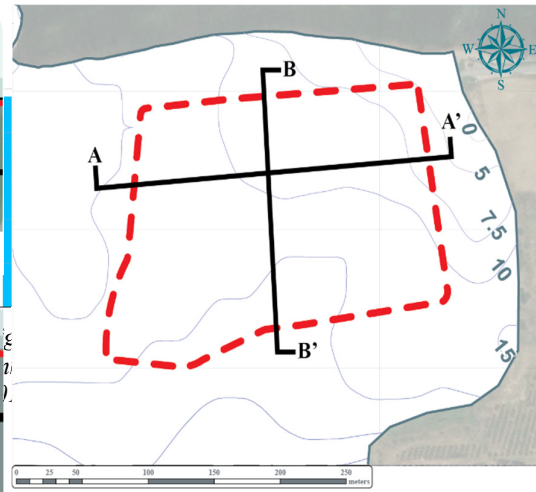


Figure 271. Site topography (Authors via Adobe Illustrator)

2.2.2. Precipitation:

The region receives most of its rainfall during the winter months. Annual precipitation averages around 600mm, with November and December being the wettest months. Summers are typically very dry, with July receiving minimal rainfall (0.1 inches on average).

2.2.3. Humidity and Wind:

Humidity levels vary throughout the year, with higher humidity during summer months. The region experiences prevailing winds from the west during winter and from the east during summer. Average wind speeds range from 12 KM/H in August to 15.5 KM/H in December and January. But due to the nature of the city being exposed to the sea from north and the empty agricultural terrains from both east and west, the region can experience unstable and unpredictable wind speeds during a short period (See Figure. 34).

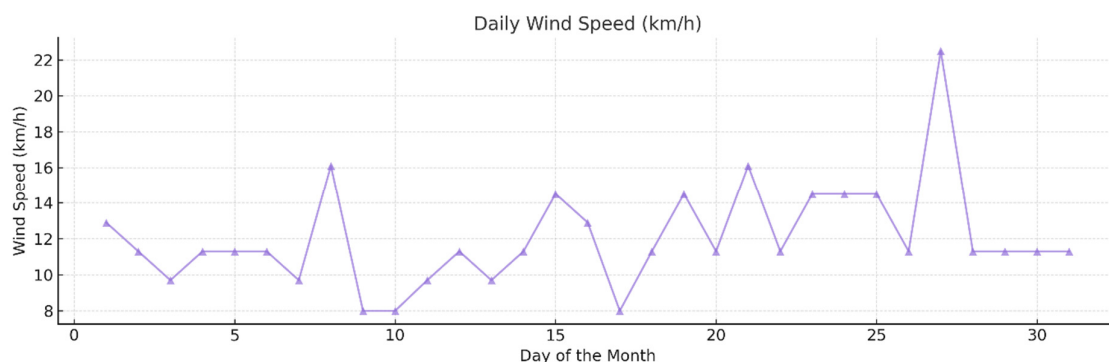


Figure 294. Daily wind speed of Hadjret Ennous in October 2020 (Authors based on Hadjerat Ennous, Tipaza, DZ Climate Zone, Monthly Averages, Historical Weather Data, 2015)

The Climatic characteristics of Hadjret Ennous are synthesized in table 5.

Table 6. Climate characteristics of Hadjret Ennous synthesis table.

Season	Temperature	Precipitation	Characteristics
Winter	7°C to 17°C	High: 48.3–53.3 mm/month	Mild, rainy with occasional winds
Spring	9°C to 24°C	Moderate, decreasing	Pleasant temperatures, flower blooming period
Summer	18°C to 32°C	Very low: 2.5–7.6 mm/month	Hot, dry, clear skies, peak tourist season
Autumn	11°C to 29°C	Increasing: 17.8–53.3 mm/month	Cooling temperatures, increasing precipitation

However, the current date is subject to change according to the “**IPCC Sixth Assessment Report**”, as the impact of climate change on the Mediterranean region is expected to be significant. Here are some of the future climate projections (Based on IPCC Sixth Assessment Report)

2.2.4. Future climatic projections:

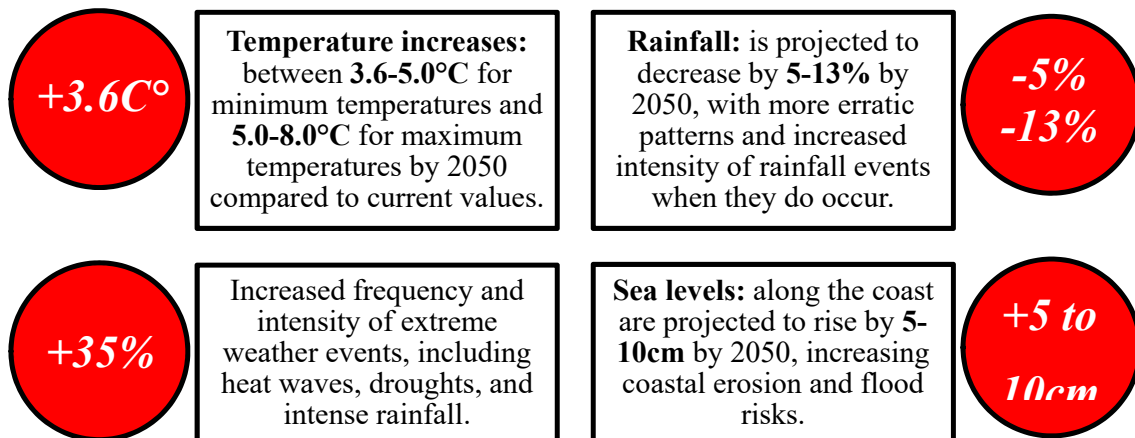


Figure 35. Future climatic projections (Authors based on IPCC Sixth Assessment Report)

2.3. Hydrological Features:

The hydrological system of Hadjret Ennous is primarily influenced by:

- **Mediterranean Sea:** Forming the northern boundary of the region
- **Seasonal streams:** Small seasonal watercourses that flow during the rainy season
- **Groundwater:** Limited freshwater aquifers that are increasingly under pressure due to saltwater intrusion.

2.4. Local Geological Features:

The geological features of Hadjret Ennous are summarised in table 7.

Table 7. Geological features of Hadjret Ennous

Rock Types	Soil Composition	Hydrogeology
Sedimentary rocks (limestone, sandstone)	Mediterranean brown soils	Limited groundwater aquifers
Quaternary deposits along the coast	Calcareous soils derived from limestone parent material	Evidence of saltwater intrusion in coastal aquifers
Marine sediments	Alluvial deposits in low-lying areas	Water resources affected by salinization, particularly in the nearby Nador plain
Distinctive coastal rock formations (for which the town is named)	Evidence of soil salinization in coastal zones	Groundwater recharge primarily during spring and winter

2.5. Flora:

The flora of Hadjret Ennous is representative of the Mediterranean Basin's plant biodiversity, characterized by species adapted to the distinctive Mediterranean climate with its seasonal drought conditions. The region hosts a variety of plant communities that have evolved to thrive in the local environmental conditions. Primary Vegetation Types include:

Mediterranean Forests: Dominated by drought-resistant tree species such as Aleppo pine (*Pinus halepensis*), stone pine (*Pinus pinea*), and various oak species including holm oak (*Quercus ilex*) and kermes oak (*Quercus coccifera*).

Maquis and Garrigue: Shrubland ecosystems characterized by aromatic shrubs such as rosemary (*Rosmarinus officinalis*), thyme (*Thymus vulgaris*), lavender (*Lavandula* spp.), and mastic (*Pistacia lentiscus*).

Coastal Vegetation: Plants adapted to sandy and rocky coastal environments, often with specialized adaptations for salt tolerance.

Agricultural Flora: The region supports traditional Mediterranean crops, including olive trees (*Olea europaea*), fig trees (*Ficus carica*), grapevines (*Vitis vinifera*), and various citrus species.

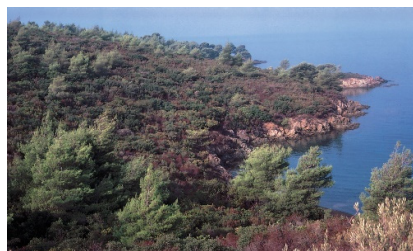


Figure 30. Maquis (Petruzzello, 1998)



Figure 31. *Cistus populifolius* (Mayer, 2018)

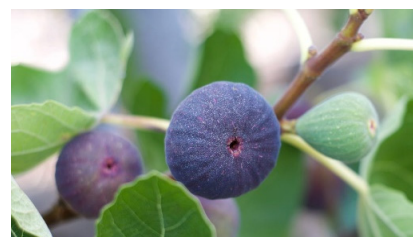


Figure 32. Fig (The Editors, 2018)

2.6. Fauna:

The fauna of Hadjret Ennous and the surrounding Tipaza region exhibits the characteristic biodiversity of Mediterranean coastal ecosystems. The area's diverse habitats—from coastal waters and beaches to shrublands and forests—support a wide variety of animal species. (See table 8)

Table 8. Fauna types in Hadjret Ennous

Mammals	Birds	Reptiles and Amphibians
-Barbary Macaque (<i>Macaca sylvanus</i>) An endangered primate	-Migratory birds using the Mediterranean	-Mediterranean Chameleon (<i>Chamaeleo chamaeleon</i>) -Moorish Gecko (<i>Tarentola mauritanica</i>)

native to North Africa -Common Jackal (Canis aureus) -Red Fox (Vulpes vulpes) -Wild Boar (Sus scrofa) - Algerian Hedgehog (Atelerix algirus) -Small rodents including the Algerian Mouse (Mus spretus)	flyway -European Spoonbill (Platalea leucorodia) -Various raptors including the Lanner Falcon (Falco biarmicus) -Egyptian Vulture (Neophron percnopterus) - Common coastal birds such as gulls and terns	-Algerian Whip Snake (Hemorrhois algirus) -Mediterranean Pond Turtle (Mauremys leprosa) - North African Fire Toad (Sclerophrys mauritanica)
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It should be noted that the Mediterranean waters off Hadjret Ennous support a rich diversity of marine life, though this ecosystem faces various pressures from fishing, pollution, and climate change. (See table 9)

Table 9. Marine Fauna in Hadjret Ennous

Fish and Marine Vertebrates	Marine Invertebrates
-Various dolphin species including Common Bottlenose Dolphin (Tursiops truncatus).	-Various mollusc species including octopus, squid, and cuttlefish.
-Sea turtles, including the Loggerhead Sea Turtle (Caretta caretta).	-Commercial crustaceans such as shrimp, crabs, and lobsters.
-Commercial fish species such as Sardines (Sardina pilchardus), Anchovies (Engraulis encrasicolus), and various Seabream species (Sparidae family).	-Sea urchins and starfish. -Jellyfish species, including some potentially invasive species.

3. Socio-Economic features of Hadjret Ennous:

For urban planning and climate adaptation plans to be both equitable and successful, a thorough socioeconomic analysis is essential.

3.1. Demographic evolution:

The demographic evolution of Hadjret Ennous from 1998 to 2025 (figure 37) reveals a steady and sustained population increase, reflecting the broader patterns of urban growth observed

along Algeria’s coastal zones. According to local planning data, the population rose from under 2,000 inhabitants in 1998 to an estimated 2,500 by 2021, with projections indicating a further increase to nearly 3,000 by 2025. This continuous upward trend underscores the intensifying residential demand in the area, driven by factors such as internal migration, coastal attractiveness, and expanding economic opportunities. Such demographic pressure places a considerable strain on the town’s physical and environmental resources, especially in the context of constrained topography and limited land availability. The growth trajectory highlights the urgent need for urban strategies that can accommodate this rising population without exacerbating spatial fragmentation or ecological degradation. It also reinforces the relevance of rethinking residential typologies—favoring context-sensitive, higher-density

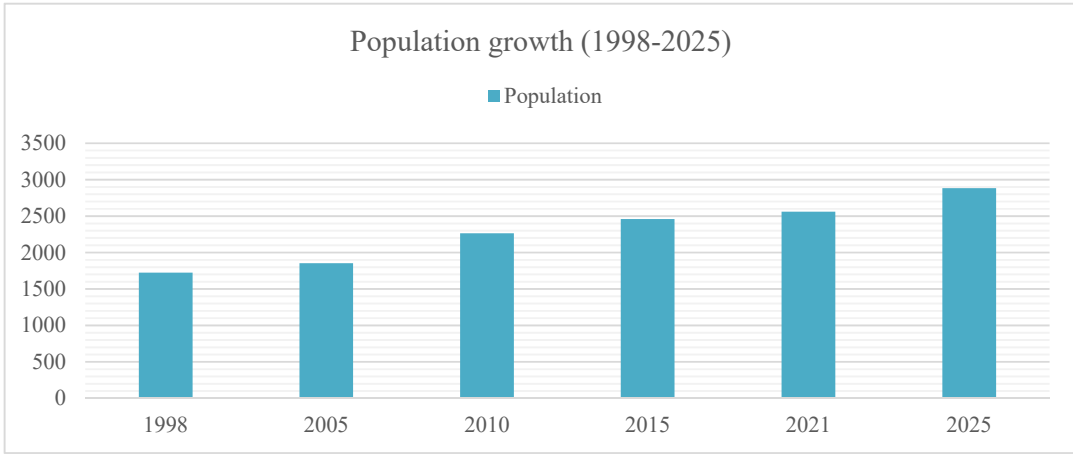


Figure 33. Population growth (1998-2025) in Hadjret Ennous (Based on on *Opportunités offertes d’investissements économique dans la commune de Hadjret Ennous 2.28.1. Cadre General, n.d*)

models such as the pyramidal organization of collective housing—to ensure that future development aligns with both demographic realities and sustainable urban principles.

