FROM LIVED PHENOTYPE TO CULTURAL GENOTYPE: A SPACE SYNTAX ANALYSIS OF SOCIAL HOUSING APPROPRIATION IN TAZOULT, BATNA, ALGERIA

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Algerian social housing, inherited from modernist paradigms, is undergoing extensive appropriation as residents modify standardized architectural phenotypes. While often dismissed as informal disorder, this study reframes these transformations as deliberate acts of cultural inscription. The authors posit that these appropriations, far from being random, follow a deep structural logic and converge towards an identifiable socio-spatial configuration. To test this hypothesis, a mixed-methods approach was deployed in Tazoult, Batna. First, a qualitative survey of 150 units documented and modeled 17 recurring "lived phenotypes." Subsequently, these configurations were quantitatively compared against the original "designed" plans and traditional houses, serving as a cultural benchmark using Space Syntax. Comparative analysis reveals a distinct trajectory: lived phenotypes systematically diverge from the initial designed genotype, which is characterized by tree-like topologies and the dominance of circulation spaces. Instead, they converge towards a local genotype defined by the primacy of ring-like structures, the centrality of living spaces, and a dialectic of integration and segregation. These principles bear striking similarities to traditional housing, particularly in their recreation of the *Ghorfat n'ilmas* (the polyvalent central hearth room). Ultimately, this research provides quantitative evidence that appropriation acts as a cultural rewriting of space. By translating qualitative needs into objective configurational principles, this study offers an empirical knowledge base for designing adaptable and socially relevant housing.

Key words: architecture, phenotype, social housing, space syntax, Algeria.

INTRODUCTION

Mass-produced social housing presents an enduring paradox. While it effectively addressed a quantitative crisis, it simultaneously engendered a profound qualitative inadequacy a phenomenon widely documented from both sociological and architectural perspectives (Madanipour, 2003). Algeria serves as an emblematic case study in this regard. Its housing stock, largely derived from a standardized modernist genotype, has produced millions of uniform architectural phenotypes (Bachar, 2018). As highlighted by Frampton (1983), the imposition of such universal

forms often fails when it neglects regional specificity. As demonstrated by Çelik (1997), these models frequently conflict with local modes of inhabitation. Yet, faced with this disjuncture, residents have not remained passive. The widespread transformations they undertake are not mere disorder; rather, they constitute a vital signal. Following Mouaziz-Bouchentouf (2014), this study argues that these appropriations represent a cultural rewriting of space. They manifest a fundamental need for identification: the process by which inhabitants transform a generic dwelling into a meaningful home, as theorized by Serfaty-Garzon (1999) and underscored by Cooper (1974).

Scholarly literature has extensively explored this phenomenon. Foundational works, such as those by Segaud (2010), theorize the universal need to transform

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one's environment, while specific Algerian case studies by Mezrag (2015) and Tebib (2008) detail the nature of these alterations. Furthermore, housing studies link appropriation directly to well-being and place attachment (Low and Altman, 1992). Recent research has significantly advanced this understanding. Mlote *et al.* (2024), in a systematic review, emphasize that adaptability is no longer optional, but rather is a critical requirement for extending building lifespans. This aligns with the work of Ozler and Gucyeter (2024), who propose criteria-based approaches to quantitatively evaluate adaptability. Furthermore, Zeković *et al.* (2023) highlight the crucial distinction between functional adaptability and spatial flexibility, arguing that static designs fail to meet dynamic user needs. Finally, Kamara *et al.* (2020) identify the specific social, economic, and environmental "change factors" that drive residents to modify their environments, a dynamic clearly visible in the Algerian context.

However, despite confirming the urgency of the issue (Djafri *et al.*, 2019), this body of work remains predominantly qualitative. Consequently, a critical gap persists: the absence of a quantitative analysis of the configurational logic underlying these appropriations. This limitation hinders the ability to translate valuable insights into objective design principles (Gifford, 2007).

This gap frames the central research question in this study: do these spatial transformations converge towards a common configurational model? It is hypothesized that these modifications represent a collective rejection of the standardized designed genotype in favor of a local socio-spatial genotype. Drawing on theories linking form to culture (Rapoport, 1972) and space to social relations (Hall, 1978), this paper posits that this local genotype specific to the Batna region exhibits structural affinities with traditional Aurès housing. Specifically, it is argued that the residents' quest for a large, integrated central living space is a contemporary recreation of the socio-spatial logic of the *Ghorfat n'ilmas* (the polyvalent central hearth).

The objective of this paper is to empirically test this hypothesis using Space Syntax (Hillier and Hanson, 1984) as a decoding tool. This study offers two original contributions. First, it provides the first quantitative modeling of cultural convergence in Algerian social housing, establishing an evidence-based framework for adaptable and socially sustainable design (Manzi *et al.*, 2010). Second, it demonstrates that this convergence explicitly recreates the logic of a specific traditional archetype. The article proceeds by presenting a theoretical and methodological framework, detailing the comparative analysis, and finally discussing the broader implications of these findings.

THEORETICAL AND METHODOLOGICAL FRAMEWORK

To test the hypothesis, an analytical framework was constructed that bridges concepts from the sociology of housing and environmental psychology with quantitative spatial analysis.

From appropriation to genotype: A theoretical lens

The analysis begins with the phenomenon of appropriation. Following Segaud (2010), residents' transformations are not viewed here as mere modifications, but as fundamental anthropological acts through which inhabitants seek to found a place. As theorized by Serfaty-Garzon (1999) and environmental psychology (Proshansky *et al.*, 1983), this process can be interpreted as a mechanism of spatial appropriation, aiming to adapt a generic dwelling to specific cultural needs. To analyze the structural logic of these acts, the analytical lens of Hillier and Hanson (1984) is adopted, distinguishing between:

- **the architectural phenotype:** the observable, unique, and material building. In the present study, this corresponds to each individual floor plan analyzed, whether in its initial designed state or its transformed lived in state
- **the spatial genotype:** the deep, recurrent organizational logic, the set of rules, and the spatial relations that encode a culture of inhabitation. Unlike the phenotype, the genotype is not directly visible but must be deduced from the statistical consistencies found across a sample of phenotypes (Hillier and Hanson, 1984).

This distinction allows for transcending aesthetic style and uncovering the underlying rules that generate culturally specific forms, a central goal of architectural morphology (Steadman, 2008). The objective is to deduce this genotype through the comparative analysis of multiple phenotypes, moving from the documentation of individual acts to the modeling of the cultural grammar they collectively express.

Space syntax as an analytical instrument

Space syntax was selected as the primary method because of its proven capacity to move beyond geometry and reveal the "social logic of space" (Hillier and Hanson, 1984). Its strength lies in quantifying the relationship between spatial configuration and social life. Its relevance for studying the socio-spatial logic of dwellings has been consistently demonstrated in contemporary research (Cunha, 2012) and validated across diverse global contexts (van Nes and Yamu, 2021). To operationalize this approach, a battery of syntactic indicators was deployed, systematically distinguishing for each its spatial logic (the measured property) from its social logic (its interpretation in terms of human interaction). Table 1 provides a synthetic definition of these indicators and their application in this study.

Spatial structure: Topology and space types

To operationalize the analysis, the architectural plans were first translated into justified graphs. Following the typological analysis principles outlined by Heckmann *et al.* (2018), the focus was on identifying functional zoning and circulation patterns within these graphs. This initial analysis seeks to understand the fundamental nature of circulation within the dwelling.

Spatial logic: It was determined as to whether the system is tree-like (acyclic, hierarchical) or ring-like (cyclic, networked). The distribution of space types (A, B, C, D) further characterizes this structure: Types A and B define linear sequences of control, while Types C and D create circuits of choice.

Table 1. Definitions and interpretations of Space Syntax indicators used in the analysis
(Source: Authors, 2025).

