GLL
Geomatics, Landmanagement and Landscape No. 4 • 2024, 217–236

ISSN 2300-1496 https://doi.org/10.15576/GLL/192446

Research paper

Received: 1.05.2024
Accepted: 18.08.2024
Published: 31.12.2024

Assessing the health conditions of residential allotments

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Summary

This study presents an assessment of the health conditions of residential allotment in El-Eulma city, Algeria, using a case study framework. Its aim is to identify the indicators affecting human physiological comfort in the environment of residential housing. The study was carried out in two phases The first phase was conducted on site, revealing that the residential allotment underwent both horizontal and vertical densification, horizontally, nearly half of the initial plots were subdivided into smaller parcels, vertically, building heights were increased, furthermore, the strictly residential function was transformed into a mixed function, incorporating commercial spaces on most ground floors. The second phase involved a simulation generated by the ArcGis10.4 software assess the health conditions on three levels: the first level included a multicriteria analysis, which made it possible to identify adverse health conditions of the building; the second level involved a shading tool, which allowed to detect the zones with external adverse influence on health conditions, and finally, the third level was the evaluation of affected buildings based on four indicators: division, building height, commercial function, degree of change, with the shading indicator supported by the hierarchical analysis process. Finally, the paper concluded that the method and tools employed to address the issue of health conditions can be regarded as preliminary and diagnostic, specifically dedicated to examining the condition of residential allotment, such as the case study.

Keywords

health conditions • residential allotment • ArcGIS 10.4 • shading tool • hierarchical analysis process • El-Eulma

1. Introduction

People usually prefer individual housing, because of the privilege of the right to own and enjoy it. Individual housing also gives its residents the freedom to use and exploit it according to their desires and needs. Their needs, which they consider as basic and possible, can be fulfilled in their property. It should be noted that there is a dialectic between meeting the need and maintaining the health conditions of the dwelling. These conditions are often affected by deep and gradual changes in housing structure that do not take into account the balance between the two sides of the equation when meeting the extended family's need for shelter and the material security of its members.

1.1. Types of individual housing

There are many types of individual housing in modern cities. We can be group them into three types: 1) the individual housing complex, in which a group of dwellings is implemented by real estate developer, 2) the individual housing that is not connected to a larger housing complex, and finally 3) the planned individual housing where the production of free plots available for building is integrated into an overall development plan [Cerama 2015]. The last type has become the most common in Algeria, under the name of residential allotment. It is a land developed by a private or public developer, who then sells the plots to the owners, so that they can build their own homes with the right to choose their own projects, but with the obligation to respect the specifications drawn up in accordance with town planning and building regulations.

1.2. Residential allotments

Allain [2004] argues that residential allotment was initially nothing more than the division of one or more plots of land, which was gradually considered by the legislation as an urban planning process in its own right. Masboungi [2008], on the other hand, sees it as consisting of individual houses that often lack urban planning and are rarely synonymous with architectural and urban quality. What seems necessary is the quality of use rather than the desire for architectural creativity. The author quotes what Philippe Panerais, an urban planning engineer, deduced from his travels in the Netherlands, when he analysed the appropriation of housing by users. Panerais observed that stylistic diversity and functional innovation are far from what architecture critics care about.

Prigent's study indicates that the logic of zonal division of the functional planning of cities has been broken by mixing the functions of housing, economic, and commercial activity [Prigent 2007]. We believe that the study led by Masboungi made an explicit and urgent call to consider that the urban reality demands more energy and complexity, including the challenge of designing the city with its ground floors [Masboungi 2013].

As far as Algeria is concerned, we believe that the modern trends in architecture have contributed to the prevalence of residential allotments in urban planning, by imposing controls and health requirements, focusing on placing a building mass in the centre and with a garden in front and a courtyard behind the building. This means

ignoring the people, who may see such planning as undermining their freedom to deal with their property, when they want to satisfy their needs.

1.3. Need and housing

The study [Jawad Kadhim et al. 2019] showed that the changing social needs, methods of dealing with them, and the emergence of new jobs often cause instability of the architectural model and its original structure. These changes can occur individually (e.g., a shift in a single societal need) or collectively (e.g., a combination of factors impacting society).