Table 10. Population Growth over 20 years in Hadjret Ennous

	Pop. 2005	Growth Rate	Pop. 2010	Growth Rate	Pop. 2015	Growth Rate	Pop. 2025
Main Town	1,853	4.09%	2,264	1.68%	2,461	1.60%	2,884
Sparsely Populated Area	10	1.92%	11	1.68%	12	1.60%	14
Total	1,863	4.08%	2,275	1.68%	2,473	1.60%	2,898

Based on The review of resident population of ordinary and collective households, it is estimated that the male gender is 50.6% of the total population while the remaining 49.4% is female (figure 40).

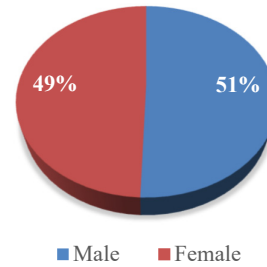


Figure 34. Gender repartition in Hadjret Ennous (based on Opportunités offertes d'investissements économique dans la commune de Hadjret)

As for the distribution of the population according to age ranges, the figure 41 illustrates that the town's residents are predominantly young with 58.7% under the age of 35 while the older population (above 65) is 5.8%

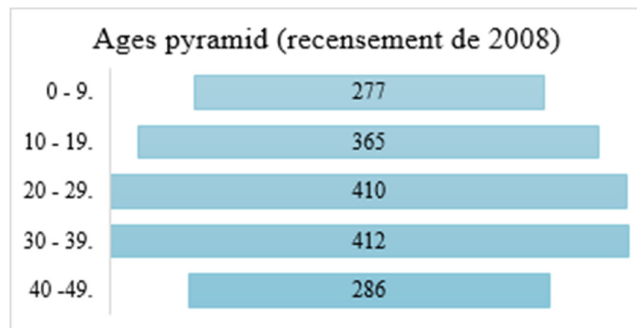


Figure 35. Age pyramide of Hadjret Ennous (Authors based on ONS 1998-2008)

3.2. School enrollment rate:

For the primary school cycle, there is no deficit. For the middle school cycle, there is a deficit of seven classrooms. For the high school cycle, there is no existing establishment.

Table 11. School enrollment rate and facilities needs (Based on Opportunités offertes d'investissements économique Hadjret Ennous)

	School-Age Population	Population to Be Schooled	Enrollment Rate (Objectif)	Needs	Existing
Primary School	424	403	30	13	13
Middle School	266	253	34	7	6
High school	216	108	/	7	0

3.3. Employment/Unemployment rates:

Table 12. Employment situation as of 2022 (La Carte Territoriale Des Opportunités Offertes à l'Investissement Économique Dans La Commune de Hadjeret Ennous 2.28.1. Cadre Generale. n.d.)

Labor force	Unemployed population	Employed population	Activity rate (%)	Employment rate (%)	Unemployment rate (%)
981	125	856	45,8	40,24	12,74

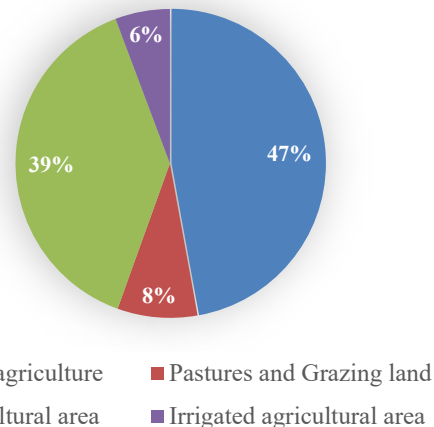
3.4. Local economy:

3.4.1. Commercial sector :

In 2002, the Wilaya's primary sectors of activity were as follows: services (23.10%), industrial production (15.05%), retail trade and consumer commodities (32.90%), wholesale trade (2.97%), imports and exports (2.61%), and artisanal activities (0.22%).

3.4.2. Agriculture:

The agriculture sector plays a particularly significant role in the Wilaya's economic life due to the proportion of hills and piedmonts (33.8%) and plains (35.8%).



3.4.3. Tourism:

The commune possesses significant tourism potential. During the summer season, Tipasa is one of the most visited regions in Algeria due to the quality of its beaches. There are a total of 3 beaches in the commune, with hosting capacity measured at 9200 person per day. As for camping there's Gounini with a capacity of 300 beds.

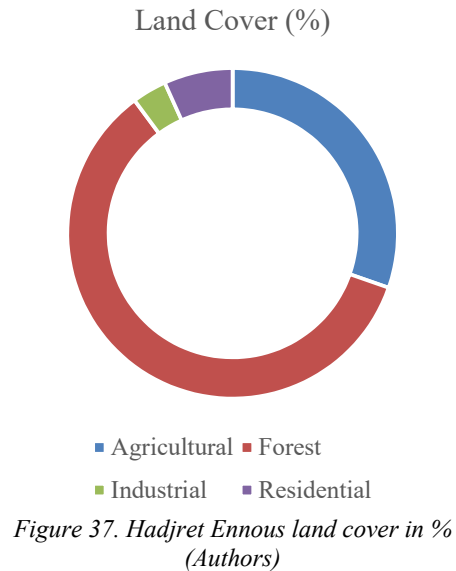
Figure 36. Agricultural potential in Hadjeret Ennous (Based on Opportunités offertes d'investissements économique Hadjeret Ennous)

4. Urban analysis of Hadjeret Ennous and project site:

4.1. Land Cover and land Use:

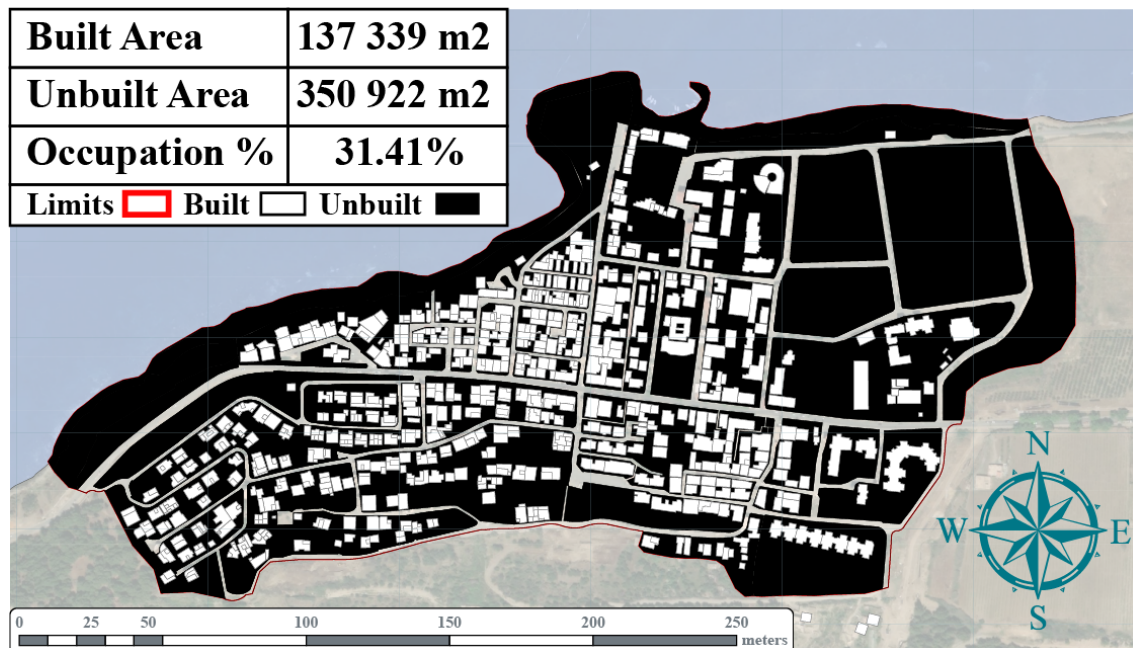
The land cover within the Hadjeret Ennous region is diverse:

- **Urban areas:** Residential and commercial zones 6%
- **Agricultural land:** 27% cropland within 2 miles of the town
- **Natural vegetation:** 11% grassland within 2 miles
- **Forest:** In 2020, Hadjret Ennous had 1.25 kha of natural forest, covering 53% of its total land area
- **Industrial:** Covers 3% of the totale area, notable presence of the Hadjret Ennous power plant, a 1,200MW gas-fired facility.



4.2. The built and the unbuilt areas:

The built area totals 137,339.77 m², representing 38.41% of the land within the defined limits. The remaining 350,922.09 m² (61.59%) is unbuilt, mainly due to the presence of protected forest and preserved agricultural land, which restrict development in those zones. (see Figure 42)



As for our project site it is divided into 3 parcels, it is a multi-functional zone. The eastern parcel contains the municipal stadium of the city (18,000m²). The northern left parcel has foundations for a project, while the southern west parcel has a middle school (4,300m²).

The built area percentage is 55% (2.2 hectares).

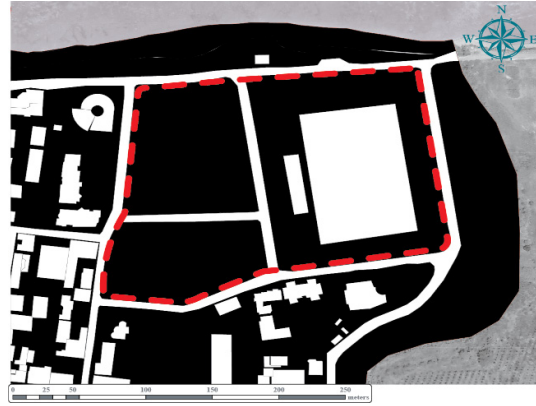


Figure 39. project site context built/unbuilt areas
(Authors via ArcMap 10.8)

4.3. Functions and activities:

Although the city is a tourist destination and hosts many people during the holidays, it remains entirely residential, with governmental and commercial facilities being the only other functions. Except for a diving club (See Figure. 47).

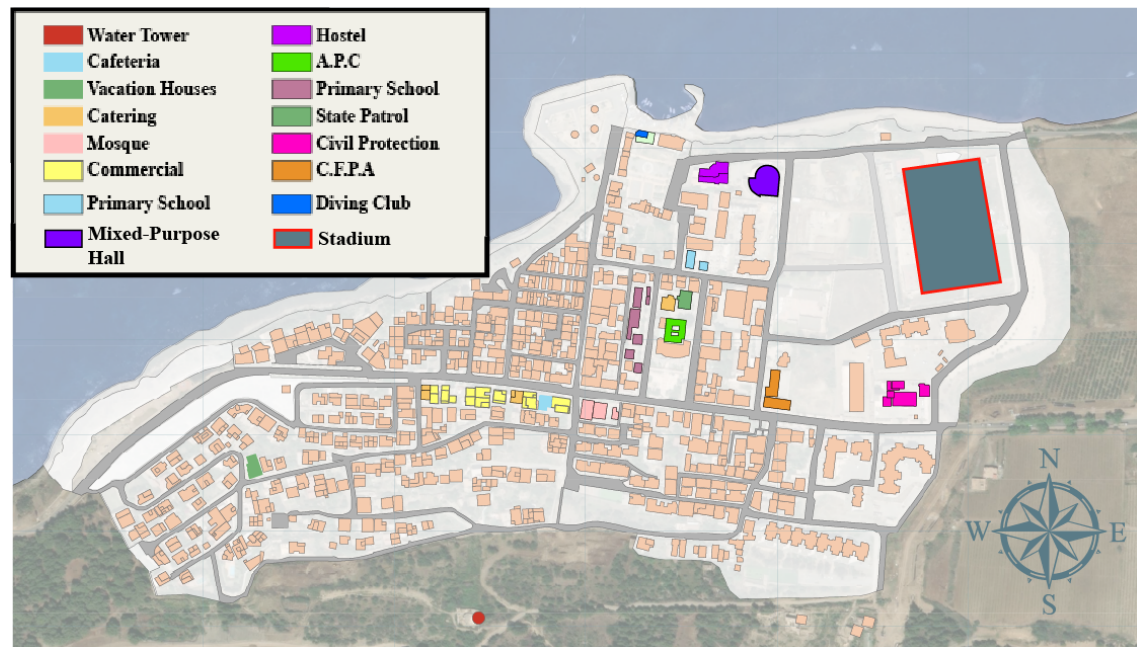


Figure 47. Building function/activity map of Hadjret Ennous (Authors via ArcMap 10.8)

Our project site is characterized by the presence of the municipal stadium (see Figure 48) with a surface area of 16,500 m². It is situated adjacent to residential developments on both south and west, as well as a multi-function hall. To the east side, the site is bordered by agricultural land.



Figure 48. Site context of the building function map of Hadjret Ennous (Authors via ArcMap 10.8)

4.4. Road network and accessibility:

The city is only accessible via one major road “RN 11” only 950m of the road crosses the city, while being intersected in the middle with multiple secondary roads and another principal road that acts as a breakthrough towards the sea (360m from both extremes). A total of 7km of roads and 17 km of tracks can be counted. There is also an abundance of dead ends, which lead to residential zones. (See Figure. 49)

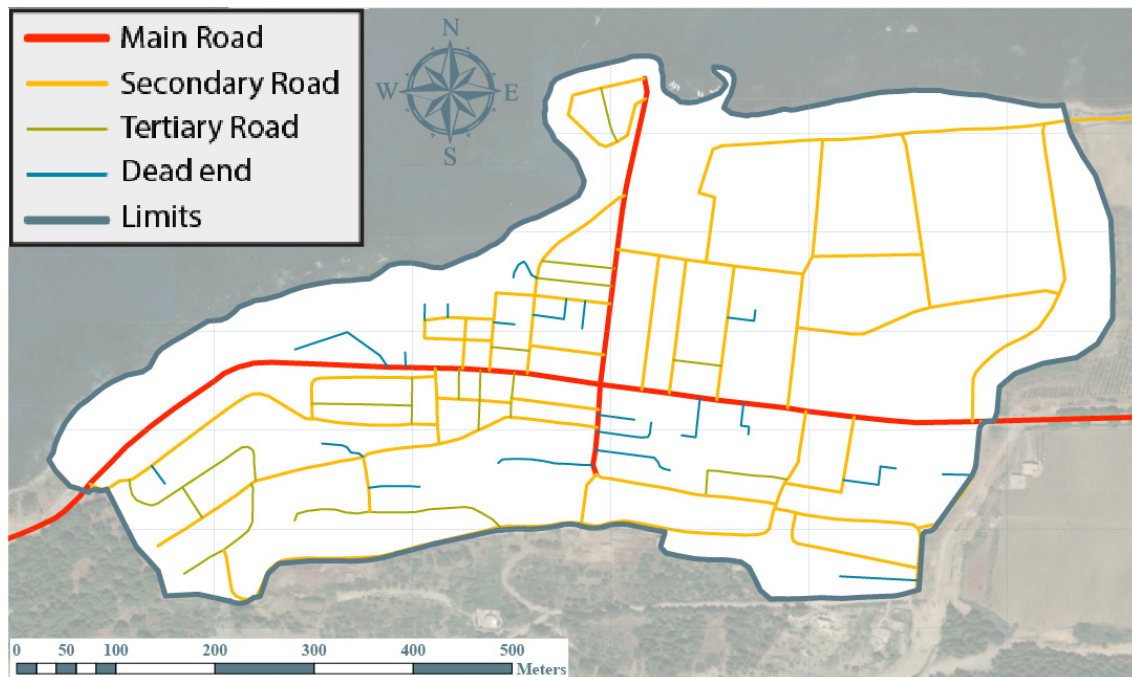


Figure 409. Road network map of Hadjret Ennous (Authors via ArcMap 10.8)

Our project site is surrounded by four roads and divided into two in order to increase convenience and allow for division of parcels. The northern road is a coastal road that provides convenient access to the west-facing beach. At the same time, the two roads at perpendicular angles serve as urban breakouts that provide access from the city to the sea and vice versa. Meaning that the site is easily accessible.