Indicator	Definition and calculation logic	Socio-spatial interpretation
Justified graph (Topology)	Represents the layout as a network of nodes (spaces) and edges (connections). Spaces are categorized by type: A (dead-end), B (passage), C (simple ring), D (complex ring).	Choice and flexibility: Tree-like (Types A+B): Enforces control and linear sequences. Ring-like (Types C+D): Offers route choices and spatial flexibility.
Mean Depth (MD)	The average number of topological steps required to reach all other spaces from a given root space.	Accessibility: A basic measure of isolation. High depth signifies a space that is topologically distant and often associated with privacy.
Integration (i) / RRA	A normalized measure of centrality based on Real Relative Asymmetry. It standardizes the Mean Depth relative to a theoretical system of the same size (Dk), allowing comparison across different buildings. Note: Integration (i) is the inverse of RRA.	Centrality and potential movement: The primary predictor of social interaction. High Integration (Low RRA): Identifies living cores and social hubs. Low Integration: identifies segregated zones (retreat/privacy).
Control Value (CV)	A local measure of connectivity. Each space distributes a value of 1 equally among its neighbors. CV is the sum of values a space receives.	Local power: Identifies spaces that govern local circulation. High CV (>1): indicates a strong distribution role (e.g., a "gatekeeper" hall or corridor controlling access to neighbors).
Difference factor (H / H*)	Based on Shannon's entropy, H measures the spread of integration values. H* normalizes this to compare systems of different sizes.	Differentiation: Quantifies the strength of the social code. Low H*: strong functional differentiation (structured/ heterogeneous system). High H* (near 1): Functional ambiguity (homogeneous system).
Point Depth Entropy (PDE)	Measure of the distribution of visual depth from a single location (VGA).	Visual surveillance: Low PDE: indicates a space offering a strategic, unobstructed visual field over the system (high surveillance potential).
Clustering Coefficient (CC)	Measure of the inter-visibility (convexity) of the visual neighborhood (VGA).	Conviviality: High CC: Indicates a convex space where people can easily see each other, fostering static social interaction (gathering potential).

Social logic: A tree-like structure encodes a logic of control and segregation, typical of formal institutions. Conversely, a ring-like structure encodes a logic of choice, integration, and flexibility, fostering encounters and fluidifying social relations.

Social hierarchy: Centrality and control

This analysis measures the position of each space within the social system of the dwelling.

Spatial logic: Integration (i) was calculated, which quantifies topological centrality (mean depth from all other spaces), and Control (CV), which measures local dominance over immediate neighbors.

Social logic: Integration is a powerful predictor of human interaction (Penn *et al.*, 1998), identifying social hubs (highly integrated "warm" spaces) versus spaces of retreat (segregated "cold" spaces). Control, in turn, reveals the spatial "gatekeepers," the obligatory points of passage that govern circulation and surveillance.

Perceptual experience: Visibility Graph Analysis (VGA)

Finally, the visual experience of space was analyzed.

Spatial logic: Visibility Graph Analysis (Turner *et al.*, 2001) was used to measure visual permeability via Point Depth Entropy (PDE) and the convexity of the visual field via the Clustering Coefficient (CC).

Social logic: This approach reveals two key social properties. PDE identifies strategic surveillance points (low entropy) and visual refuges (high entropy), informing privacy management. The CC reveals potential "hearths" for social gathering (high CC) and spaces of transit (low CC), allowing for an analysis of spatial conviviality (Bellal and Brown, 2003; Assassi and Bellal, 2016).

FIELD RESEARCH PROTOCOL: CONSTRUCTING THE ANALYTICAL CORPUS

The empirical research focuses on social housing estates in Tazoult, located in the Batna province of Algeria (Figure 1). Specifically, the study focuses on the "200 Logements" estate, commissioned by the OPGI (Office of Real Estate Promotion and Management) and delivered in 1984. This estate comprises a homogeneous set of 5-story buildings (Ground floor + 4), primarily consisting of 3-room (F3) apartments. To facilitate a rigorous comparative analysis, a stratified corpus was established encompassing three distinct phenotype families:

Designed phenotypes: This category includes the original architectural plans of two dominant social housing typologies: the standard public rental model (LSL) and the participatory model (LSP). Constructed between 1980 and 2000, these estates epitomize the standardized mass housing produced by the Algerian state.

Lived phenotypes: This core dataset is derived from an in-depth qualitative field study. Although an initial stratified sampling strategy targeted two major estates, privacy constraints necessitated a controlled snowball sampling procedure to access domestic interiors. Consequently, this method yielded a final sample of 150 units, selected to preserve variability across floor levels and orientations. Using a Grounded Theory approach (Glaser and Strauss,
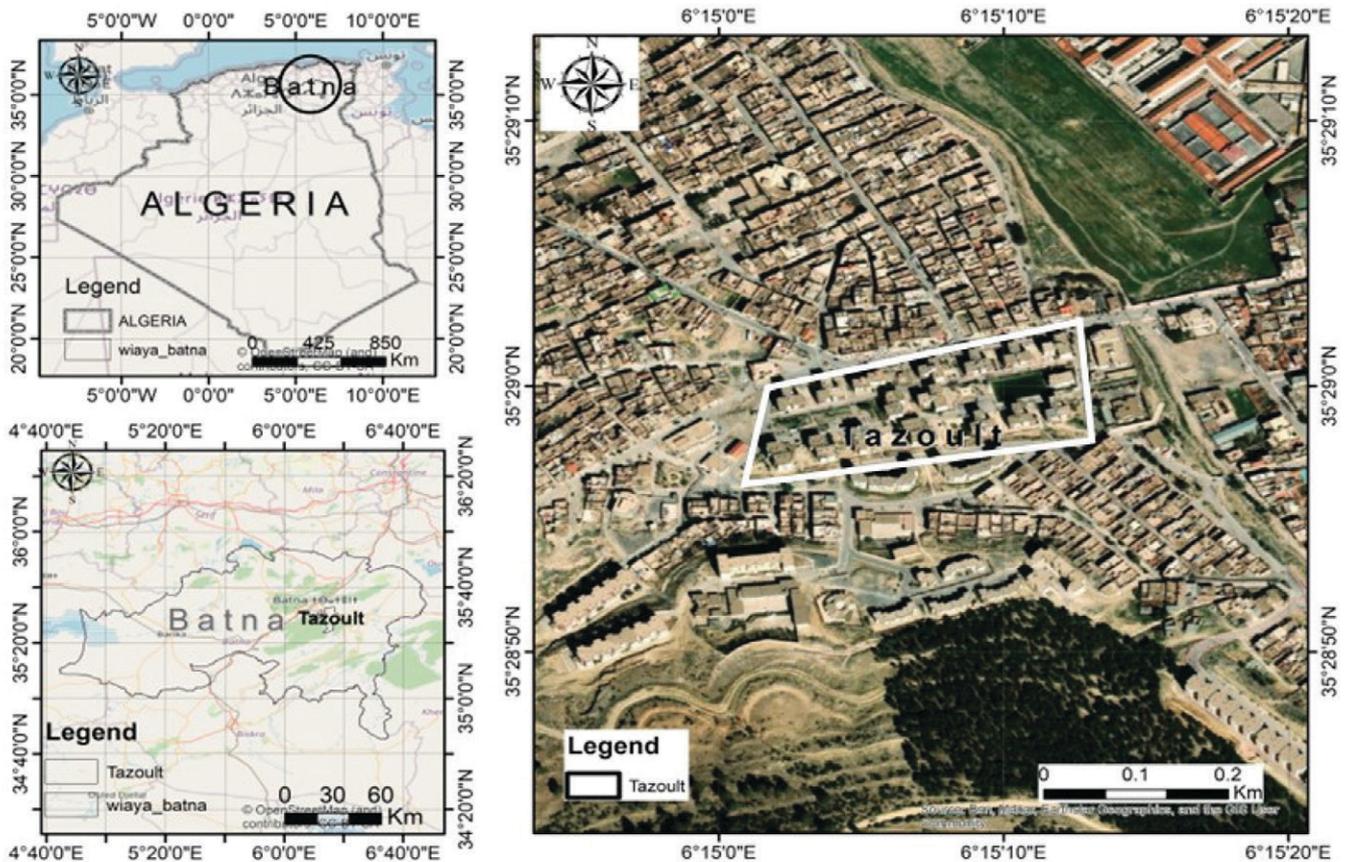
Figure 1. Geographic location of the study area
(Source: Authors, 2025)

1967), these data were distilled into 17 distinct lived phenotypes, which are synthetic models representing the most recurrent spatial transformations.