One of the most prominent theories based on the concept of need is Maslow's theory. Maslow proposed a hierarchical organization of needs that concluded with self-fulfilment as the highest. It is also commonly known that higher needs do not drive an individual's behavior before the lower ones are satisfied.

However, as Maslow makes clear, it is not necessary to fully satisfy a need in order to move to the upper-level needs. It is, indeed, possible to satisfy human's needs within a certain percentage intervals before jumping to the higher level; and to specify intervals with certain proportions to jump from one level to another. He estimates that 85% of the needs are biological, 70% of the needs are safety, and 50% of the needs are related to social belonging, and 40% of them are self-realization. Al-Youssef and Al-Hasani [2018] suggested that the percentage decreases as we move up in the pyramid, and that the base of the pyramid is the one that needs to be largely met by the largest possible percentage. In view of this criterion, there is a percentage minimum need that remains unsatisfied for any person, but regardless of the lack he can jump to higher levels.

However, the issue does not seem so rigid, as Maslow corrected his theory, for the first time in 1954, when he considered the possibility of fluctuations between the needs, His second correction, in 1987, emphasized that most behaviors have multiple motivations, and asserted that humans tend to determine their behavior according to many or all of them [McCloud 2018]. Similarly, it can be said that it is the importance of needs to individuals that controls their move to higher needs, and not just the satisfaction or fulfillment of lower needs.

In the case of the extended family, where married children need housing, two needs can be satisfied at the same time: the need for shelter and the need for belonging to a family. A third need arises when families desire to invest in their dwellings to meet the need for material security for their members – it motivates them to use the ground floors partially or completely for commercial uses or services, given the lack of regulations and regulatory procedures.

1.4. Health conditions of housing

Numerous studies [Hobday and Dancer 2013, Ezratty and Ormandy 2020, Osibona et al. 2021] have addressed the problem under consideration of this paper, concluding that neither a home nor a city can be healthy, if either of them is unhealthy, and

that the built environment has a significant and an important impact on public health, because poor quality of housing has a direct and an indirect impact on human mental and physical health. The terminology adopted by these studies varied from a safe and healthy home, to poor housing, to healthy housing, healthcare buildings, healthcare environment, and inadequate housing conditions.

Housing health conditions rely on multiple indicators, such as climate, in particular the sun, which Hassan Fathi described as the main source of light and heat, and which is the basis for other climate phenomena, such as ventilation and humidity. Thus the sun and climate are considered to have great influence on the human physiological comfort [Fathy 2003, 1986]. This is what our study focused on in order to diagnose the reasons for its lack in residential allotments.

If the buildings do not have sufficient slopes, whether between opposite buildings on both sides of the road or those adjacent to the inner courtyards, there occurs a deficiency of solar radiation, lighting and air movement, as the influence of the sun in the process of moving the air is decisive, as confirmed by the architect Hassan Fathy. He asserted that utilizing the sun as a 'driving force' guarantees a continuous movement of air, which should be one of the objectives of an architect in order to achieve human physiological comfort in designed buildings [Fathy 1986, 2003]. The shade falling on the neighboring buildings also has an impact on air movement, thus limiting the effectiveness of 'natural self-ventilation' [Waziri 2003]. This is often the case when the height of the buildings does not respect the maximum limit that ensures that solar radiation reaches the outer facades of the houses, as well as their walls facing the inner courtyard.

2. Method and tools

This work aims to study the changes made by individuals to their homes in order to meet their need for shelter and the need for material security, and to monitor its impact on the physiological comfort of residents, which necessarily affects dwelling health conditions. The Bellala residential allotment was chosen as a representative sample of residential housing in Algeria. It is located in the urban center of El-Eulma city. Its area is estimated about eight hectares, and it contains 195 buildings.

The study was carried out in two stages. The first stage was devoted to the in-situ diagnosis of the changes that occurred in the housing through four indicators. The first three indicators represent the direct cause of these changes, including: a) the division of the plots which increases the horizontal density of the urban fabric, b) the commercial use of parts of the building, which alters its original function, c) the consequences of the building's height, which increases vertical densification, and the fourth indicator is used to determine how the building is changed. We have derived this finding from our exploratory study on the site, where these indicators represent the prominent manifestations of these changes that occur in the urban form of residential allotments and impact on the health condition of the dwellings being evaluated.