Figure 419. Site context of the road network map of Hadjret Ennous (Authors via ArcMap 10.8)

4.5. Housing typologies:

A housing typology map was necessary due to the city's predominantly residential nature. Individual houses dominate, making up 93.2% of the housing stock. Collective housing appears in the newer parts of town, accounting for 3%, while a private intermediate type represents 3.8% of the total housing buildings. (See Figure. 50)

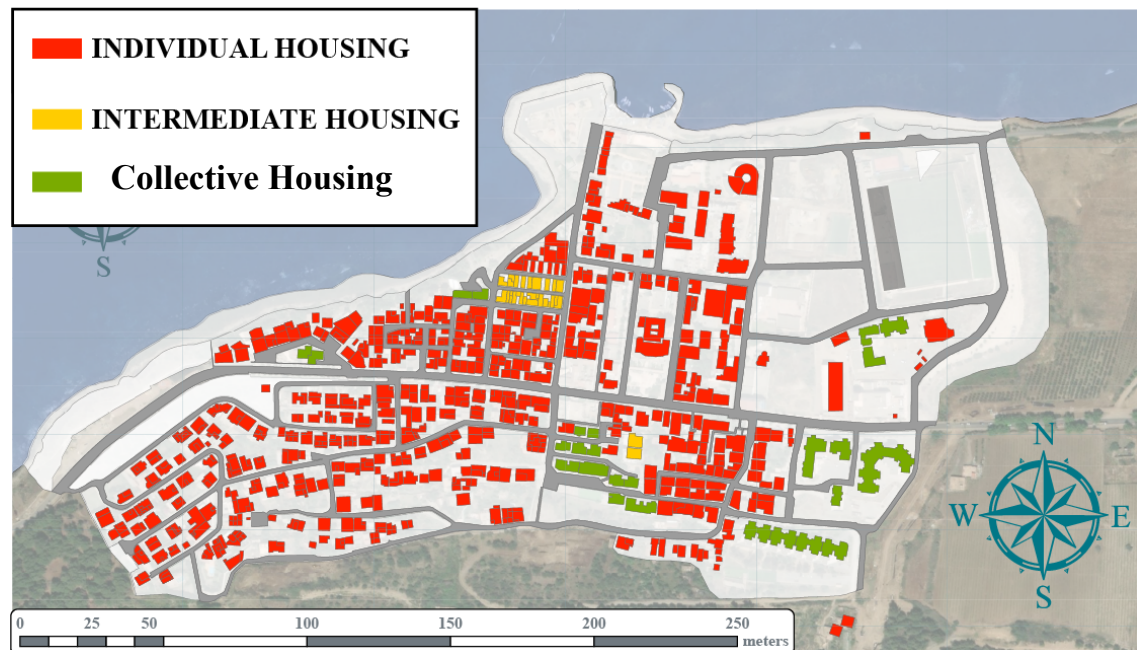


Figure 50. Building typology of Hadjret Ennous (Authors via ArcMap 10.8)

The main building typology surrounding our projet site is individual housing with a collective housing building on the south side and a youth housing center on the west side. (Cf. 51)



Figure 51. Site context of the building typology map of Hadjret Ennous

4.6. Zoning height limits:

The dominating building height in the city being the R+1 model. Some newer collective housing building surpasses R+5 (AADL). Regarding our project site, it is surrounded by different height buildings, the tallest being R+5 collective housing buildings (south side of the site) surrounded by unfinished projects foundations. On the west side of the project there's an unfinished project with an estimated height of R+5 next to a multi-purpose hall with a height of R+1. As for the southeast side (Residential plot), the dominant height is R+1. (Cf. 52)

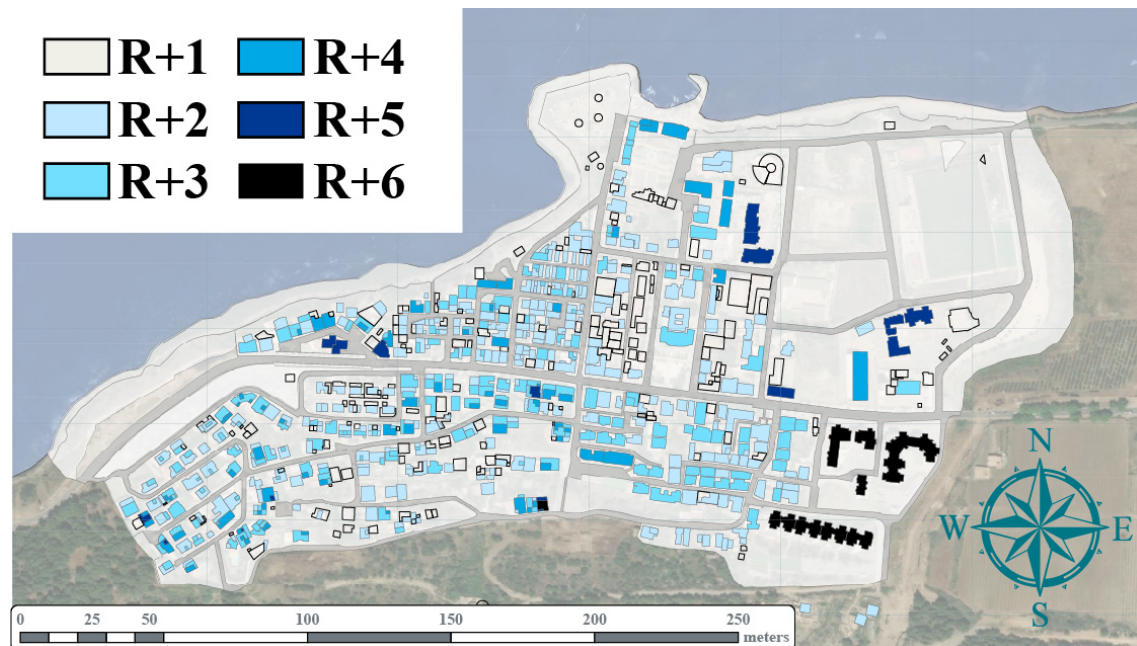


Figure 422. Building height map of Hadjret Ennous (Authors via ArcMap 10.8)

4.7. Current State of the Built Environment:

The city displays a variety of building conditions, ranging from heavily degraded structures (6.95%) concentrated in the northwest, to well-maintained and newer buildings (82.5%). A significant portion of buildings (10.55%) falls within an intermediate state of maintenance (see Figure 53).

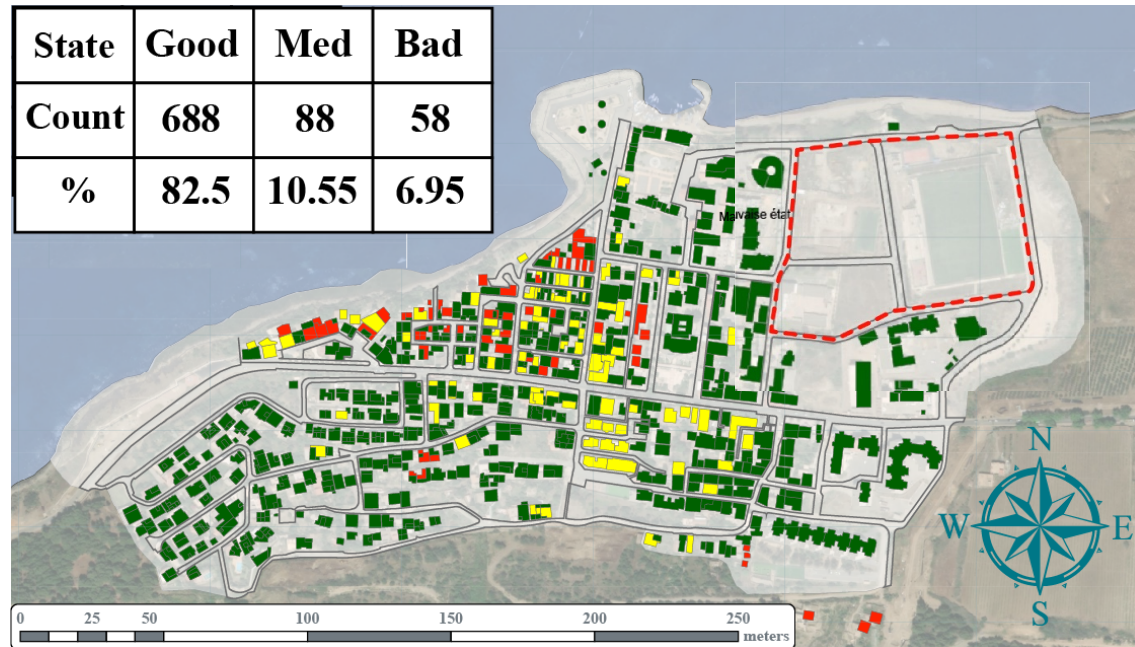
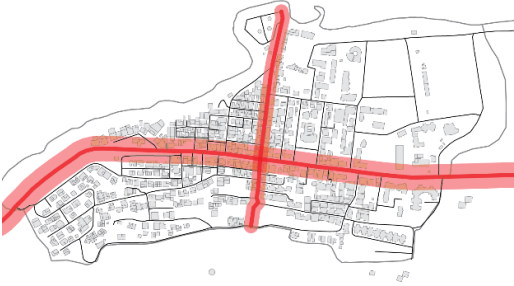
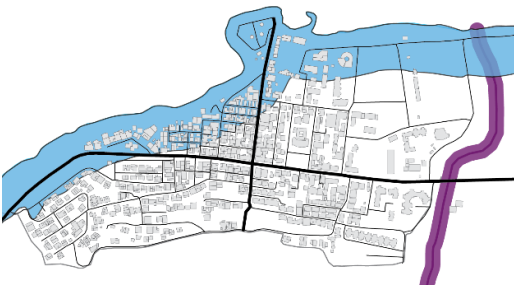


Figure 53. Building state map of Hadjret Ennous (Authors via ArcMap 10.8)

4.8. Urban Challenges and Structural Issues in Hadjret Ennous:

This section provides a comprehensive analysis of the critical dysfunctions affecting the town's physical, environmental, and socio-economic fabric. It highlights the key issues detailed and illustrated in table 11 and synthesized in figure 54. The aim is to identify and understand the root causes of spatial fragmentation, social vulnerability, and ecological stress in order to inform a more sustainable and inclusive urban renewal strategy tailored to the local context. (See table 13).