Benchmark phenotypes: To establish a cultural baseline, three traditional Aurès houses were included. This strategic inclusion made it possible to empirically test the hypothesis of convergence towards a vernacular genotype. Specifically, houses organized around the Ghorfat n'ilmas were selected.

Defining the vernacular model: The Ghorfat n'ilmas (or Hearth room)

The Ghorfat n'ilmas must be understood not merely as a specific room, but as a topological operator that forms the socio-spatial heart of the domestic genotype. Ethnographic studies define it as the symbolic and functional center of the house, which, through its composition, organizes the entire dwelling (Adjali, 2002). From a syntactic perspective, this space represents a unique configuration where convexity (occupation) and connectivity (movement) overlap. Unlike the standardized corridor-based layout typical of Algerian social housing, which serves purely for circulation, or the open courtyard found in other regions, the Ghorfat n'ilmas is an enclosed, highly integrated living space.

However, it is crucial to distinguish here between geometric centrality and functional centrality. As illustrated in the floor plans presented in Figure 2, the positioning of the Ghorfat n'ilmas varies: it may be located laterally adjacent to a courtyard or occupy a central position in dwellings without one. Yet, regardless of its location, it operates as the undisputed socio-

spatial core of the dwelling. Unlike the courtyard, which often acts merely as a light well or a transient space, the Ghorfat n'ilmas is the permanent hub for family gathering, dining, and social interaction, demonstrating that in the local genotype, centrality is defined by activity rather than geometry.

This variability in configuration is clearly observed in the appropriated dwelling plans. As demonstrated in Figure 2, two distinct variations of the Ghorfat n'ilmas layout are identified. In the first typology (a), found in dwellings with a central courtyard, the Ghorfat n'ilmas is located laterally to maintain privacy while opening onto the semi-private courtyard space. In the second typology (b), characteristic of dwellings without a courtyard, the Ghorfat n'ilmas shifts to occupy the central geometric position, acting directly as the primary distribution and gathering hub. In both cases, regardless of its specific geometric location, this room functions as the invariant socio-spatial core of the household.

A detailed analysis of the traditional Ghorfat n'ilmas further reveals that the adaptability of this local genotype relies on a sophisticated spatio-temporal logic. Functional divisions are not achieved through vertical walls, but through a subtle management of the floor plane using simple elevations or built-in benches that define specific zones without breaking visual integration. Unlike modern static rooms, the Ghorfat n'ilmas is defined not by a fixed function, but by the time of day. Its rhythms the stages of daily life, shifting from periodic family gatherings around the hearth to women's cooking activities.
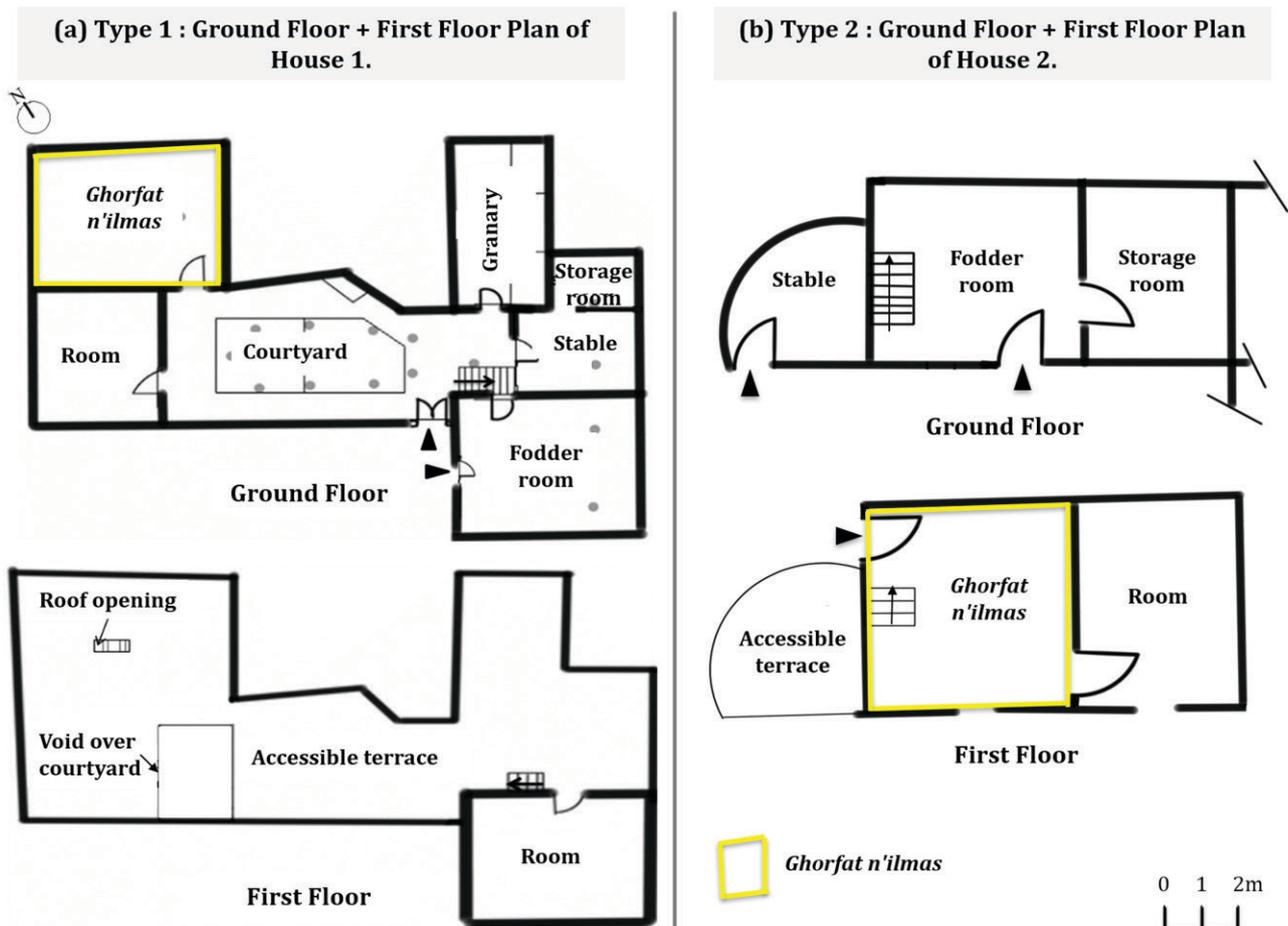
(a) Type 1 : Ground Floor + First Floor Plan of House 1.

(b) Type 2 : Ground Floor + First Floor Plan of House 2.