The second stage involved the simulation process, using the geographic information system. The study area was identified and the digital terrain model (MNT) map was

downloaded. After its reprocessing, it was coupled with the downloaded satellite image with a resolution of 1 m. The ArcGIS 10.4 program allowed the creation of a digital spatial database for each building in the residential allotment perimeter. This enabled us to create geoprocessing files to obtain maps showing the status of the changes made to the buildings through the four indicators separately. This way it was possible to conduct the first assessment with a multi-criteria analysis method.

The study posits that the combination of these factors – the subdivision of the plot, building heights ranging from three to five storeys without adequate spacing, and commercial use on the ground floor leading to the elimination of internal courtyards – may not only affect the buildings themselves also have repercussions for neighbouring buildings within the urban fabric.

Since the study focuses on the urban form of residential housing, we chose the shading tool for ArcGIS10.4, as it can classify buildings according to the degree of their exposure to solar radiation. This, enabled us to define different zones in relation to the level of shading. Using this analysis, we obtained the second assessment.

In order to create the evaluation matrix, all indicators were valued according to their significant, so that their weights are automatically calculated for each building using the ArcGIS 10.4 hierarchical analysis model. Finally, in the third assessment of the impact of the architectural changes on the health condition of the residential housing switched from 'favorable' to 'very unfavorable'.

3. Presentation of the case study

3.1. El Eulma City

El Eulma City is located in the east of Algeria, 300 km from the capital, and it is one of the municipalities of the Setif province (Fig. 1). It was established by the French occupation on the road to Constantine in the place called Taftika, by virtue of a decree dated 28 April 1862 under the name of Saint Arnaud [Mazzia 1954]. Its name was changed to El-Eulma after the independence in 1962. Currently, the municipality of El-Eulma covers an area estimated at 74.4 km^2. Since its foundation, it has been known for its flourishing of wholesale trade of all kinds. This is due to its location on the axis of the National Road No 5, considered one of the most important axes that crosses the region from east to west. There is also the National Road No 77, which crosses the region from north to south. The railway axis extending from the east to the west is also worth mentioning[1].

This trend towards commercial activity in the city has continued to the present day, and has even developed into specialized trade in most of the city's neighborhoods, especially in the residential areas located in the center and west of the city. The dominance of the commerce over the employment structure of the municipality was confirmed by the economic statistics carried out by [CENEAD 2011] with 57.4%.

[1] The master plan for the development and reconstruction of El Elma municipality, approved in 2016.

Source: Authors' own study, 2023

Fig. 1. Situation of El Eulma city

3.2. Bellala residential allotment

The Bellala residential allotment was approved in 1963, one year after the independence, and consists of 138 plots.[2] It was established by a private developer who owns the plot of land on which the allotment was built.

No commercial activity was envisioned for the residential allotment, because it was designed purely for residential function, in the form of houses with a front garden and a backyard, height not exceeding ground floor with one additional floor, as shown in the pictures of the houses that preserved their initial structure (Fig. 2).

However, its urban fabric has undergone a number of changes, some caused by the municipality, including the establishment of public projects in the two squares located in the allotment perimeter (Fig. 3).

There are also the changes to the buildings done by individuals over the past 30 years, as shown by Figure 4.

[2] Order No. 63-186/32, approving the Haddoud allotment, 18-12-1963.

Photo: Aicha Chaib, September 2022

Fig. 2. Houses that preserved their initial structure

Photo: Aicha Chaib, September 2022

Fig. 3. Projects including by the municipality (library and mosque)

Photo: Aicha Chaib, September 2022

Fig. 4. Succession of changes of the residential housing

4. Changes to residential allotment

The study of the urban form requires addressing it from multiple perspectives, in recognition of its complexity, as discussed by P. Merlin and F. Choay. On this basis, it is necessary to extend the database when carrying out the study [Lévy 2005]. The following dwelling-related indicators are used in this study:

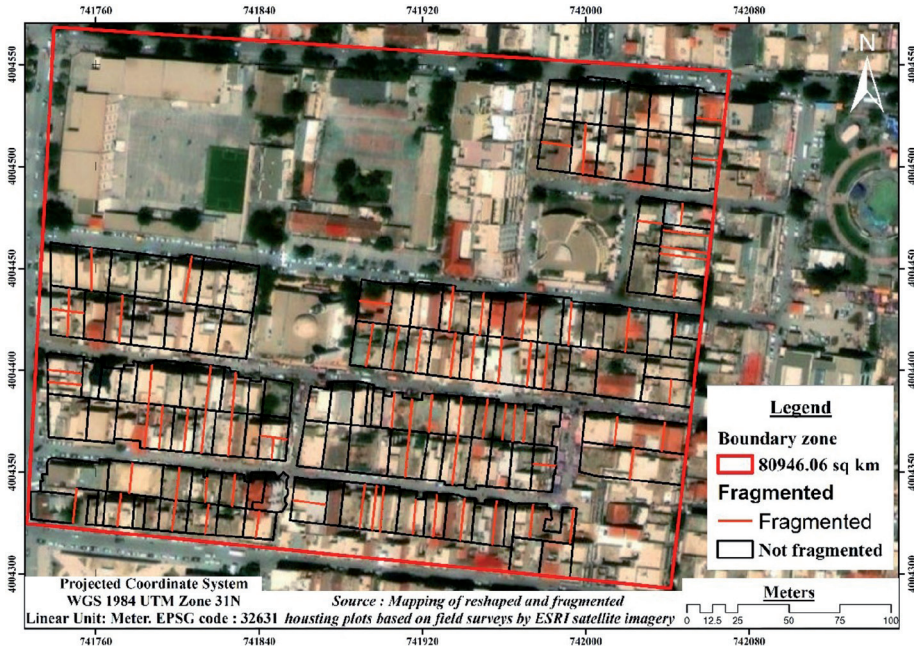
4.1. Division (fragmentation) of the plots

As soon as the Bellala residential allotment was established, the plots underwent a process of subdivision that was also applied to other allotments that were established later (the Goutali allotment, for example), where an exceptional decision was issued by the relevant administration[3].

[3] Decision No.: 33/667-72 of June 22, 1972.

During the on-site survey and interviews with old employees, we were able to determine the main reasons that led to this division, such as the lack of financial resources for individuals directly after the end of the French occupation of Algeria, which forced some of those, who wanted their own plots of land for housing construction in town, to enter joint ownership, while others had to sell their shares to their neighbours as they could not afford the construction costs.

A detailed examination of the position of all the buildings in the allotment perimeter, as shown in Figure 5, revealed that 67 out of the 138 plots had been divided. It is noted that only 16 of the divided plots are located in the corner of the block. This means that at least one share can benefit from two facades on each corner, whereas the remaining plots are located within the blocks. Consequently, they possess only a single facade with a width not exceeding 6.5 m.



Source: Authors' own study, 2023

Fig. 5. Plots divided in the Bellala residential allotment

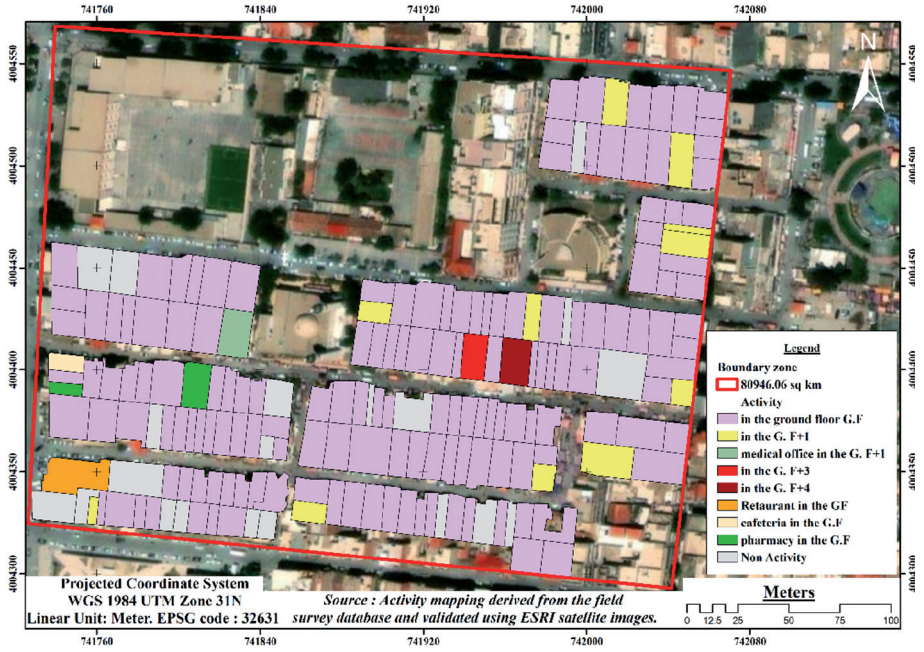
4.2. Commercial use of the residential housing