Table 13. Hadjret Ennous urban diagnostic

Problems	Illustrations
Major road easement zone: Construction within the 35m easement zone along major roads is prohibited to ensure safety and proper traffic flow. Total number of buildings is 261 31.29%. (Cf 54)	 Figure 434. RN11 easement zone in Hadjret Ennous (Authors via Arcmap 10.8)
Sea and river easement zone: Construction within the 100m easement zone near the sea was originally prohibited to protect the environment and safety. Due to widespread violations, the zone has been reduced to 30m, acknowledging that nearly half of the city is affected by this issue. New developments must comply with the 30m restriction. Total number of violating buildings is 290 = 34.77%. In addition, constructions within the 15m easement zone along the river are prohibited to protect the environment and prevent flooding. (Cf. 55)	 Figure 445. Sea and river easement zone in Hadjret Ennous (Authors via Arcmap 10.8)

Facilities concentration: Facilities are concentrated in the northeastern side of the town, leading to imbalances in accessibility and strain on local infrastructure. This concentration creates challenges in service distribution and efficient land use across the rest of the area. (Cf. 56)

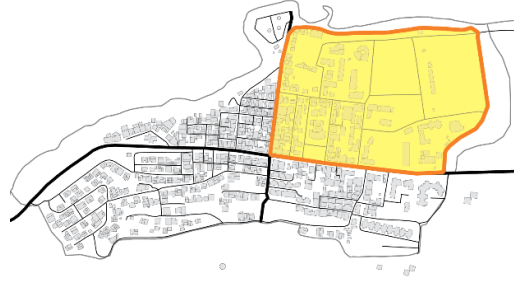


Figure 456. Building height inconsistency in Hadjret Ennous (Authors via Arcmap 10.8)

Inconsistent building heights: Some buildings are tall skyscrapers “AADL” with R+5 while the surrounding buildings are a small single-story structure, resulting in an even skyline, and lack of privacy for these smaller structures. (Cf. 57)

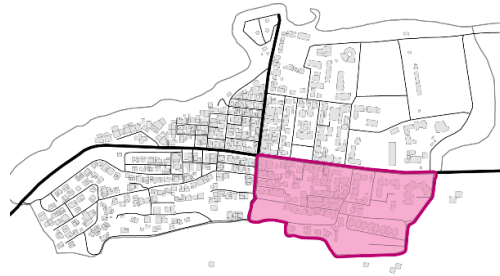
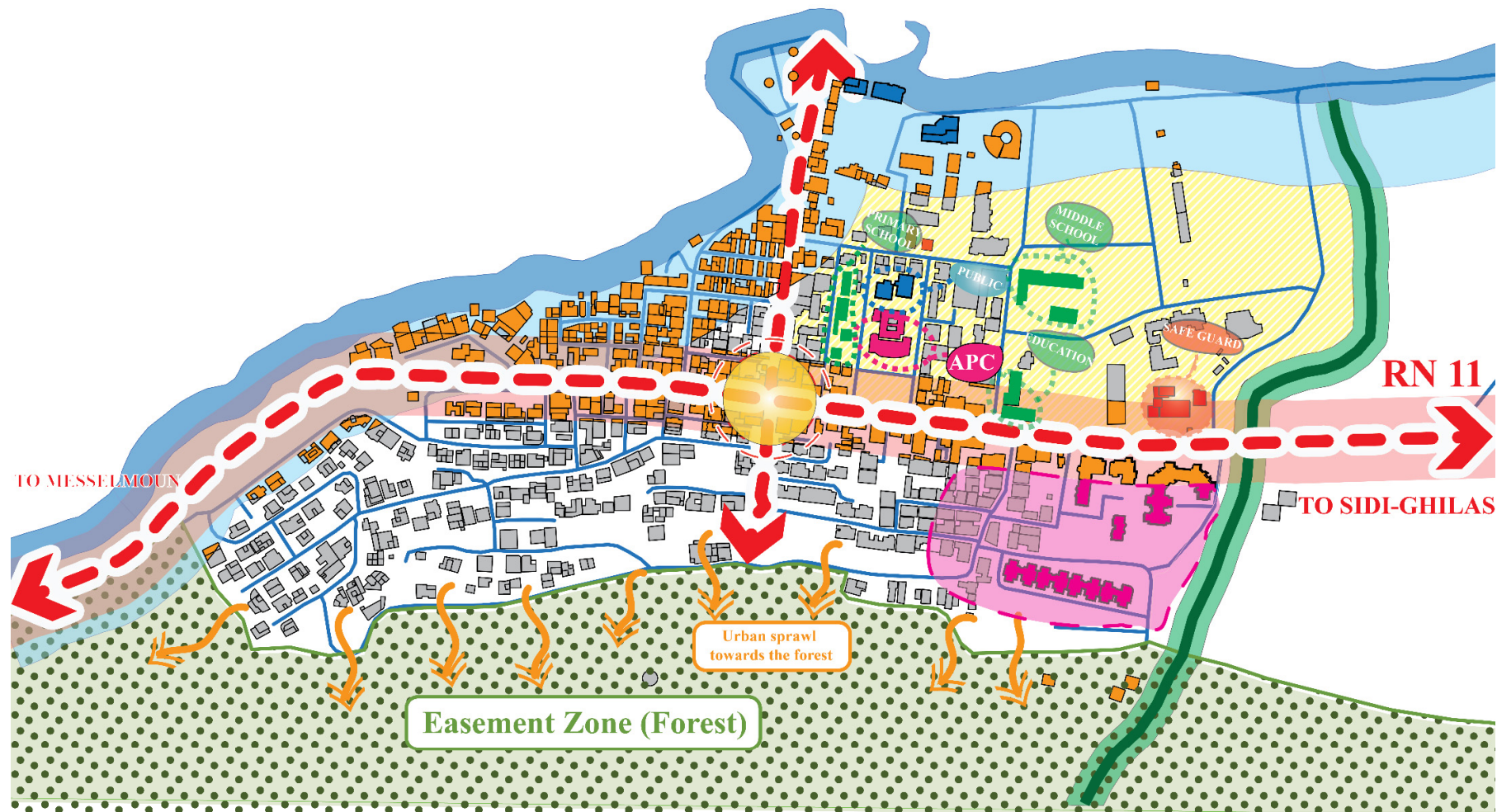


Figure 467. Building height inconsistency in Hadjret Ennous (Authors via Arcmap 10.8)

Forest servitude: Urban sprawl towards the forest can lead to violation for the environmental servitude and eventually the destruction of protected woodland. (Cf. 58)



Figure 478. Urban sprawl towards the forest in Hadjret Ennous (Authors via Arcmap 10.8)



Legend						Institute of Architecture and Urban Planning - Blida 1	
Easement zones						Developed by:	Hezaimia Abderrahmene
Forest		River		Traffic Jam		Supervised by:	Kalem Mohammed Rayane
Sea		Sea Optimised		Traffic Node			DR.P. Mustapha Benhammouche
Road		Faulty Buildings		Urban Sprawl		Option:	Urban Architecture
				High Buildings		Group:	1
				Facilities		Academic year:	2024 / 2025
				Concentration			
				Tight Roads			

Figure 489. Hadjret Ennous, urban Challenges and Structural Issues (Authors via ArcMap 10.8)

5. Proposed Urban Interventions:

This section outlines a series of urban and architectural interventions developed through a strategic analysis of the site, incorporating principles of functional zoning, environmental sensitivity, and spatial optimization. These interventions aim to address the multifaceted challenges of Hadjret Ennous by enhancing spatial coherence, alleviating existing constraints, and promoting sustainable urban development (see Figure 62).

5.1. Decentralization of Public Facilities:

In response to the over-concentration of services in the town center, public and institutional facilities have been strategically redistributed across the urban fabric. This decentralization enhances accessibility, promotes equitable service provision, and reduces the spatial and functional pressure on core urban areas.

5.2. Rerouting of National Road NR11:

The existing trajectory of NR11 was modified to mitigate its disruptive impact on the site. The proposed rerouting reduces vehicular conflicts, enhances pedestrian safety, and liberates valuable central land for community-oriented functions, thereby fostering urban integration.

5.3. Seasonal Traffic Diversion for Beachgoers:

To manage peak seasonal flows and minimize disturbances in residential zones, a dedicated circulation route has been proposed for beachgoers. This measure facilitates direct access to the seafront while preserving the quality of life for local residents and optimizing urban mobility.

5.4. Adjustment of the Coastal Buffer Zone:

The legal setback of 100 meters along the coastline has been revised to 30 meters, based on updated environmental assessments. This adjustment allows for the recovery of buildable land while maintaining compliance with safety and environmental standards.

5.5. Preservation of the River Easement Corridor:

The existing 15-meter easement along the riverbank has been retained to ensure ecological continuity, flood risk mitigation, and public accessibility. This corridor acts as a natural buffer that supports both environmental stewardship and urban resilience.

5.6. Adaptive Reconfiguration of Forest Easement Zones:

Forest protection boundaries were recalculated based on ecological value and proposed infrastructural alignments. This adaptive approach balances environmental conservation with the functional need for connectivity and circulation across the site.

5.7. Relocation of the Sports Stadium:

To alleviate spatial congestion and improve accessibility, the current sports stadium has been relocated further south. The new location offers enhanced connectivity and integration with the broader urban framework.

5.8. Redevelopment of the Former Stadium Site:

The vacated stadium site has been reimagined as a multifunctional urban hub. The proposed redevelopment includes public amenities, recreational spaces, and mixed-use facilities designed to catalyze neighborhood revitalization and reinforce the town's cultural and spatial identity.

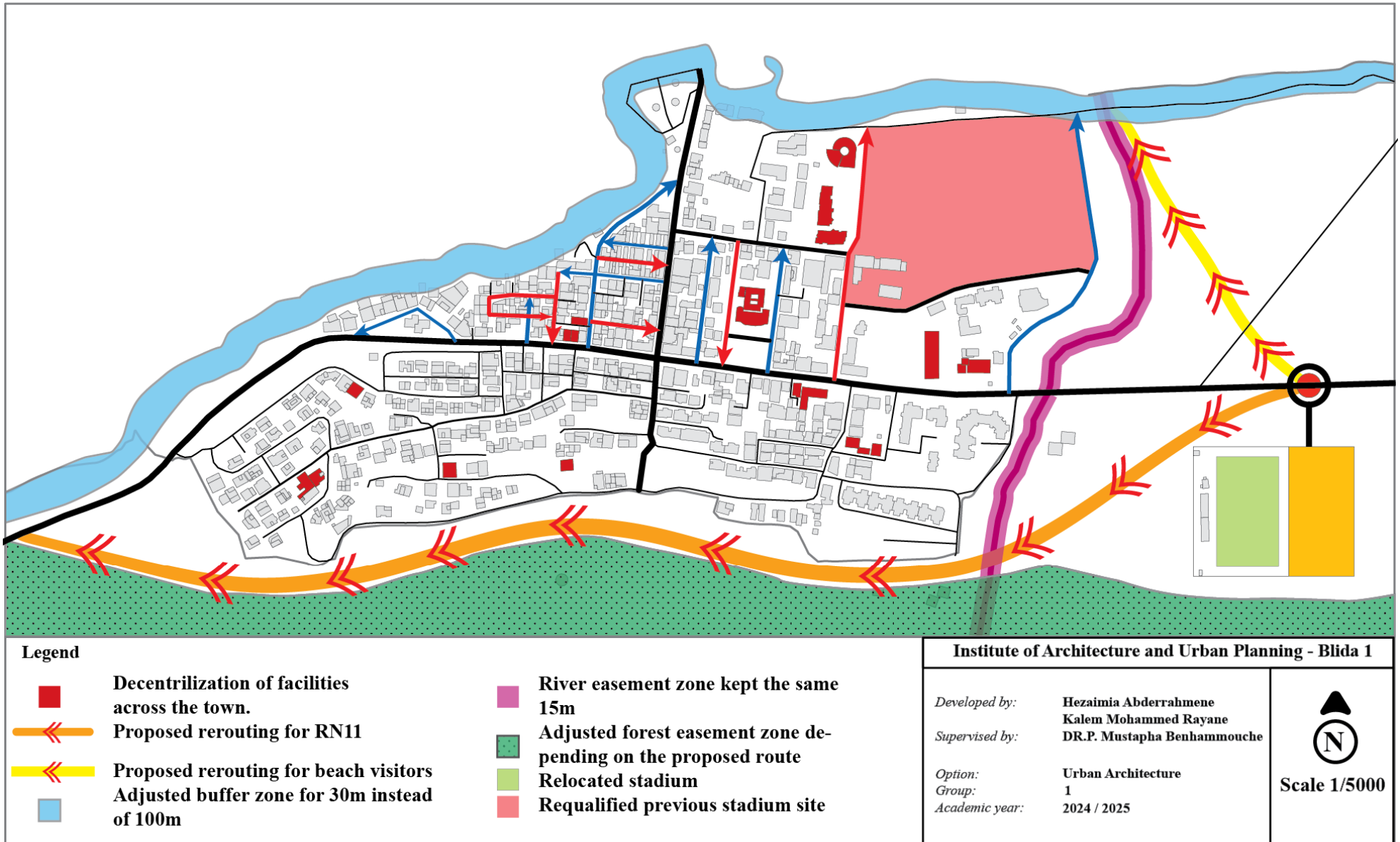


Figure 60. Proposed urban problems solution (by authors via ArcMap 10.8 and Adobe illustrator)

6. The Project of pyramidal housing in Hadjret Ennous :

6.1. Technical sheet

Location: Hadjret Ennous, Tipaza. - **Function:** Collective Housing. - **Site Area:** 41,225 m²

Built Area (Housing): 24,670 m² - **Built Area (Education):** 2,860 m² –

Circulation Area: 11,926 m² - **COS:** 66.9% - **CES:** 3.25



Figure 49. Project axonometric view
(Authors)

6.2. Organizational Logic:

The urban alignment along the site's structuring axes played a major role in our design principle. This approach aimed to seamlessly adapt our project into the existing urban fabric, ensuring a coherence and legibility within the landscape. Furthermore, the project's core concept was to create a collective environment while retaining the benefits of the individual housing model. Also, a key objective was preserving the essence of the Mediterranean lifestyle. Unlike the social housing projects that are being built in the region, where only 1% to 5% of the total house area constitutes as a terrace. In contrast our project emphasizes the importance of "Open to Sky" terraces, which, particularly between May and September, serve as a multifunctional space for daily activities while maintaining privacy. (Cf. 62)