Figure 2. Appropriated dwelling floor plans showing two variations of the Ghorfat n'ilmas configuration
(Source: Authors, 2025)

Based on this theoretical framework, this study hypothesizes that the spatial modifications observed in social housing represent a tacit attempt to retrieve this specific structure. Specifically, it argues that residents seek to re-establish a protected yet central social core within standardized plans that originally lacked one. This appropriation process can be visualized as a fundamental structural shift, as illustrated in Figure 3. The comparison highlights the transition from the initial designed genotype (a), characterized by a rigid, tree-like structure where a sterile corridor serves as the sole central integrator, to an emerging cultural genotype (b). In this appropriated configuration, a ring-like structure appears, and the central integrator shifts to a genuine living space (kitchen or living room), effectively mirroring the socio-spatial logic of the traditional Ghorfat n'ilmas.

Protocol synthesis

The proposed protocol applies space syntax tools across this entire corpus to systematically compare the configurational properties of each phenotype family. This comparative analysis is specifically designed to reveal the underlying logic of the "cultural rewriting" at play in the appropriation process.

RESULTS: A COMPARATIVE ANALYSIS OF CONFIGURATIONS

This section details the empirical findings of the comparative syntactic analysis, illustrating the transition from "designed" to "lived" layouts (Figure 4: (a) Designed Phenotype vs. (b) Lived Phenotype, showing the living room expansion). By systematically contrasting the configurational properties of "designed," "lived," and "traditional" phenotypes, this paper demonstrates the convergence of resident appropriations within the specific context of Batna towards an identifiable local genotype.

The analysis reveals a fundamental structural shift. While the designed models initially exhibit predominantly deep, hierarchical structures rooted in circulation spaces (even when minor rings exist), the lived phenotypes shift towards shallower systems through a rich diversity of strategies. These range from internal functional reorganization to create a central dining hub, to the creation of integrated open living cores, or the establishment of new connectivity loops linking the dwelling to its surroundings. This diversified connectivity strikingly mirrors the complex topological logic of the traditional reference.

Furthermore, the Visibility Graph Analysis maps the experiential qualities of the space and confirms a crucial shift: the potential for surveillance and social gathering
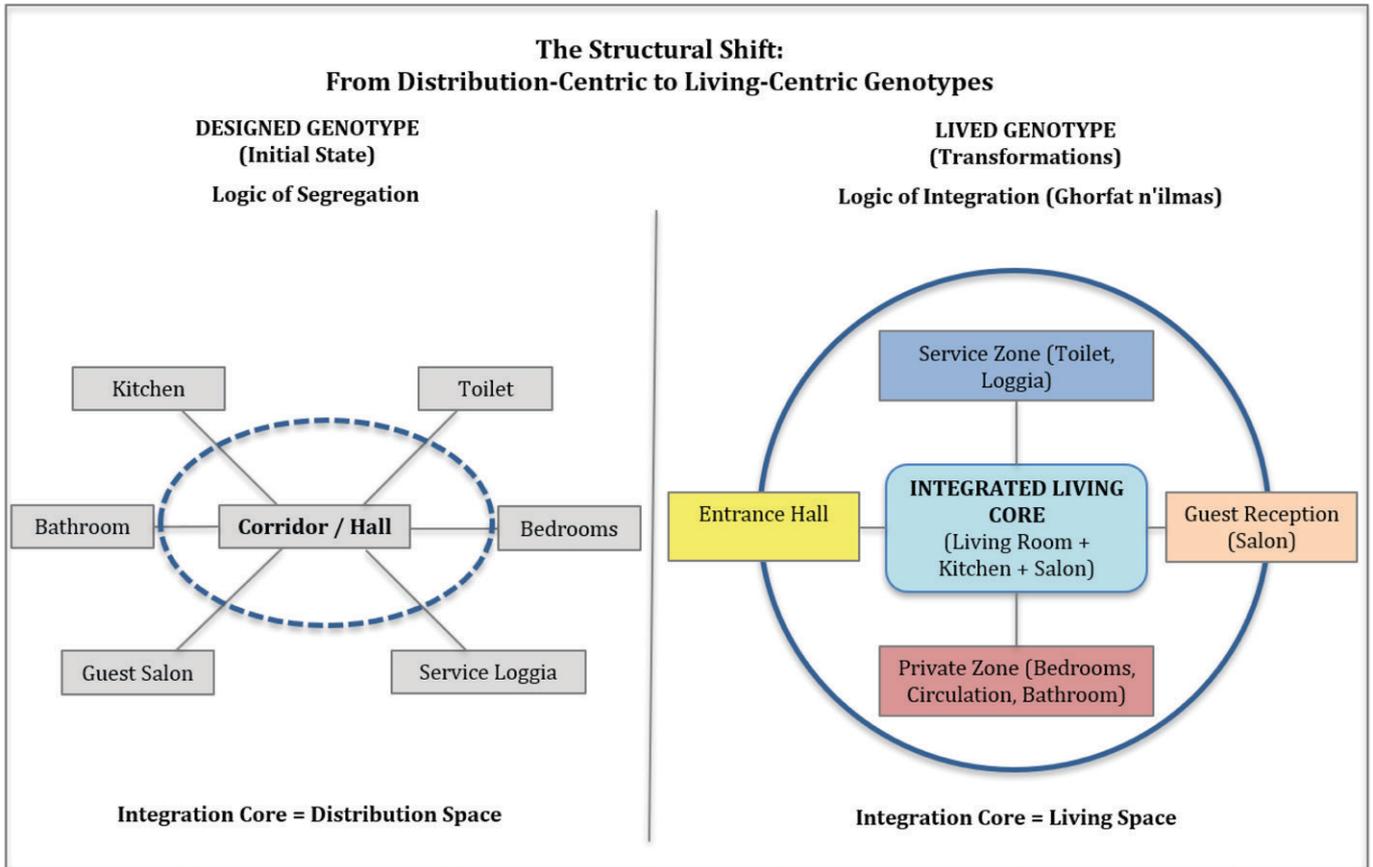
Figure 3. The Structural shift towards the Ghorfat n'ilmas logic
(Source: Authors, 2025)

migrates from the sterile circulation spaces of the initial design to the active living cores of the appropriated homes, effectively recreating the socio-spatial logic of the traditional Ghorfat n'ilmas.

Interpreting the shift: Introverted centrality

Crucially, the central living space emerging from these transformations represents a unique socio-spatial hybrid. Geometrically, it occupies the central position traditionally
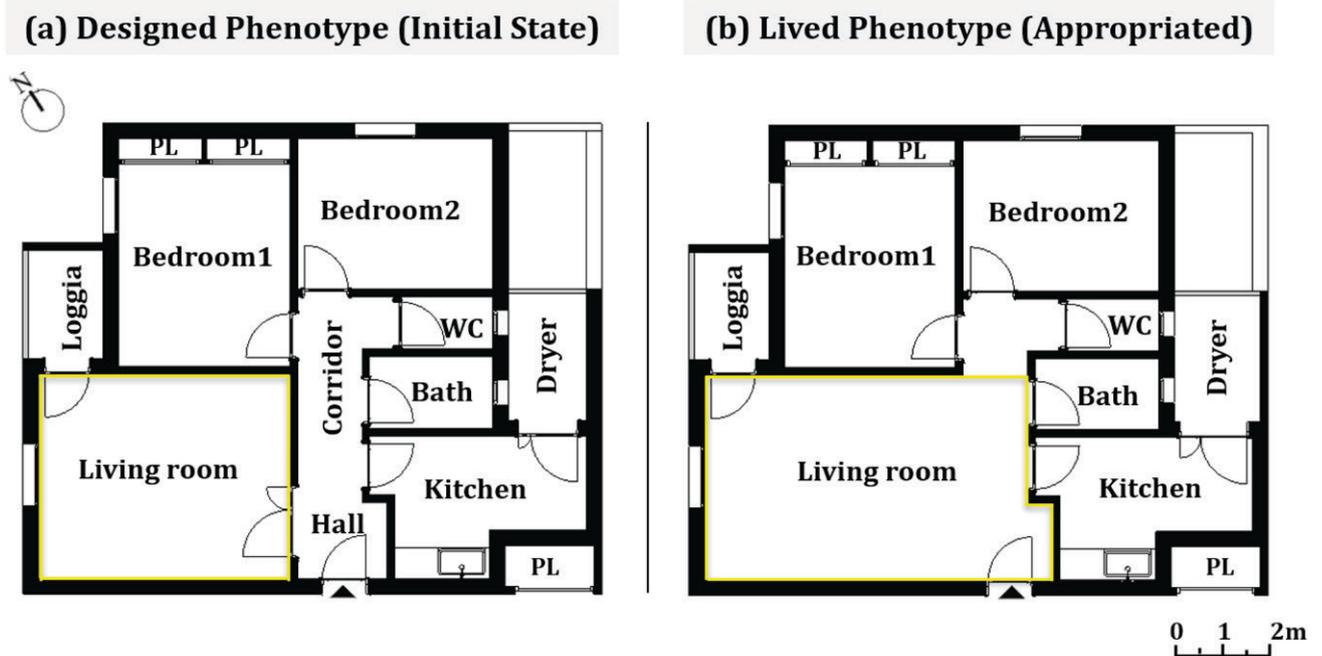