The area in which the Bellala allotment was established is recognized for its commercial activities, with the weekly market located in the north-eastern section and the covered market in the southern section. In contrast, the northern section saw the emergence of a chaotic market, which contributed to the expansion of the commercial function within

the allotment. The first stores began to appear along the east-west axis of the allotment, resulting in the covered market and those situated adjacent to the north street.

Following the decision to remove the chaotic market, most of the traders moved to the Balala allotment. The ground floors were rented out for commercial purposes, resulting in a widespread mixed-use of the majority of the buildings. The in-situ study allowed to refine the statistics presented in Figure 6. Only 21 buildings have retained their residential character – the rest underwent a conversion to a mixed use. Two of these were exclusively transformed into commercial premises.

It was observed that in 78% of the buildings, the majority or entirety of the ground floor area was dedicated to commercial activities. Furthermore, in 7% of the buildings, both the first and second floors were similarly converted for commercial use.

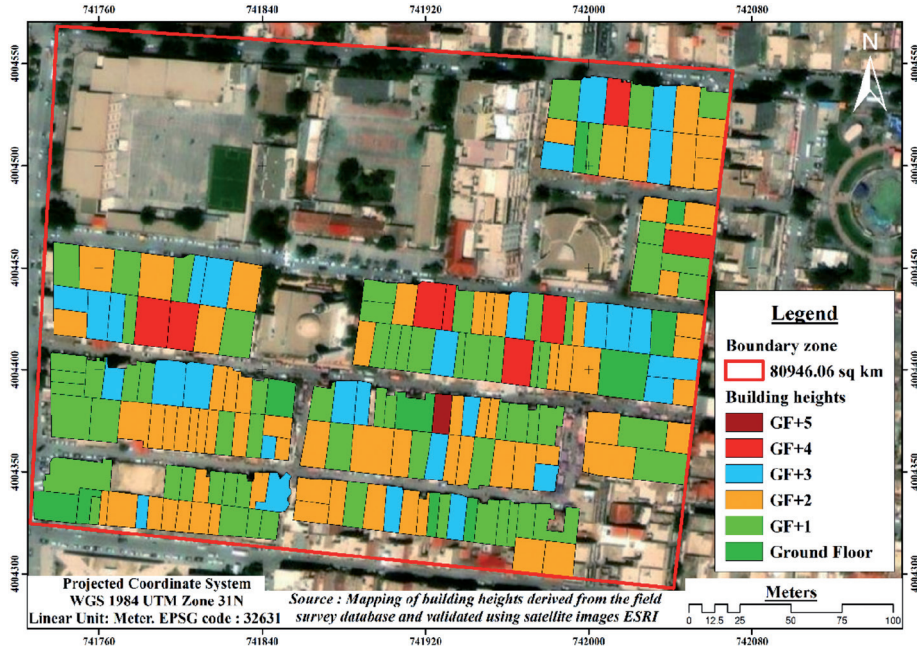


Source: Authors' own study, 2023

Fig. 6. Commercial use in the Bellala residential allotment

4.3. Vertical extension of buildings (building height)

The conditions set forth in the specifications for the Bellala allotment permitted the construction of buildings with a maximum height of two floors: the ground floor and one additional floor (GF+1). However, we observed a varied change in height within the allotment perimeter, as illustrated in Figure 7. This figure depicts our findings regarding building heights, indicating that approximately eighty buildings adhered to the aforementioned two-floor height requirement.



Source: Authors' own study, 2023

Fig. 7. Vertical extension of buildings in the Bellala residential allotment

This includes those resulting from the division, which is estimated 40%. However, the commercial utilization of ground floors led to a vertical extension of buildings to accommodate the need for shelter of extended families. In terms of height, buildings with three floors (GF+2) constituted 36.6%, while those with four floors (GF+3) reached 15.2%.