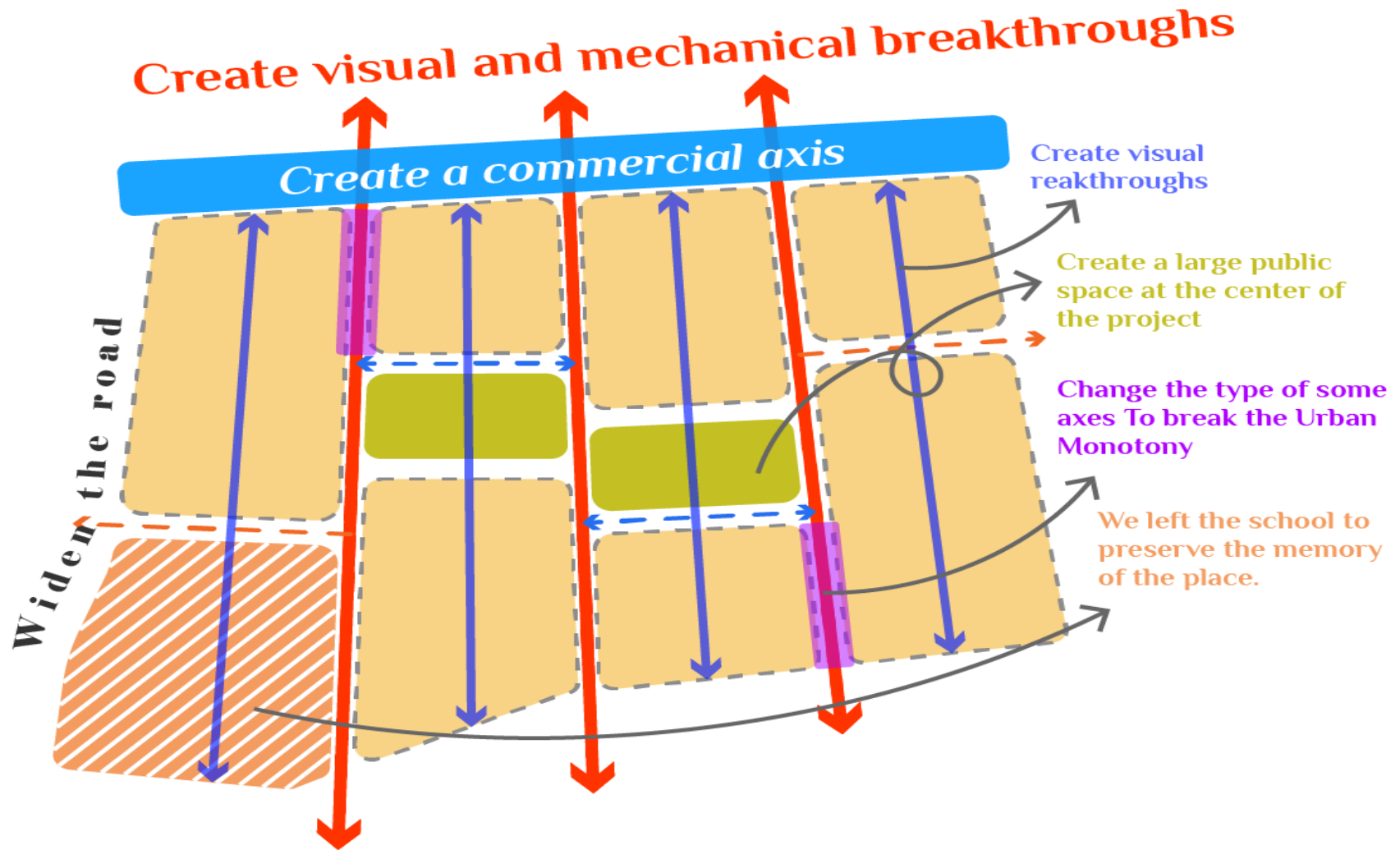


Figure 502. Organization Logic (Authors via Illustrator)

6.3. Project Genesis:

The diagram illustrates the different phases the project was conceptualized (See Figure. 63)

- ✓ **Contextual Foundation:** Begin by studying the city's existing radial and colonial residential typologies to inform the design.
- ✓ **Vertical Reconfiguration:**
Transform traditional single-story dwellings into multi-level structures to increase housing density.
- ✓ **Pyramidal Articulation:** Implement a stepped design, introducing setbacks on each ascending floor to create a pyramidal form.
- ✓ **Modular Separation:** Design paired housing units with interstitial spaces accommodating staircases and individual entrances, enhancing privacy and accessibility.
- ✓ **Height Variation:** Introduce staggered volumes and height differences to enhance natural light penetration and improve spatial quality.

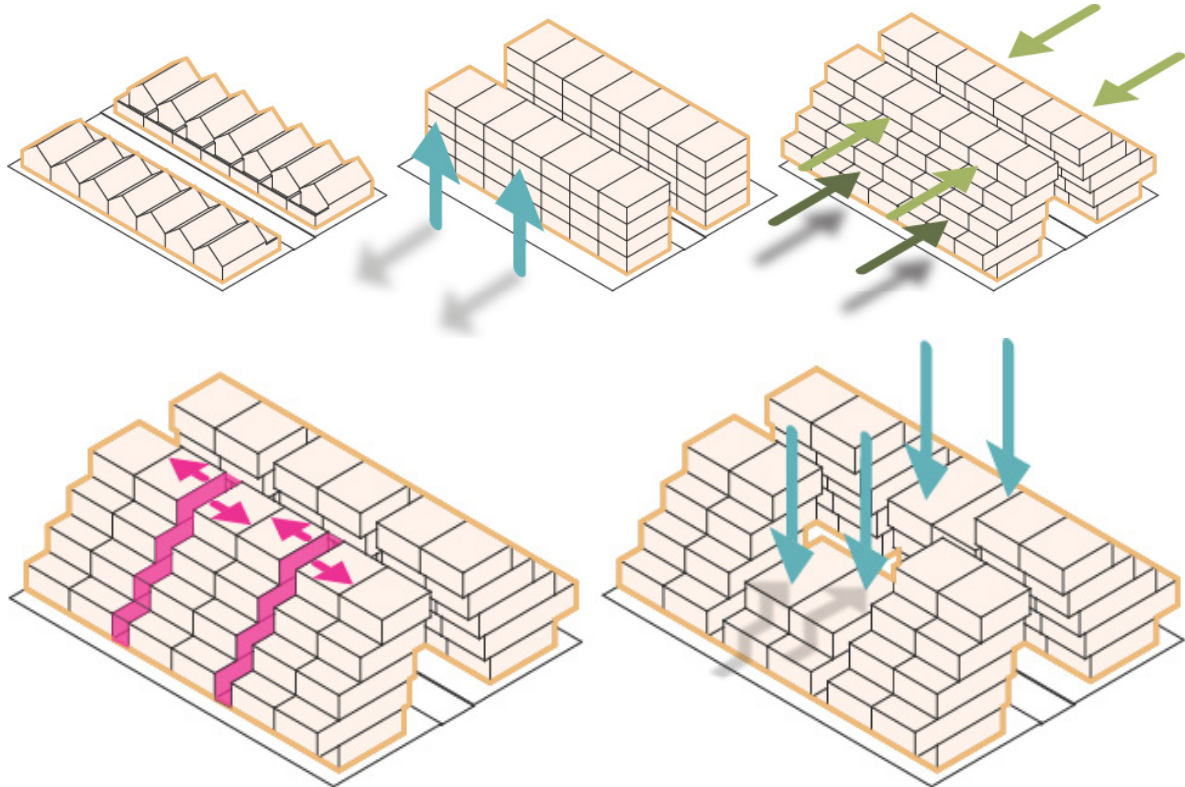


Figure 513. Project genesis (Authors via Sketchup and Adobe Illustrator)

6.4. Mass Plan:



6.5. Plans and units:

Maximizing plan reusability and replication, while reducing construction time and costs, are major key factors in the decision to adopt the pyramidal organizational building typology. We have opted to develop a modular building form that can be standardized and deployed across various sites and regions while maintaining and not compromising the functionality of the units. This five-level apartment complex consists of a ground floor and four levels above, with unequal floor plans to serve unequal housing needs. Each floor offers access to a personal outdoor space, making use of optimum outside living space for each home.



Figure 535. Chosen layout plan (Authors via Autocad and Photoshop)

This diagram represents different types of units in the project. (Cf. 66)

F5: 58 unit. (Blue)

F4: 88 unit. (Red)

F3: 144 unit. (Green)

Ground floor units facing the public gardens and the beach are reclaimed as shops.

The upper 2 floors constitute a duplex unit.

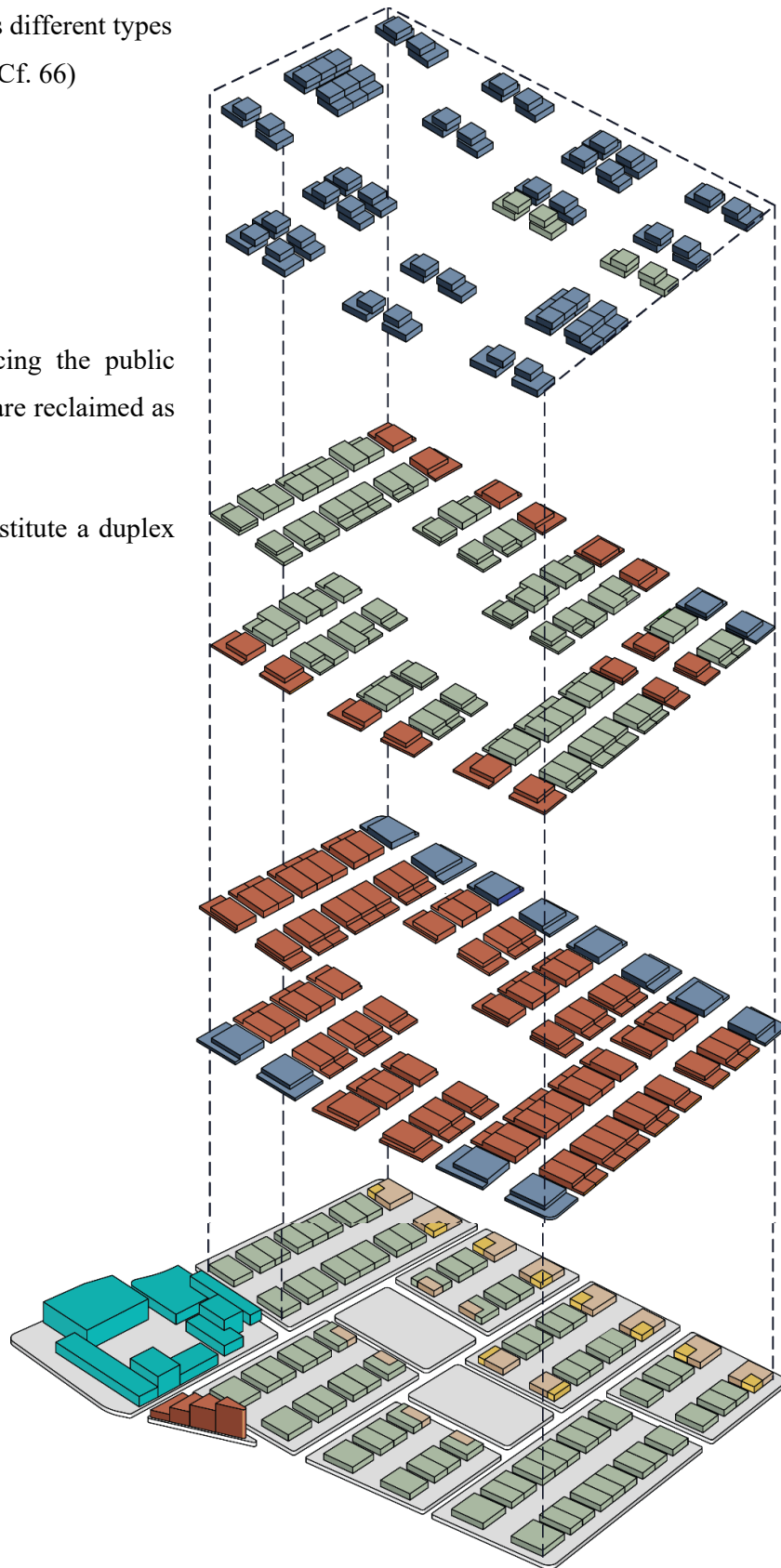


Figure 546. Units Diagram (Authors via Sketchup and Illustrator)

6.6. Site ventilation:

The diagram (See Figure. 64) illustrates the wind dynamics (blue arrows) within the project (brown blocks). The blocks are distributed in a way that maximizes air flow and ventilation. The dark blue arrows represent the primary ventilation channels and are aligned to the prevailing summer winds. The pyramidal shape of the housing blocks also improves air movement by creating tiered voids where wind can pass through multiple levels without obstruction. This design technique not only improves quality in microclimate but also reduces dependency on mechanical ventilation, which is in accordance with sustainable design principles. The spiral arrows represent air circulation and turbulence. Where wind is deflected and redirected. These zones promote thermal comfort and reduce heat accumulation during warmer periods. (Cf. 67)

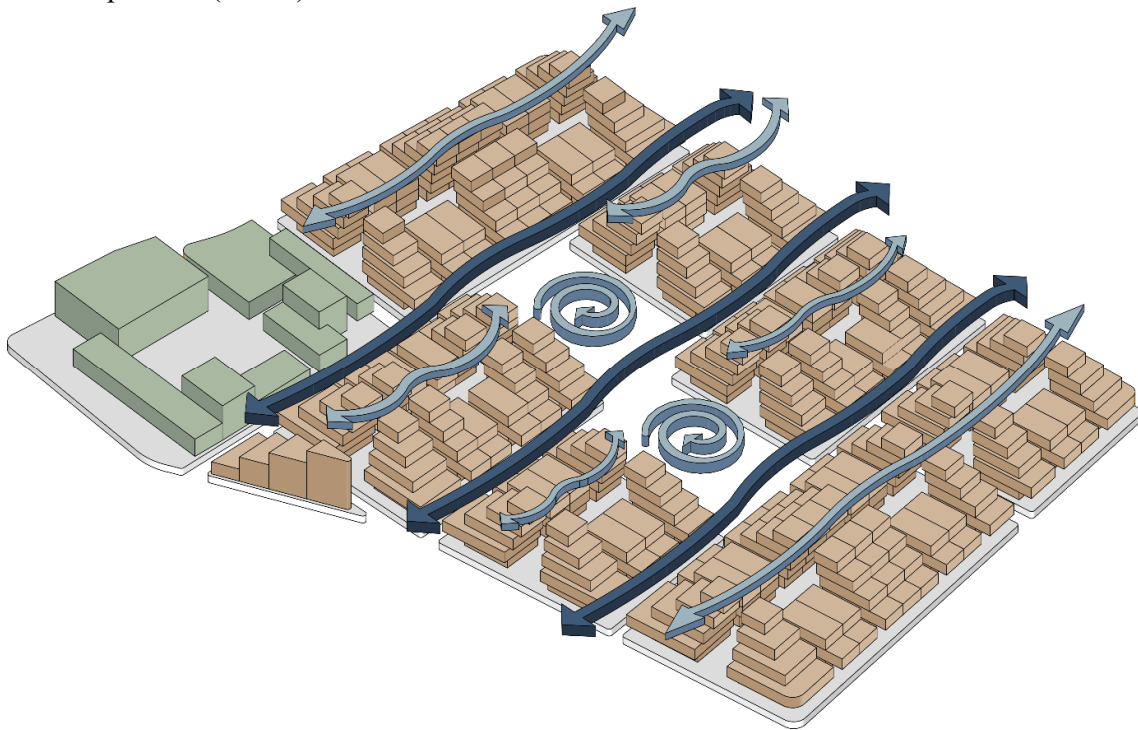


Figure 557. Wind penetration and flow (Authors via Sketchup and Illustrator)

6.7. Sun Path and light Penetration:

The sun path diagram (See Figure. 66) illustrates the sun orientation and light penetration logic applied to the project. The two orange spheres represent summer sun (Highest) and winter sun (Lowest). The layout is aimed at maximizing light penetration for terraces while minimizing direct harsh exposure on building facades during peak hours. The blocks are designed to have open interior corridors and setbacks such that the daylight reaches further into the urban tissue, including lower levels and common areas.