Figure 4. Floor plan comparison illustrating the configurational shift in the LSP model
(Source: Authors, 2025)

held by the courtyard, organizing circulation around it. However, functionally and climatically, it operates as a *Ghorfat n'ilmas*: an enclosed, protected, and polyvalent living core. This distinction is vital to separate it from the generic modern open plan. While both favor spatial integration, their syntactic logic differs. The modern open plan often seeks spatial continuity and transparency towards the exterior (extroverted). In contrast, this local genotype creates an *introverted centrality*: the living space is highly integrated to facilitate family gathering, yet it remains topologically deep or protected from the entrance to preserve the sanctity of private life. Residents do not seek unstructured openness; they construct a hierarchical openness that balances social interaction with strict privacy control.

Rejecting the tree: The systematic quest for ring-like structures

The primary investigation targeted the plan's most fundamental characteristic: its topology.

Spatial logic (empirical evidence)

The analysis of justified graphs reveals a pronounced and unambiguous trend (Table 2), highlighting a radical dichotomy between designed models and their lived or traditional counterparts. Precisely, the specific designed phenotypes analyzed in Batna encompassing both LSL and LSP typologies are consistently exhibited on a purely tree-like (arborescent) structure. In contrast, a substantial majority of lived LSL phenotypes (77%) disrupt this logic by introducing at least one ring structure (internal, external, or complex). This feature is not incidental; it is systematically present in 100% of the traditional phenotypes.

This structural shift is further corroborated at the level of elementary components. While designed plans rely exclusively on Type A (destinations) and Type B (obligatory passages), resident transformations foster the significant emergence of Type C (simple circuits) and Type D (complex circuits), which are the fundamental building blocks of ring topologies.

Social logic (interpretation)

This topological reconfiguration signifies more than a technical adjustment; it evidences a collective rejection of the initial standardized layout. The tree-like structure, encoding a logic of control and segregation, is systematically deconstructed by residents. By introducing rings, they embed choice and fluidity into the spatial system. This is not mere sophistication but a response to specific social imperatives, such as segregating guest and family circulation paths, refining privacy management, or simply streamlining daily life. Residents effectively modify the spatial configuration to increase connectivity and integration values within the dwelling.

The case of LSP housing offers a critical counterpoint. Constrained by the absence of residential ground floors, LSP transformations failed to generate external rings, resulting in the persistence of tree-like structures. This confirms that the quest for flexibility is often contingent upon the capacity to renegotiate the dwelling's interface with its environment.

Synthesis

Consequently, this quantitative analysis demonstrates that resident modifications are neither random nor chaotic. They follow a clear trajectory towards greater integration, converging strikingly with the ring-based logic of traditional housing. The first indicator of the local genotype is thus established: the primacy of the ring.

Shifting the social core: the primacy of living space over distribution

Having examined the global topological structure, the second analysis interrogates the internal hierarchy of the dwelling. This phase compares indicators of centrality (Integration i) and dominance (Control CV) across each phenotype family to map the distribution of socio-spatial power.

Spatial logic (empirical evidence)

The analysis reveals a radical reconfiguration of the dwelling's "core". Table 3 synthesizes the mean indicators and, crucially, identifies the space type that consistently functions as the integration hub.

Two findings emerge from this data. First, lived phenotypes exhibit a higher degree of global integration (lower mean RA) compared to their designed counterparts. A granular analysis confirms that this improvement is primarily

Table 2. Comparison of topological structures by phenotype family
(Source: Authors, 2025)

Phenotype family	Tree-like topology (arborescent)	Ring-like topology (internal, external, or complex)
LSL (designed)	100%	0%
LSL (lived)	23%	77%
LSP (designed)	100%	0%
LSP (lived)	100%	0%
Traditional benchmark	0%	100%

Table 3. Comparison of mean syntactic indicators and the integration core by phenotype family
(Source: Authors, 2025)

Phenotype family	Mean relative asymmetry (RA)	Most integrated space (system core)
Designed phenotypes	0.30	Distribution space (corridor/hall)
Lived phenotypes	0.29	Active living space (living room/kitchen)
Traditional phenotypes	0.31	Central living core (courtyard/Ghorfat n'ilmas)

driven by LSL transformations where ring structures were successfully introduced. Second, and most significantly, the nature of the integration core undergoes a fundamental shift. In designed plans, the core is invariably a space of pure distribution (corridor/hall). In lived plans, this core migrates to a genuine living space (living room/kitchen), aligning perfectly with the logic of the traditional model where the courtyard or Ghorfat n'ilmas serves as the central hub.

Social logic (interpretation)

This structural shift constitutes a compelling indicator of the emergence of an alternative genotype. The standardized layout of the analyzed social housing units subordinates social life to circulation; its structural core effectively functions as an internal corridor. The observed transformations systematically reduce this dominance of transit. By reconfiguring their homes, they reposition living spaces at the center of the spatial configuration, creating a central hub for social interaction. This reconfiguration prioritizes spaces of social interaction over purely functional circulation areas. The detailed analysis uncovers two distinct strategies for this recentering: the elevation of the kitchen as the hub of informal daily life, and the promotion of the living room as the locus of formal reception.

However, this drive for integration does not compromise privacy. Analysis of Control (CV) values indicates that circulation spaces retain high control over access to private zones across all phenotypes.

Synthesis

Consequently, the second and third rules of the local genotype are established. Rule 2: The system's core must be a space for living and gathering, not merely distribution. Rule 3: This integrated core must articulate with a segregated, controlled private zone. Residents are thus engineering a sophisticated balance between social integration and the protection of intimacy.

Heterogeneity and perceptual experience: refining the genotype

To refine the modeling of the genotype, two complementary analyses were conducted focusing on spatial diversity and visual perception. Table 4 presents the synthesized mean indicators supporting this investigation.

The quest for structured heterogeneity (H* Analysis)

Spatial logic (empirical evidence)

As indicated in Table 4, H* values remain consistently low and stable across all LSL/LSP models, confirming the persistence of strong spatial heterogeneity. The traditional

model, with a significantly higher value (-0.22), exhibits greater configurational polyvalence.

Social logic (interpretation)

This persistence suggests that residents are not seeking undifferentiated or homogenized spaces. Conversely, they actively maintain a clear differentiation of social roles within the domestic environment. The fourth rule of the local genotype is thus defined: the system must be heterogeneous, offering a clear articulation of varying degrees of intimacy and functional distinction.