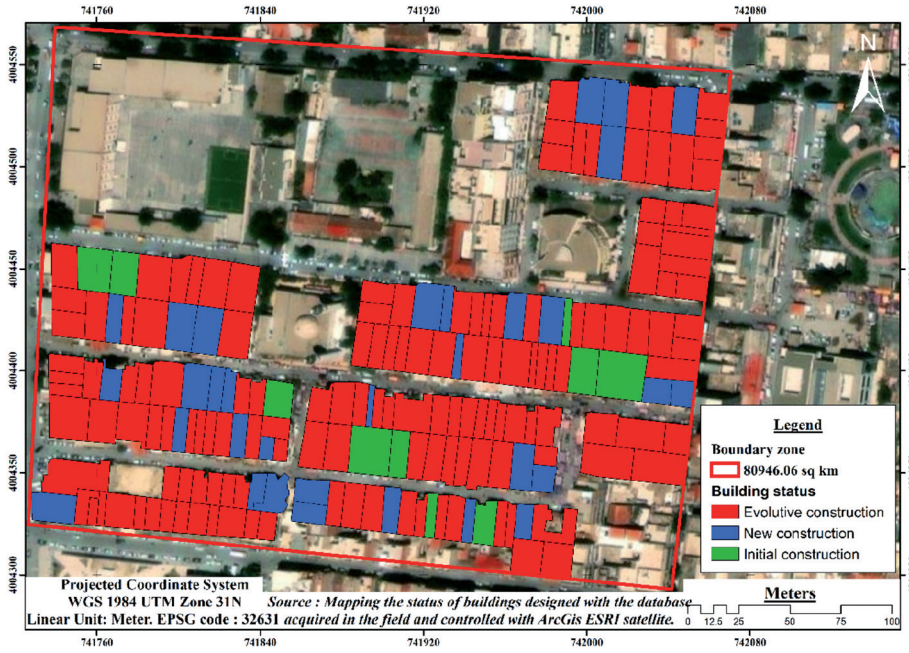
It was noted that in instances where more than one floor was designated for commercial purposes, individuals' aspirations to transform dwellings into sources of wealth resulted in an extension to five (GF+4) or six floors (GF+5), accounting for 7.6% of the total. This trend contributed to a rise in vertical density without a significant spacing between buildings.

4.4. Nature of changes to the buildings (building status)

We categorized our examination of building conditions based on the nature of the changes into three groups (Fig. 8): initial constructions account for 6%, evolving constructions for 77%, and new constructions for 17% of the total.

The interviews with former municipal employees and residents revealed that changes began moderately with the introduction of commercial functions in areas facing the street, such as garages or living rooms, with parts of the front garden. This

initial phase gradually resulted in almost complete utilization of the ground floor, due to which gardens and parts of the backyard were abandoned. This process continued with the first floor, until the entire building was also converted for commerce.



Source: Authors' own study, 2023

Fig. 8. Building stratus in the Bellala residential area

Following the enactment of Law 15/08, which streamlined approval procedures for alterations not complying with construction requirements, the urban fabric was renewed through the demolition of old structures and their reconstruction. The new buildings, for the most part, featured a mixed use and were distinguished by increased height.

5. Results

The fulfillment of needs in a dwelling aims to render it suitable conducive to the protection of family members from external influences and to enhance its effectiveness in providing a range of benefits. Among these benefits, the most crucial is derived from ensuring physiological comfort through optimal conditions of solar radiation, natural ventilation, and lighting, thereby promoting health within the dwelling.