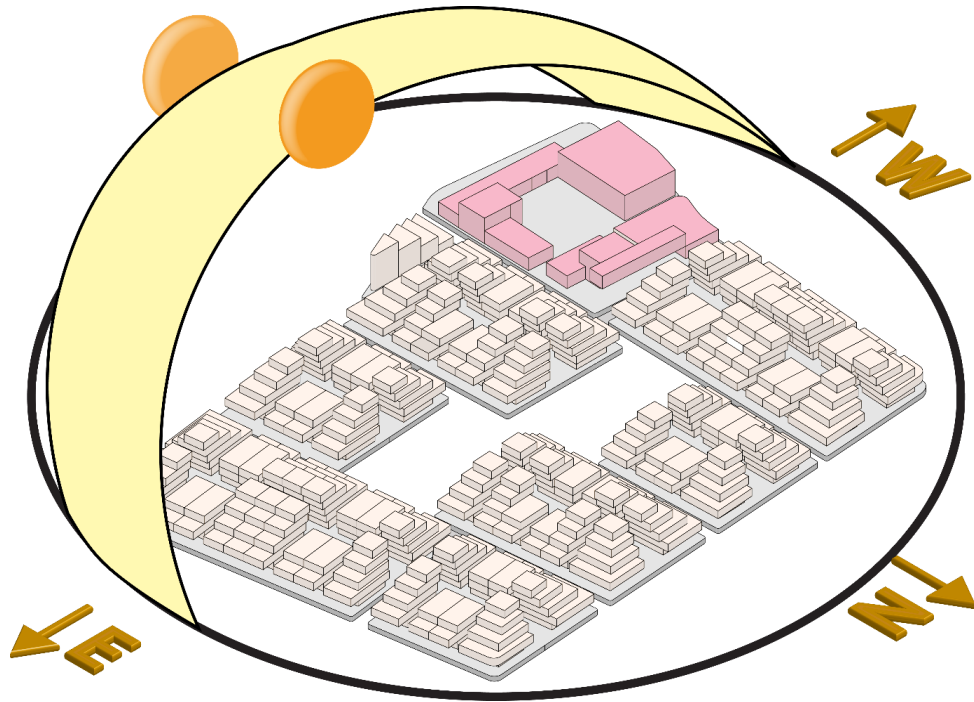


Figure 68. Sun path and light penetration diagram (Authors via Sketchup and Illustrator)

Conclusion:

This chapter has offered a multidimensional portrait of Hadjret Ennous, presenting it not only as a historically rich and environmentally sensitive coastal town in Tipaza Province, but also as a locality navigating the complex pressures of contemporary urbanization. Through an integrated analysis of its geographical setting, historical trajectory, socio-economic dynamics, and urban morphology, key spatial and developmental patterns have been illuminated.

Geographically, Hadjret Ennous is shaped by a delicate equilibrium between its coastal topography, Mediterranean climate, and ecological assets—elements that simultaneously enrich and constrain its urban potential. Environmental factors such as saltwater intrusion, seasonal watercourses, and forest conservation zones necessitate strategic land-use governance.

Historically, the town's layered identity—from its pre-Roman monolithic heritage to its roles during Roman, Ottoman, and colonial periods—underscores its long-standing socio-cultural relevance. Post-independence industrialization, notably the introduction of a power plant, has accelerated demographic growth and spatial transformation, introducing both opportunities and vulnerabilities.

Socio-economically, the population is characterized by its youthfulness and reliance on seasonal sectors such as tourism and agriculture, with commerce serving as the primary economic driver. However, the town still contends with moderate unemployment and critical gaps in education and public infrastructure, especially in terms of secondary schooling and the spatial distribution of amenities.

Urbanistically, Hadjret Ennous suffers from widespread planning inconsistencies, including easement violations and fragmented development patterns. In response, a suite of strategic interventions has been proposed: spatial decentralization of public services to promote equity, reconfiguration of transportation infrastructure to enhance connectivity, recalibration of buffer zones to reconcile urban growth with ecological preservation, and the repurposing of underutilized land such as the stadium site to support multifunctional development.

Collectively, these insights establish a comprehensive foundation for the subsequent design and planning strategies developed in this thesis. They also highlight the necessity for context-sensitive, integrative, and forward-thinking solutions capable of fostering sustainable urban resilience in Hadjret Ennous.

GENERAL CONCLUSION

GENERAL CONCLUSION:

Hadjret Ennous stands at a crossroads between **preserving its natural heritage** and **accommodating growth**. The proposed interventions aim to address **spatial inequalities, environmental pressures, and infrastructure deficits**, ensuring sustainable development. Future planning must prioritize **integrated strategies** that harmonize urban expansion with ecological and historical preservation, leveraging the town's potential as both a **residential hub and tourist destination**.

This comprehensive analysis of Hadjret Ennous in Tipaza, revealed a coastal community with distinctive geographic and geological features, situated in a Mediterranean climate zone that is increasingly vulnerable to the effects of climate change. In fact, the geographic and geological setting of Hadjret Ennous creates several vulnerability factors related to:

Sea Level Rise: With projected sea level rise of 5-10cm by 2050, Hadjret Ennous faces increased risks of:

- Coastal flooding during storm events.
- Permanent inundation of low-lying areas.
- Saltwater intrusion into freshwater aquifers.
- Damage to coastal infrastructure.

Coastal Erosion: The coastal areas of Hadjret Ennous are vulnerable to accelerated erosion due to:

- Increased wave energy from storm events.
- Rising sea levels undermining coastal structures.
- Changes in sediment transport patterns.
- Reduced natural protection from degraded coastal ecosystems.

Extreme Weather Events: Projected increases in extreme weather events pose risks including:

- More frequent and intense heat waves.
- Extended drought periods affecting water resources.
- Flash flooding from intense rainfall events.
- Strong wind events and coastal storms.

Water Resources: Water resources in the region face multiple pressures:

- Reduced precipitation and increased evaporation
- Salinization of coastal aquifers
- Increased water demand due to higher temperatures
- Competition between agricultural, industrial, and urban water uses

Recommendations: By preplanning and implementing the following recommendations while continuing to monitor and research the environmental conditions of Hadjret Ennous, stakeholders can work toward a more resilient and sustainable future for this distinctive coastal community in the face of ongoing climate and environmental changes. The study concludes with the following proposed recommendations:

Climate Adaptation Strategies: Addressing the urgent issues of environmental vulnerability and climate change requires developing a comprehensive coastal protection plan, implementing water conservation and management system, establishing heat action plans for vulnerable populations and most importantly, designing climate resilient infrastructures.

Environmental Conservation: Conserving and restoring coastal habitat as natural defenses against environmental threats is key to a sustainable future for our environment and our ecosystems. If biodiversity is to be saved, this must be matched with designation of marine protected areas, and proper forest management. In addition, promoting sustainable farming activities that also carefully monitor and safeguard water resources is also paramount in preserving the natural systems and vital sources for generations to follow.

Land Use Planning: This forms the hub of the production of climate-resilient urban space.

- Develop setback zones for coastal development
- Identify and protect critical natural infrastructure (e.g. Forests)
- Design green urban spaces to reduce heat island effects (Creation of micro-climates)

Research & Monitoring: Continuing research and monitoring are essential to adaptive decision-making and management based on data. Appropriate geological risk appraisal provides the basis for site-specific risk awareness, while continued monitoring of coastal change and erosion patterns allows for early detection of environmental change. Further, ongoing adaptation measure effectiveness review helps ensure that approaches remain responsive, evidence-based, and aligned with evolving climatic and ecological conditions.

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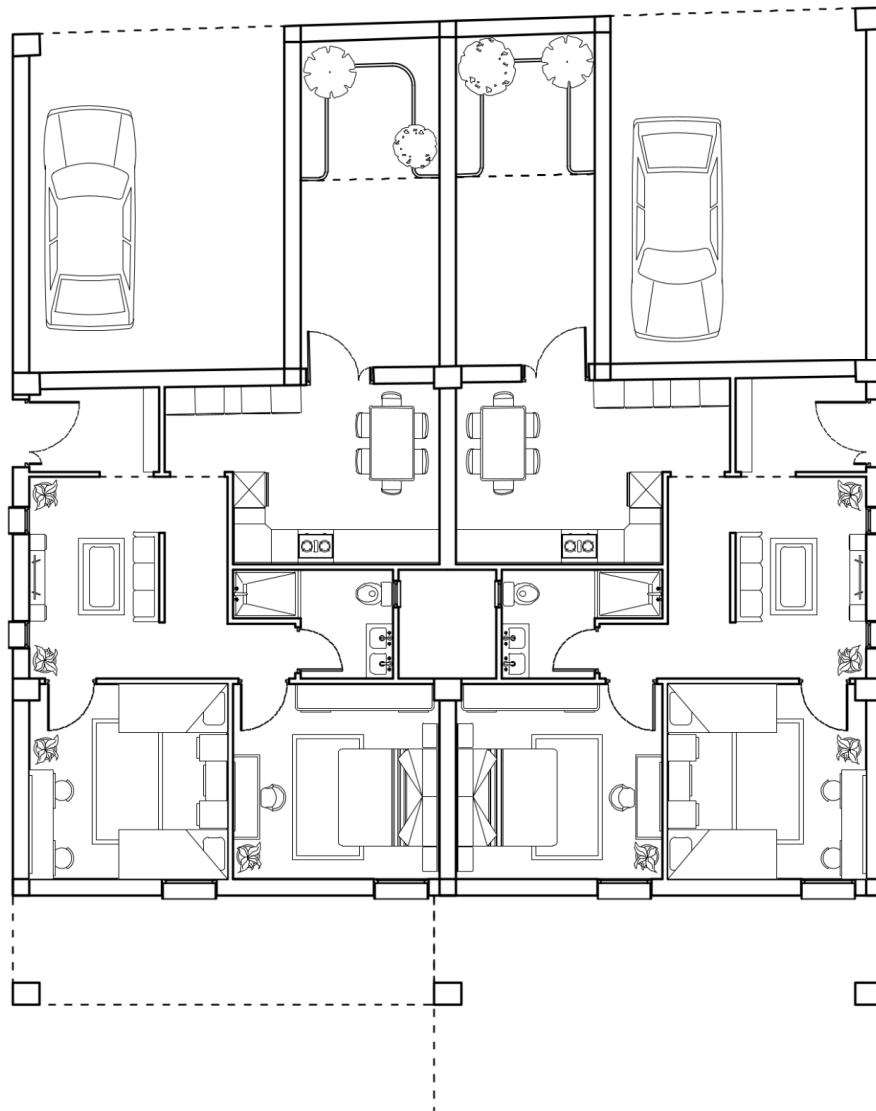
ANNEXES

ANNEXES

1.1. Ground Floor (F3 Unit)

The occupancy of this unit is versatile as full-time residence or weekend rental to visitors. This level is arranged to accommodate an F3 apartment containing:

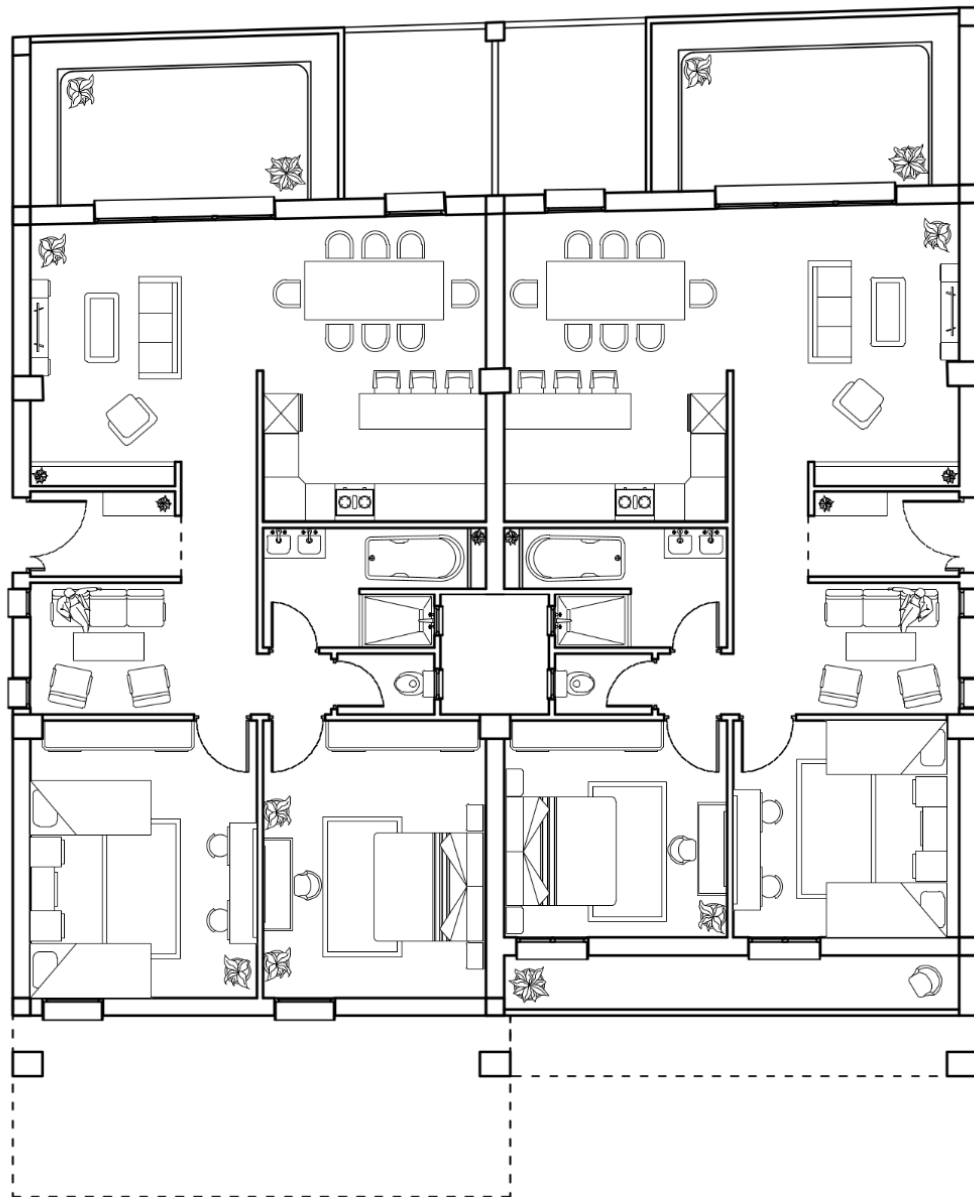
- 2 bedrooms
- Living room
- Kitchenette
- Bathroom
- Access to personal patio