Synthesis

This specific finding is crucial for defining the complete social logic of the dwelling. While residents actively seek integration (Rules 1 and 2), they explicitly reject spatial confusion. By maintaining low H* values, they reaffirm Rule 4: the necessity of a structured heterogeneity. This validates the dialectic identified in Rule 3 (integration/segregation), demonstrating that the local genotype is a sophisticated system that balances the fluidity of the day-zone with a strict, readable hierarchy of privacy for the night-zone. Taken together, these analytical findings ranging from topological shifts to hierarchical inversions reveal the emergence of a coherent spatial logic that modern open plans often fail to capture.

The quest for visual co-presence (VGA analysis)

Spatial logic (Empirical evidence)

Table 3 reveals a clear convergence in visibility indicators. Quantitative data indicates that lived phenotypes (LSL CC=0.821; LSP CC=0.813) significantly enhance their performance in terms of Gathering Potential (CC), achieving levels nearly identical to the traditional benchmark (0.828). A parallel trend of improvement is observed for Strategic Visibility (PDE). Qualitative analysis of the visibility maps clarifies the mechanism behind this gain: it results from a systematic displacement of the most performant visual zones (low PDE and CC values) from the transit spaces of designed plans to the central living spaces of lived and traditional phenotypes.

Social logic (interpretation)

Residents reconfigure their dwellings to ensure that internal "public square" loci of gathering and informal social control coincide with primary living spaces. Consequently, the fifth rule of the genotype is established: the social and visual core of the dwelling must be a living space, facilitating both co-presence and a continuous awareness of domestic activity.

Table 4. Comparison of mean indicators of diversity and visual perception by phenotype family
(Source: Authors, 2025)

Phenotype family	Mean relative difference factor (H*)	Mean point depth entropy (PDE)	Mean clustering coefficient (CC)
LSL (designed)	-0.33	1.79	0.834
LSL (lived)	-0.36	1.69	0.821
LSP (designed)	-0.33	1.51	0.854
LSP (lived)	-0.32	1.59	0.813
Traditional benchmark	-0.22	1.41	0.828

Synthesis

These quantitative trends that drive for a more integrated system anchored by a central living space strongly suggest a convergence towards the properties inherent in traditional housing. To structurally confirm this hypothesis, a final visual analysis was performed using abstracted graphs, demonstrating the recreation of the Ghorfat n'ilmas logic.

Visualizing convergence: the Ghorfat n'ilmas as a genotypical model

To synthesize and visualize the convergence of social logics, a final comparative analysis was conducted using abstracted justified graphs. This method re-categorizes spaces based on their primary social function. To facilitate visual comparison, spaces were categorized by social activity following a coding schema adapted from housing analysis typologies (Heckman *et al.*, 2018; Nishihara, 1968). The nodes were labeled as follows: Exterior space (E), Collective social space like the immediate vicinity (C), Semi-collective social space like landings and stairwells (SC), Transition space like the entrance hall (T), Reception space like the guest salon (R), Service space including kitchen and bathrooms (S), Family space like the living room or Ghorfat n'ilmas (F), and Intimate space for bedrooms (I). This abstraction facilitates a direct comparison of the 'social syntax' across divergent phenotype families.

Spatial logic (empirical evidence)

Figure 5 represents a comparative analysis of abstracted justified graphs through a selection of representative cases. As can be observed, the matrix illustrates a distinct configurational shift from the rigid, tree-like structures of the designed models (left column) to the ring-like, integrated structures of the lived transformations (right column). In these graphs, the dotted line marks the threshold of the domestic sphere. Crucially, the emergence of rings in the lived phenotypes highlights a morphological convergence towards the vernacular model (bottom row).

Figure 5. Comparative analysis of abstracted justified graphs by social function
(Source: Authors, 2025)

Social logic (interpretation)

The visual evidence in Figure 5 corroborates the quantitative findings, revealing a process of spatial reconfiguration driven by cultural patterns (Rapoport, 1969) unfolding in three distinct phases:

- **Designed logic:** Designed phenotypes consistently exhibit a linear, hierarchical, tree-like structure. The underlying social syntax is characterized by linear distribution and functional separation.
- **Lived logic:** Lived phenotypes demonstrate a systematic rupture from this model. Residents explore diverse solutions, ranging from constrained adaptations that merely complicate the tree structure to the creation of simple or complex ring topologies. The social syntax shifts towards flexibility and enhanced social integration; and
- **Convergence with the traditional model:** The logic of the most successful lived phenotypes converges remarkably with the traditional benchmark. Crucially, this benchmark was strategically selected: it is organized not around an open courtyard, but around a large, polyvalent central living space the Ghorfat n'ilmas (polyvalent central hearth). This space functions as an interior hearth, a spatial form directly comparable to the integrated living room/kitchen of a modern dwelling.

Synthesis: The Ghorfat n'ilmas as the archetype of the local genotype

The Ghorfat n'ilmas embodies the precise social logic of centrality manifest in residents' transformations, where the living room or kitchen assumes the role of the dwelling's core. This finding is pivotal: it demonstrates that the fundamental principle of the local genotype is not merely a courtyard, but rather a large, covered, and integrated interior living space. The Ghorfat n'ilmas thus serves as the historical and cultural validation of the contemporary resident's spatial quest.

Ultimately, this visual analysis provides definitive proof of the central argument. Residents are not merely displacing or moving walls; they are rewriting the syntax of relations between social functions. They are transitioning from a model of hierarchical segregation to one of networked integration, attempting to recreate the logic of the Ghorfat n'ilmas as the heart of social life within the constraints of the imposed standardized phenotype.

DISCUSSION

Modeling the social and spatial genotype

The findings from the comparative analysis demonstrate that the transformations undertaken by residents in Batna are not random disorder, but a coherent cultural pattern. This discussion synthesizes these findings to extract their primary significance: they constitute empirical evidence of a deliberate cultural rewriting of space.

The convergence of phenotypes: Transitioning from standardized layouts to culturally adapted configurations

Analysis has revealed three convergent trends of striking clarity:

- **Topological rupture**: Residents systematically reject the tree-like structure of designed plans in favor of circulation rings, thereby prioritizing flexibility of movement;
- **Shift in the social core:** The dwelling's center of gravity migrates from spaces of distribution (corridors) to genuine living spaces (living room or kitchen), subordinating circulation to social life; and
- **Dialectic of balance**: While integrating spaces, the transformations maintain a high degree of functional differentiation and a clear protection of the private sphere, consistent with the logic of traditional housing.

In sum, residents are rewriting their dwellings according to a spatial grammar that is radically distinct from the designed genotype. A significant finding of this analysis is that this new grammar is not a novel invention, but a cultural retrieval.

This comparative analysis with traditional housing reveals that the residents' quest for a large, central, and integrated living space is a contemporary recreation of the socio-spatial logic of the Ghorfat n'ilmas the polyvalent central hearth of the traditional Aurès home. This vernacular model, much like the transformed living room, acts as the integrated pivot organizing all domestic life. Therefore, the observed convergence is not merely a trend towards generic open layouts; it suggests the persistence of a spatial preference for centralized living configurations. This process goes beyond simple renovation; it represents a reconfiguration of the spatial syntax, shifting from a model of hierarchical segregation to one of networked integration, in an attempt to recreate the logic of the Ghorfat n'ilmas within the imposed standardized phenotype.

Modeling the local genotype: Five principles for a relevant design framework

The convergence of empirical trends towards the logic of the Ghorfat n'ilmas enables the modeling of the sought-after social and spatial genotype. This model is not a rigid standard plan, but a set of five configurational principles that constitute its grammar. This modeling represents the central contribution of this paper; it gives an objective voice to the resident's cry for adaptability and transforms qualitative needs into an evidence-based design framework:

Primacy of the ring (Flexibility of paths)

- **Theory:** The systematic shift from tree-like to ring-like graphs in lived phenotypes indicates a critical need for multiple circulation routes and spatial fluidity.
- **Architectural application:** Architects must move away from rigid, corridor-based distribution. Instead, floor plans must offer potential connections between adjacent living spaces (e.g., via knock-out panels or double doors connecting the kitchen to the living room). This enables residents to activate circular circulation

rings when needed, mimicking the fluid flow of the traditional courtyard house.