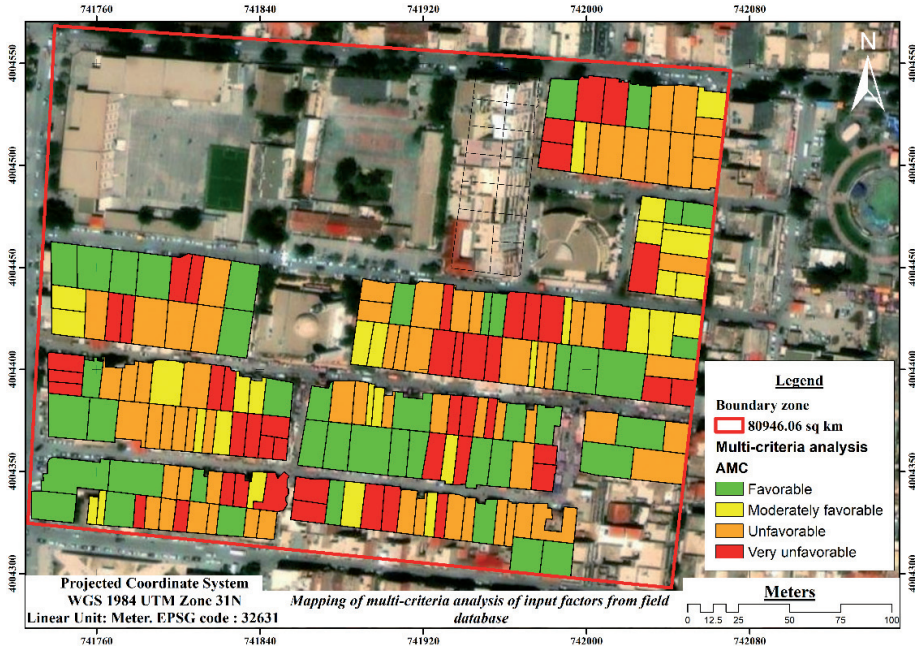
Nevertheless, the vertical expansion of dwellings, carried out to meet the shelter requirements of family members through the addition of extra floors with small courtyards, leads to compromising the building's design. This includes the dispensing with

ground floor courtyards in order to utilize larger areas for commercial or service functions, as well as addressing the needs for material security or the aspiration to convert the dwelling into a source of wealth by dedicating multiple floors for such purposes.

In this context the significance of height becomes evident. Consequently, an imbalance in courtyard dimensions emerges, hindering the attainment of physiological comfort. This imbalance may result in a decrease in 'the effectiveness of the yard and the efficiency of its work as an environmental technology' [Waziri 2002], potentially impacting the health conditions of the dwelling. This is in relation to the building itself. However, if the buildings rise without sufficient spacing between them, the damage extends to neighboring buildings by blocking solar radiation. This could exacerbate the negative influence on health conditions, which is assessed as follows.

5.1. First assessment: Adverse health effects endogenous to the building

Through the multi-criteria analysis, we were able to categorize the buildings into four classifications, ranging from 'favorable' to 'very unfavorable' (Fig. 9).

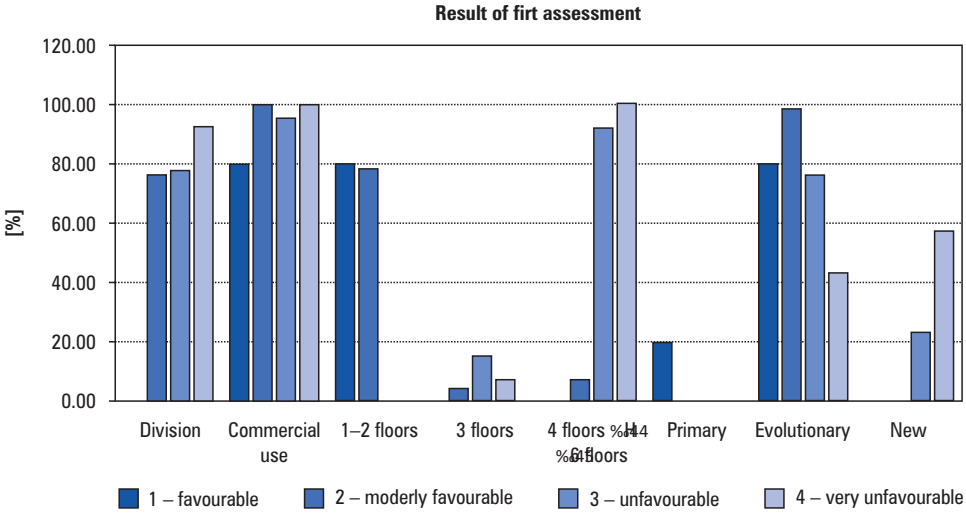


Source: Authors' own study, 2023

Fig. 9. The first assessment, adverse health effects endogenous to the building

As Figure 10 presents, this step allowed us to determine the adverse health effects that are endogenous to the building, whether affecting the entirety of the building or only its part. The findings revealed that buildings created after plot subdivisions, with

a height exceeding GF+3 and commercial use on one or more floors, were predominantly classified as 'very unfavorable', accounting for 21.15% of the total. Additionally, after including the 'unfavorable' dwellings, which constituted 34.53%, a total of 55.68% of the monitored housing units experienced a deterioration of health conditions. It is noteworthy that the majority of new buildings were classified as 'very unfavorable.' Exceptions were observed for buildings that did not exceed GF+2.