1.2. First Floor (F4 unit)

The purpose is largest residential apartment, suitable for big families. The configuration consists of:

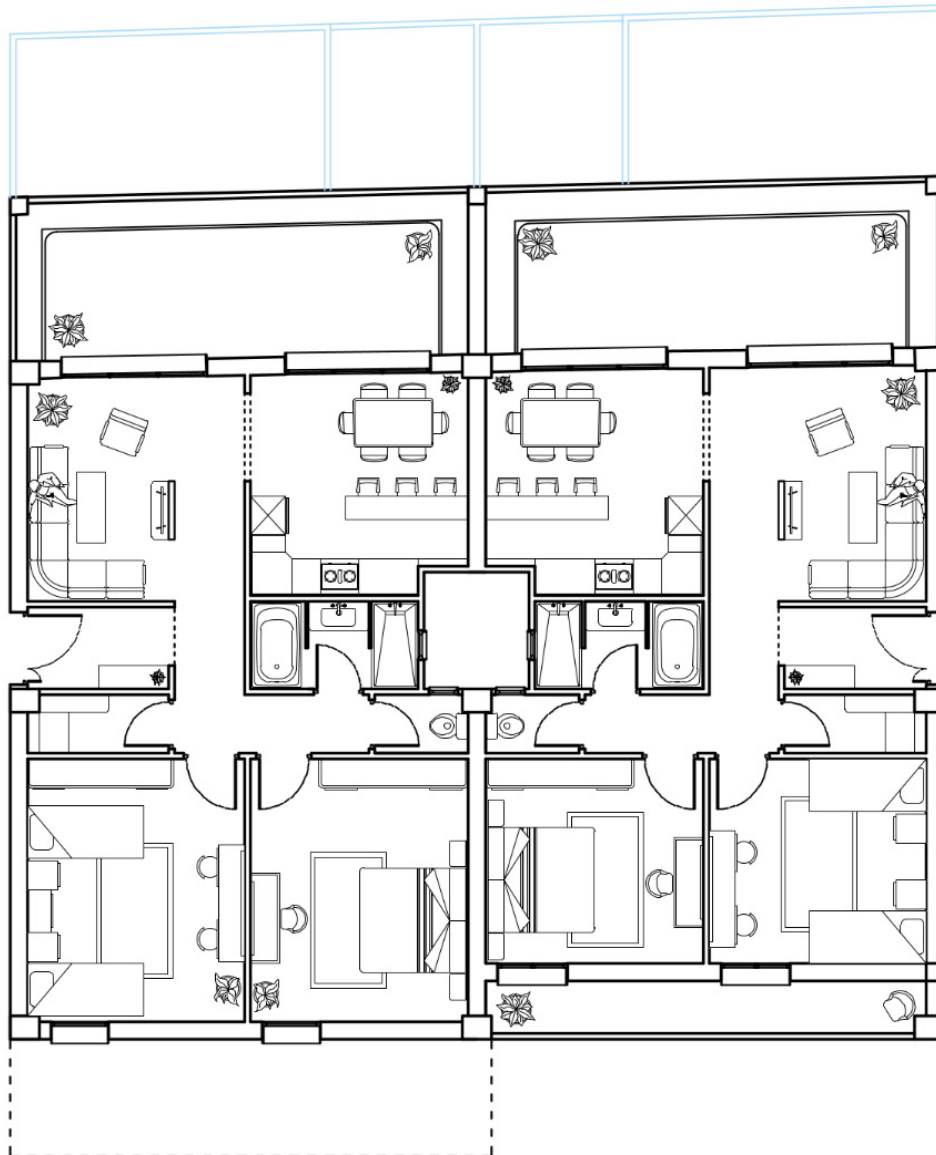
- 2 Bedrooms (Some with verandah access).
- 1 Bathroom and 1 Toilet.
- Kitchen.
- 1 Living Room and 1 living space.
- Private Terrace.



1.3. Intermediate Floor (F3 unit)

Purpose: Economical floor plan for small families. Its configuration contains:

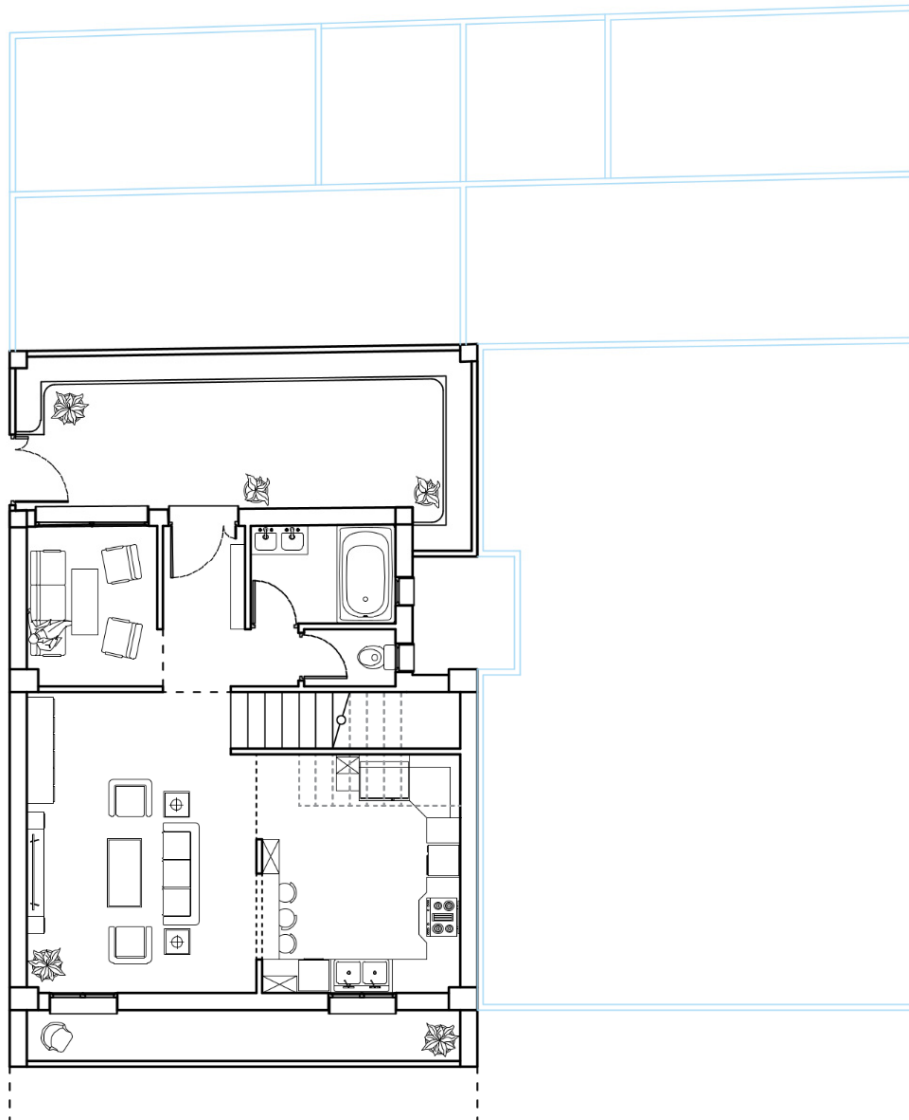
- 2 bedrooms.
- Kitchen.
- 1 Living Room 1 living space.
- Bathroom.
- Private Terrace.

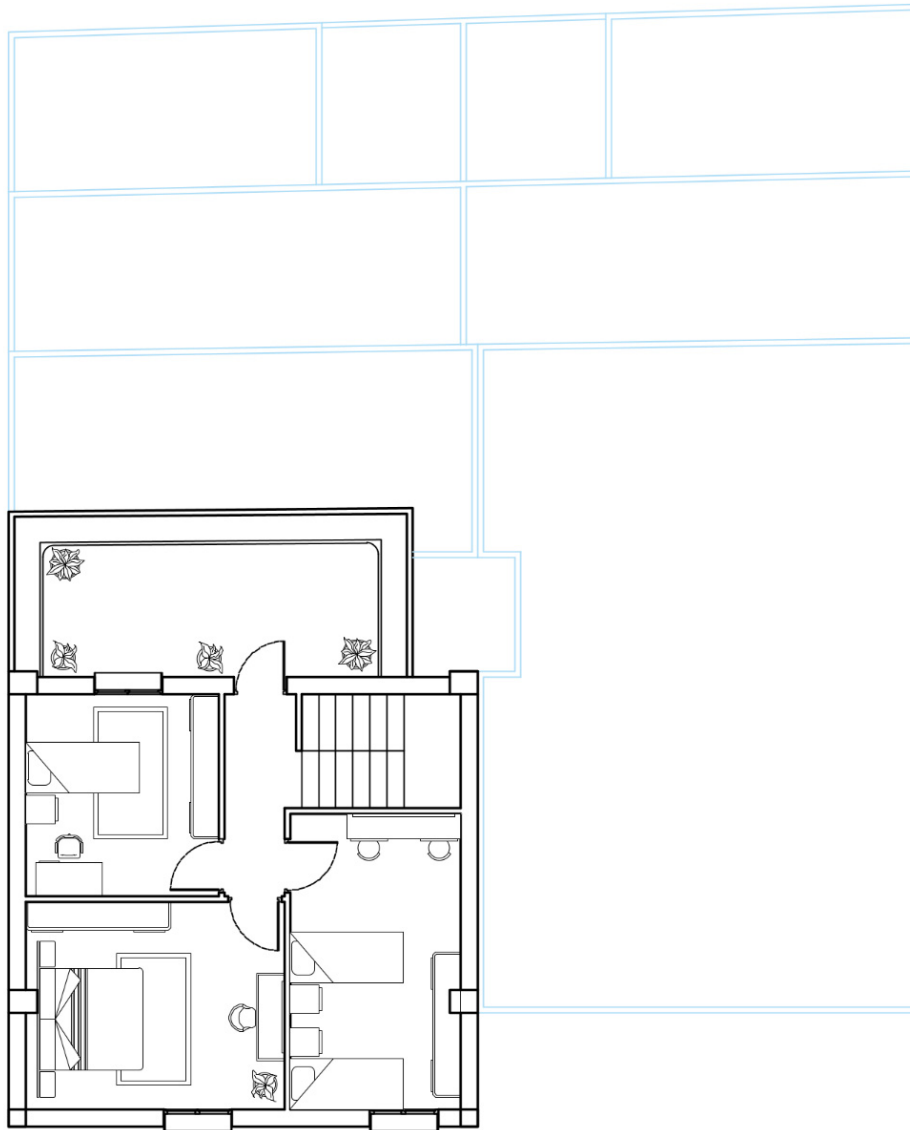


1.4. Third & Fourth Floors (Duplex Unit)

Purpose: Maisonette lifestyle for families requiring vertically configured space. Configuration (spread over two floors):

- Kitchen.
- 4 bedrooms.
- Kitchen.
- Living Room.
- 1 Bathroom and 1 toilet.
- Staircase.
- 2 Private terraces.





2. Structure:

The load-bearing columns are 40 cm in dimension, whereas the beams are proportionally sized to the depth necessary for structural efficiency. The bracing posts were added to distribute the load of the recessed and staggered floor levels to provide stability, and minimize stress in the primary supports.

The floor system uses a mix of hollow-core slabs and solid concrete slabs depending on different areas of the buildings. This approach is adopted in order to reduce weight on the cantilevered sections.