The centrality of the living space (Social hierarchy)

- **Theory:** The lived graphs reveal that the living area consistently becomes the most integrated node, replacing the corridor.

- **Architectural application:** Future layouts should reposition the main living area as the gravitational center of the home, to be a high-integration hub rather than a segregated room. This space must act as the primary distributor, directly controlling access to peripheral zones to minimize spatial depth and maximize social interaction.

The dialectic of integration and segregation (Control of intimacy)

- **Theory:** The local genotype demands a paradox: high integration in the day zone for social fluidity, but strict structural segregation for the night zone to preserve privacy.

- **Architectural application:** Designs must incorporate a dynamic management of privacy. The boundary between the semi-public reception zone and the private family sanctuary must not be static. Partitions should be designed for adaptability, allowing this cultural buffer zone to expand or contract. This enables gendered privacy to be activated temporarily during visits without permanently fragmenting the home's unity.

Structured heterogeneity (Differentiation of roles)

- **Theory:** Spaces must not be generic; the depth of the layout must clearly reflect distinct social roles.

- **Architectural application:** The depth of the layout should unambiguously differentiate between guest spaces (shallow, accessible) and family spaces (deep). This can be achieved by creating a transitional vestibule that allows direct access to a guest reception area without penetrating the family core.

Visual co-presence (Social control through visibility)

- **Theory:** Low entropy values in transformed plans indicate a strong desire for visual mastery and passive awareness of the domestic space.

- **Architectural application:** Layouts should prioritize diagonal sightlines and wide openings between day-spaces (kitchen/living/hall). This facilitates passive surveillance and social connection, favoring visual continuity rather than compartmentalizing functions behind solid walls.

Summary of the model

This model provides quantitative evidence that the appropriation of social housing is not a chaotic process, but a coherent pattern of spatial adaptation. The analysis shows that residents modify the initial standardized configuration to increase spatial integration and connectivity, aligning the layout with specific local usage patterns. This adaptation process reflects a dynamic reinterpretation of tradition rather than mere nostalgia (Rapoport, 1969); as the Ghorfat n'ilmas model demonstrates, it is the recreation of an enduring socio-spatial logic that prioritizes the integrated living core as the heart of domestic life. This research thus transforms a cultural intuition into a verifiable, evidence-based framework for design.

Contribution to the literature and global implications

These findings resonate with, and substantially enrich, the existing literature on housing appropriation and adaptable architecture, extending the debate within the context of Algerian social housing.

First, this study quantitatively substantiates the qualitative observations of local scholars such as Tebib (2008), Mezrag (2015), and Mouaziz-Bouchentouf (2014) regarding the transformative nature of Algerian social housing. However, by employing Space Syntax, this research moves beyond mere documentation to reveal the underlying structural logic of these alterations. This responds directly to long-standing calls for more analytical approaches in post-occupancy evaluation (Vischer, 2002). Furthermore, the results provide strong empirical support for the phenomenon of genotype retrieval as a widespread mechanism of the informalization of the formal. The structural conflict observed in Batna mirrors resident-led modifications documented in diverse mass housing contexts, from Cairo (Shehayeb, 2009) to Latin America (Kellett and Napier, 1995). In all these cases, residents are not merely adding space; they are fundamentally re-wiring the topological logic of the home, transforming the imposed tree-like structure of the initial plan into a ring-like structure that mirrors traditional spatial continuity. This confirms Rapoport's (1972) foundational hypothesis: residents practices aim to reintroduce the configurational principles of a deep-seated cultural model into the standardized dwelling.

Second, these findings engage critically with contemporary theories of adaptability, particularly the framework established by Schmidt and Austin (2016). While these authors argue that adaptability should be an inherent design characteristic deliberately embedded within the building's layers, the Algerian case presents an inverted scenario. Here, although the structural system (column-beam) allows for potential flexibility, the initial spatial layout was designed with high rigidity and minimal adaptability options. Yet, the sheer scale of transformations demonstrates that the cultural genotype acts as a driver far more powerful than the physical constraints of the built form. In the absence of what Schmidt and Austin define as planned adaptability, residents resort to forced adaptation, modifying the standardized layout to accommodate evolving household needs and usage patterns. This leads to a pivotal conclusion: in many developing contexts, adaptability is not a technical luxury, but a survival strategy imposed by users to reconcile the acute mismatch between a static built environment and their evolving socio-cultural needs.

Finally, the implications for policy and future design are significant. The resilience of the Ghorfat n'ilmas logic confirms a phenomenon of cultural persistence (Kent, 1990; Oliver, 1987) that must be integrated into architectural practice. The goal should no longer be to design the perfect finished phenotype, but rather an open genotype. This approach resonates with Habraken's (1972) Open Building principles, but with a crucial nuance: the support

must not be culturally neutral. It must be informed by the specific topological deep structures such as the ring-like circulation that users inevitably seek to recreate. Consequently, the modeling of this local genotype becomes a vital tool for designing a new generation of sustainable housing. By linking cultural relevance directly to long-term environmental and economic sustainability (Mlote *et al.*, 2024), this research offers a concrete path towards housing that is resilient precisely because it is culturally grounded.

CONCLUSIONS

This research began with the premise that the apparent disorder of transformations in Algerian social housing concealed a deep order, a cultural logic striving to assert itself against a rigid built form. The objective of this paper was to decode this logic through rigorous quantitative analysis. At the conclusion of this investigation, the hypothesis has been unequivocally validated.

This study demonstrates that residents' appropriations are not random interventions but systematic convergences towards an identifiable configurational model. The primary contribution of the study is, therefore, the first quantitative modeling of a socio-spatial genotype for housing in this context. The analysis proves that residents do not merely correct their dwellings; they rewrite them according to a spatial grammar of their own, transitioning the home from a standardized system for segregation to a vernacular system for connection. The most illuminating discovery is the identification of this genotype as a contemporary recreation of the socio-spatial logic of the Ghorfat n'ilmas the polyvalent central hearth of the traditional Aurès home. By rejecting the dominance of corridors in favor of a large, integrated living core, residents intuitively reintroduce the principle of centrality that lies at the heart of their housing culture.

The implications of this discovery are profound. First, it demands a paradigm shift for designers and policymakers: the focus must shift from designing the perfect, finished phenotype to designing open genotypes spatial systems that integrate, from the outset, the principles of flexibility and centrality that residents inevitably seek to recreate. Second, the proposed model provides an objective, evidence-based foundation to inform these new designs, transforming cultural intuition into a verifiable framework.

While the specific findings are local to Batna, the methodological framework developed here is transferable. Future research could fruitfully apply this syntactic analysis to other contexts of social housing appropriation, allowing for a comparative understanding of how residents adapt standardized spaces to diverse cultural needs.

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REFERENCES

Adjali, S. (2002). Habitat traditionnel dans les Aurès: Le cas de la Vallée de l'Oued Abdi. In P. R. Baduel (Ed.), *Habitat, État et société au Maghreb*. Paris: Éditions du CNRS, pp. 271-280.

Assassi, A., Bellal, T. (2016). An applied approach based on the space syntax program for decoding the interior spatial constants in traditional dwellings in south of Oued El Abiod in Algeria, *International Journal of Spaces and Urban Territory,* pp. 101-128.

Bachar, K. (2018). La (re)production urbaine en Algérie à travers le logement social collectif. La pérennisation d'un modèle devenu la norme, *Les Annales De La Recherche Urbaine,* No. 113, pp. 54-65. https://doi.org/10.3406/aru.2018.3272

Bellal, T., Brown, F. E. (2003). The visibility: an approach for the analysis of traditional domestic M'zabite spaces. In J. Hanson (Ed.), *Proceedings of the 4th International Space Syntax Symposium*. London: University College London, pp. 1-16.

Cooper, C. (1974). The house is a symbol of the self. In J. Lang, C. Burnette, W. Moleski, D. Vachon (Eds.), *Designing for human behavior*. Stroudsburg: Dowden, Hutchinson and Ross, pp. 130-146.

Cunha, N. (2012). Space syntax: a contribution to the study of the social logic of the city, *Urbe. Revista Brasileira de Gestão Urbana*, Vol. 4, No. 1, pp. 73-89.

Çelik, Z. (1997). *Urban forms and colonial confrontations: Algiers under French rule*. Berkeley: University of California Press.

Djafri, R., Mohamed Osman, M., Suzilawa, N. (2019). Social housing in Algeria: case study of Batna, *International Journal of Engineering and Advanced Technology (IJEAT)*, Vol. 8, No. 6, pp. 2282-2289.

Frampton, K. (1983). Towards a critical regionalism: Six points for an architecture of resistance. In H. Foster (Ed.), *The Anti-Aesthetic: Essays on Postmodern Culture*. Port Townsend: Bay Press, pp. 16-30.

Gifford, R. (2007). Environmental psychology and sustainable development: expansion, maturation, and challenges, *Journal of Social Issues*, Vol. 63, No. 1, pp. 199-212. https://doi.org/10.1111/j.1540-4560.2007.00503.x

Glaser, B. G., Strauss, A. L. (1967). *The discovery of grounded theory: strategies for qualitative research*. Chicago: Aldine Publishing Company.

Habraken, N. J. (1972). *Supports, an alternative to mass housing*. London: The Architectural Press.

Hall, E. T. (1978). *La dimension cachée*. Paris: Seuil.

Heckman, O., Schneider, F., Zapel, E. (2018). *Floor Plan Manual Housing*. Basel: Birkhauser Verlag Gmbh.

Hillier, B., Hanson, J. (1984). *The social logic of space*. Cambridge: Cambridge University Press.

Kamara, J. M., Heidrich, O., Tafaro, V. E., Maltese, S., Dejaco, M. C., Cecconi, F. R. (2020). Change factors and the adaptability of buildings, *Sustainability*, Vol. 12, No. 16, 6585. https://doi.org/10.3390/su12166585

Kellett, P., Napier, M. (1995). Squatter architecture? A critical examination of vernacular theory and spontaneous settlement with reference to South America and South Africa, *Traditional Dwellings and Settlements Review*, Vol. 6, No. 2, pp. 7–24. http://www.jstor.org/stable/41757181

Kendall, S. (2015). *Residential open building*. London: Routledge.

Low, S. M., Altman, I. (1992). Place attachment: A conceptual

inquiry. In I. Altman, S. M. Low (Eds.), *Place attachment.* New York: Plenum Press, pp. 1-12. https://doi.org/10.1007/978-1-4684-8753-4_1

Madanipour, A. (2003). *Public and private spaces of the city.* London: Routledge. https://doi.org/10.4324/9780203402856

Madanipour, A., Çelik, Z. (1997). *Urban forms and colonial confrontations: Algiers under French rule.* Berkeley: University of California Press.

Manzi, T., Lucas, K., Lloyd-Jones, T., Allen, J. (Eds.). (2010). *Social sustainability in urban areas: communities, connectivity and the urban fabric.* London: Routledge. https://doi.org/10.4324/9781849774956

Mezrag, H. (2015). *Le logement social collectif : entre la conception et l'usage cas de la ville de M'sila.* (Doctoral dissertation, Université Mohamed Khider, Biskra, Algérie).

Mlote, D. S., Budig, M., Cheah, L. (2024). Adaptability of buildings: a systematic review of current research, *Frontiers in Built Environment*, Vol. 10, 1376759. https://doi.org/10.3389/fbuil.2024.1376759

Mouaziz-Bouchentouf, N. (2014). Le logement social à Oran. Conception, usages et ébauche d'évaluation, *Revue Géographique De l'Est*, Vol. 54, No. 3-4, pp. 1-18. https://doi.org/10.4000/rge.5312

Nishihara, K. (1968). *Japanese houses: patterns for living.* Tokyo: Japan Publications.

Oliver, P. (1987). *Dwellings: the house across the world*. Oxford: Phaidon Press.

Özler, H., Güçyeter, B. (2024). A criteria- and case study-based approach to evaluate adaptability in buildings, *Architecture, Civil Engineering, Environment*, Vol. 17, No. 2, pp. 1-32. https://doi.org/10.2478/acee-2024-0011

Penn, A., Hillier, B., Banister, D., Xu, J. (1998). Configurational modelling of urban movement networks, *Environment and Planning B: Planning and Design*, Vol. 25, No. 1, pp. 59-84. https://doi.org/10.1068/b250059

Proshansky, H. M., Fabian, A. K., Kaminoff, R. (1983). Place-identity: Physical world socialization of the self, *Journal of Environmental Psychology*, Vol. 3, No. 1, pp. 57-83. https://doi.org/10.1016/S0272-4944(83)80021-8

Rapoport, A. (1972). *Pour une anthropologie de la maison*. Paris: Dunod.

Rapoport, A. (1969). *House form and culture*. Englewood Cliffs, N.J.: Prentice-Hall.

Schmidt, R., Austin, S. A. (2016). *Adaptable architecture: theory and practice*. London: Routledge. https://doi.org/10.4324/9781315722931

Segaud, M. (2010). *Anthropologie de l'espace : habiter, fonder, distribuer, transformer*. Paris: Armand Colin.

Serfaty-Garzon, P. (1999). *Psychologie de la maison: une archéologie de l'intimité*. Montreal: Méridien.

Shehayeb, D. K. (2009). Advantages of living in informal areas. In R. Kipper, M. Fischer (Eds.), *Cairo's informal areas: between urban challenges and hidden potentials.* Cairo: GTZ Egypt and Participatory Development Programme in Urban Areas (PDP), pp. 35–44.

Steadman, P. (2008). *The evolution of designs: biological analogy in architecture and the applied arts.* London: Routledge.

Tebib, E. H. (2008). *L'habiter dans le logement de type social à Constantine: manières et stratégies d'appropriation de l'espace.* (Doctoral dissertation, Université Mentouri, Constantine, Algérie).

Turner, A., Doxa, M., O'Sullivan, D., Penn, A. (2001). From isovists to visibility graphs: a methodology for the analysis of architectural space, *Environment and Planning B: Planning and Design*, Vol. 28, No. 1, pp. 103-121. https://doi.org/10.1068/b2684

Van Nes, A., Yamu, C. (2021). *Introduction to space syntax in urban studies.* Cham: Springer. https://doi.org/10.1007/978-3-030-59140-3

Vischer, J. C. (2001). Post-occupancy evaluation: a multifaceted tool for building improvement. In Federal Facilities Council (Ed.), *Learning from our buildings: a state-of-the-practice summary of post-occupancy evaluation.* Washington, DC: National Academies Press, pp. 23–34.

Zeković, S., Maraš, I., Krklješ, M. (2023). Exploring function adaptability and flexibility in architecture: case study of a housing vertical, *Facta Universitatis - Series: Architecture and Civil Engineering*, Vol. 21, No. 3, pp. 415-429. https://doi.org/10.2298/FUACE230614044Z

Zimring, C., Reizenstein, J. E. (1980). Post-occupancy evaluation: an overview, *Environment and Behavior*, Vol. 12, No. 4, pp. 429-450. https://doi.org/10.1177/0013916580124002