As previously before, each building includes only 2 cantilevered terraces. Load bearing columns are positioned at the back of each building and extend up to the third floor. Meaning only the second and fourth floor are cantilevered for 2m only. Ensuring structural stability

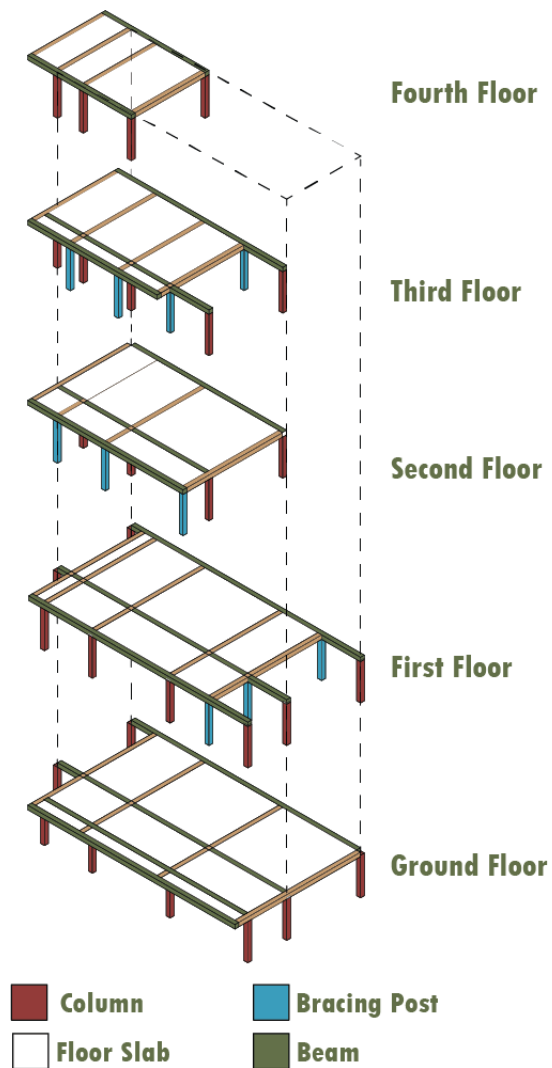
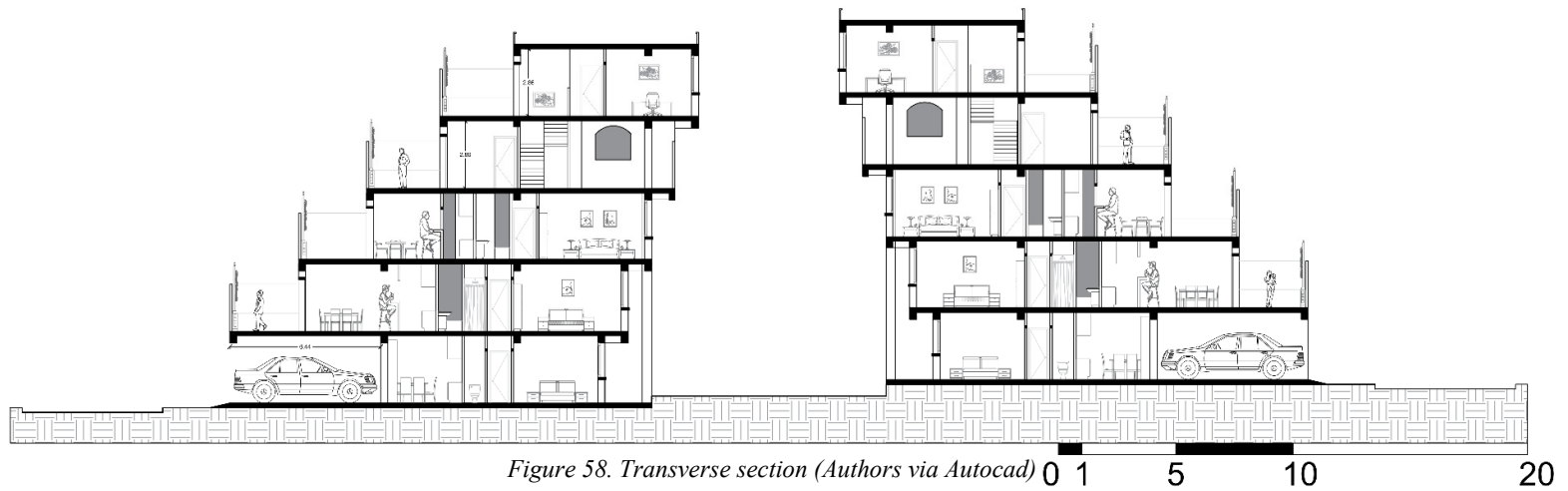
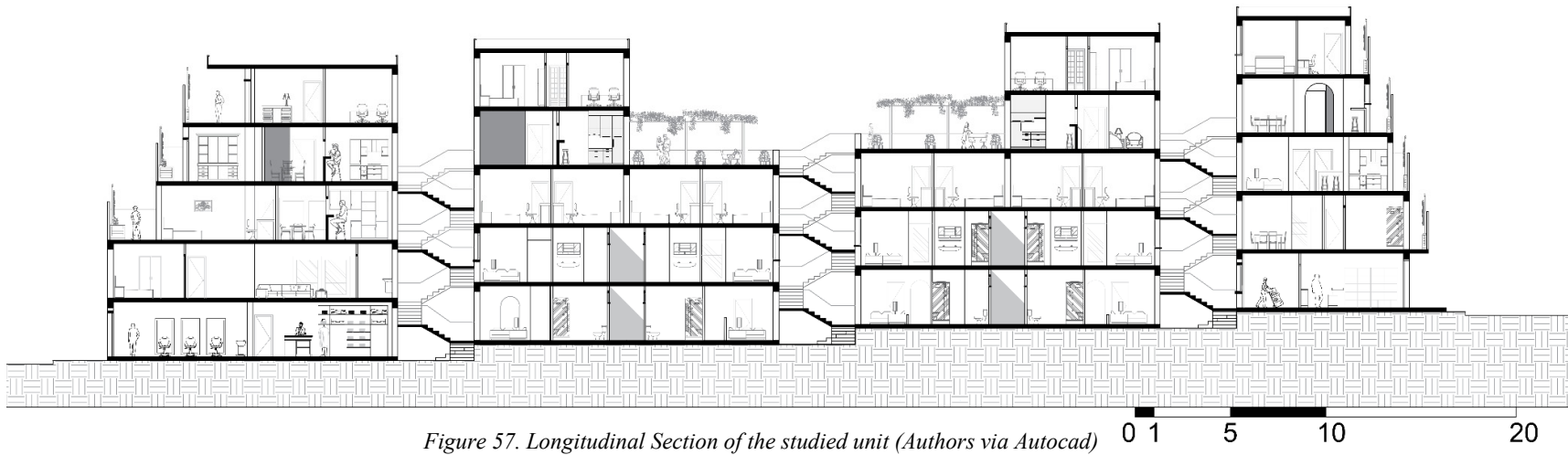


Figure 56. Structural Diagram (Authors via Sketchup and Illustrator)

3. **Sections:** Figures 71 and 72 represent sections along the studied unit, for better understanding of spaces and created platforms.



4. Facades:

The logic behind the facades is rooted to in their adaptation to the urban context of Hadjret Ennous. The context being the Mediterranean, which is known for its minimalistic and vernacular facades. In our approach, we adopted a mix of:

Drawing from the works of popular architectural building in the Mediterranean such as “Fernand Pouillion” and “Georges Candilis” while integrating references from the existing local buildings. Although seeming simple and effortless, the concept keeps the importance of the replication and easy application as a leading parameter in order to adopt the pyramidal organization as a new public housing development standard. The easy to create style of façade plays a major role in reducing time and costs to produce such a structure, while simultaneously setting a new standard for the cheap public housing developments, making it ideal for these large-scale developments.

Techniques and Strategies:

Screened Facades “Brise-soleil”: Rooted in vernacular architecture, this can be seen in the use of perforated walls and built pergolas. Acting as a sun shading device, maintains privacy and adds a layer of complexity and enrichment to the larger urban context.

Void and solid interplay and social intent: The facades present a sort of void and solid interplay is intentional for functionality reasons, for instance, when keeping a volume at two levels while adjacent structures are R+4, this allows for sunlight to penetrate lower levels to ensure the minimum two hours of daily sunlight. While reclaiming the roofs of these lower buildings as a semi-public terrace for the residents of that building. This motivates the human and social interactions among residents.

This Mediterranean style promotes for social use, maintains privacy and beautifies the overall urban context while respecting and enhancing the existing urban fabric.



Figure 59. Eastern Facade zoom-in (Authors via Autocad and Photoshop)



Figure 60. Eastern facade of the studied unit (Authors via Autocad and Photoshop)

5. 3D views and renders:

This render visualizes the main beach façade of the project.



Figure 61. Beach facade 3d render (Authors via Sketchup and Lumion)

This render represents a bird's eye view looking towards the sea.



Figure 62. View towards the sea 3d render (Authors via Sketchup and Lumion)

This is a first-person view looking towards the sea.



Figure 63. First person perspective 3d render (Authors via Sketchup and Lumion)

This render showcases the central public garden in the project.



Figure 64. Public garden 3d render (Authors via Sketchup and Lumion)

This view demonstrates the central pathway between buildings.



Figure 65. Pedestrian pathway 3d render (Authors via Sketchup and Lumion)

This is an axonometric view of the semi-public rooftop garden above R+2 buildings.



Figure 66. Axonometric view of the semi-public rooftop garden in 3D (Authors via Sketchup and Lumion)

A perspective view of the semi-public rooftop gardens.



Figure 67. First person view of the semi-public rooftop gardens in 3D (Authors via Sketchup and Lumion)

As part of our proposed intervention to address the urban problem of the city's lack of a high-school, we reimagined the existing plot containing the middle-school in our project area as a mixed school that accommodates both a high and a middle school.

This strategy serves as a solution to the infrastructural need while keeping the site's educational function legacy/memory by keeping the education function present in the plot. The following 3D renders illustrate the reimagined intervention. The following figures demonstrate the intervention

The program consists of 7 blocks in total, perpendicular blocks for High and middle school classes, a cafeteria and a library, a gym, an administration and security block.



Figure 68. 3D render of the proposed school program (Authors via Sketchup and Vray 6)

A first person view render illustrating the cafeteria (ground floor) and the library (Upper floor) block.



Figure 69. First person view of the administration block (Authors via Sketchup and Vray 6)



Figure 70. First person view of the library and cafeteria (Authors via Sketchup and Vray 6)

This render showcases the middle school block.



Figure 71. First person view of the middle school block (Authors via Sketchup and Vray 6)

An axonometric diagram representing the school in its context.

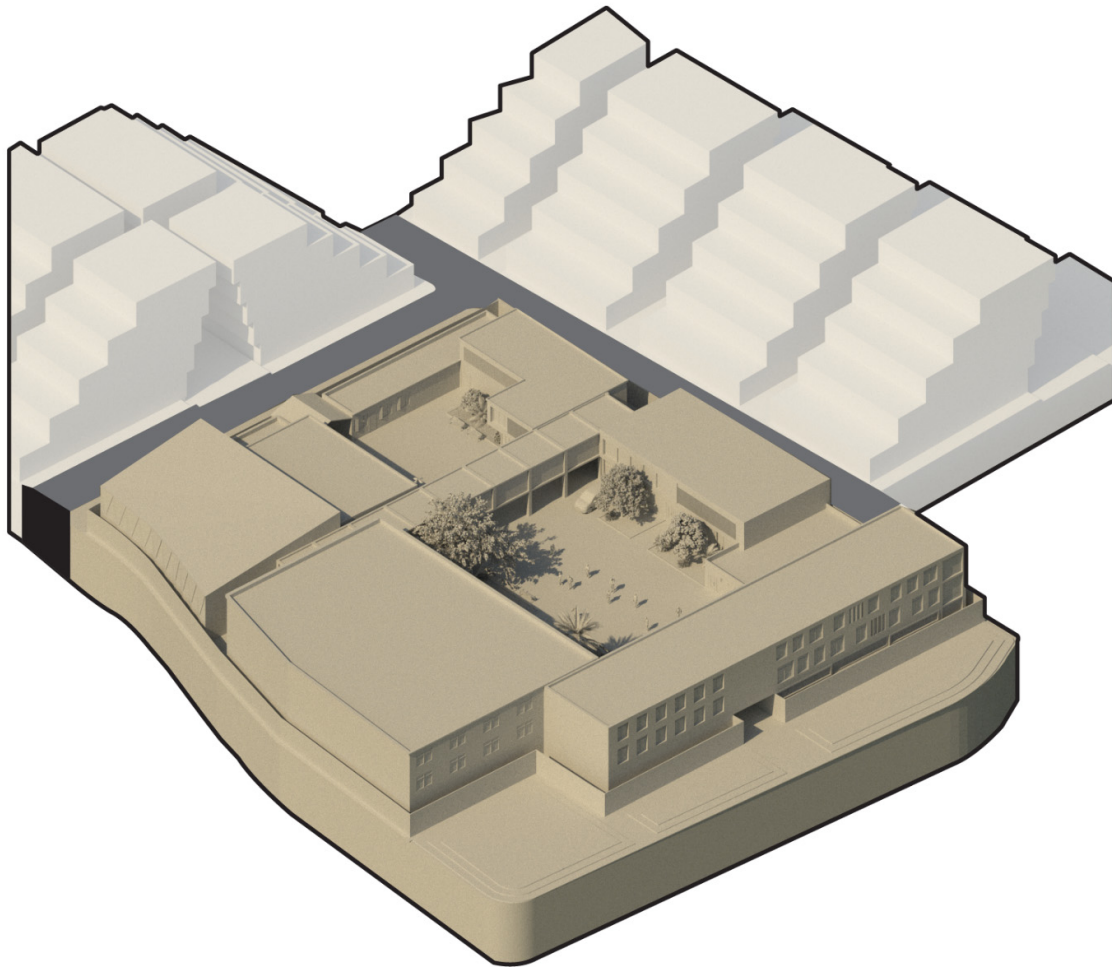


Figure 72. Axonometric view of the school in the urban context (Authors via Sketchup, Vray 6 and Illustrator)

Conclusion:

A result that stands out when applying the pyramidal model, housing density increases by at least **16.77%** compared to terrace houses. Quality of life will drastically improve with a satisfaction score estimated to be **??%** compared to standard collective housing, as measured by surveys on outdoor space quality, social cohesion, and thermal comfort.

PDAU recommends that all collective housing projects must comply to at least **60** housing units per square hectare. Pyramidal Organization has surpassed the recommended levels by **16.67%** increase with **75** housing units per square hectare.

PDAU recommendations:

Short-term housing needs: 75 units over an area of **1.25 hectares** = **60 units per hectare**.

Medium-term housing needs: 62 units over an area of **1.03 hectares** = **60 units per hectare**.

Long-term housing needs: 168 units over an area of **2.80 hectares** = **60 units per hectare**.