Source: Authors' own study, 2023

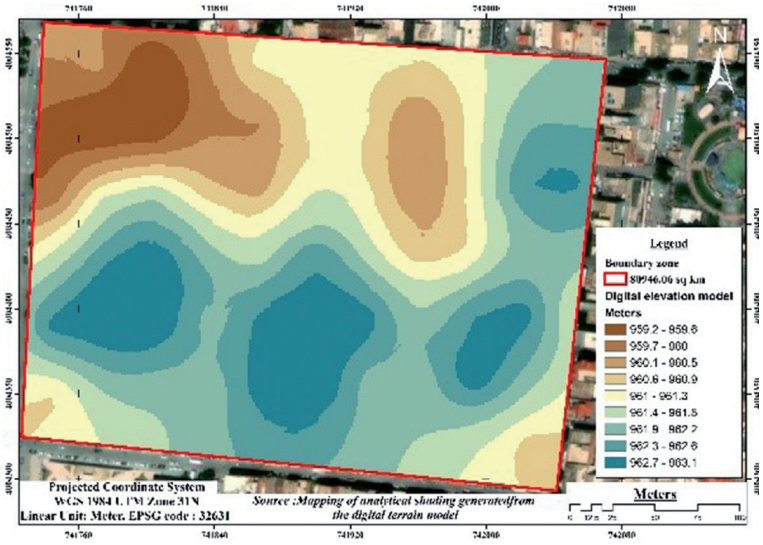
Fig. 10. Classification of buildings into four categories, from 'favourable' to 'very unfavourable'

5.2. Second assessment: zones of exogenous impact on health conditions

The application of the ArcGIS Map 10.4 spatial analysis tool enabled the integration of field data on building elevations with a digital terrain model map (Figs. 11 and 12).

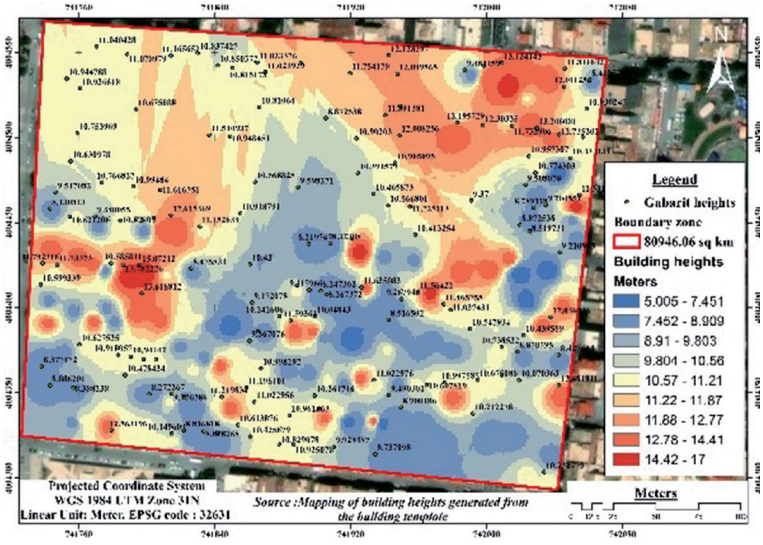
The digital shading map was generated using the software's shading tool, which determines the default illuminance of a surface by assigning illuminance values to each pixel based on the position of the light source and the direction of the surface slope [Dumas et al. 2014]. This process facilitated the creation of the digital shading map illustrated in Figure 13 and 14. It is important to note that the degree of shading on the map ranges from white to black. Areas in shades of white correspond to locations exposed to the sun, while shades of black and grey represent shaded areas.

The shading tool showed that areas with buildings classified as 'very unfavorable' and 'unfavorable' in the first assessment had dense and relatively dense shading, respectively. This observation confirms that the damage is not limited to the individual buildings but extends to neighboring buildings, where exogenous impact on health condition occurred.



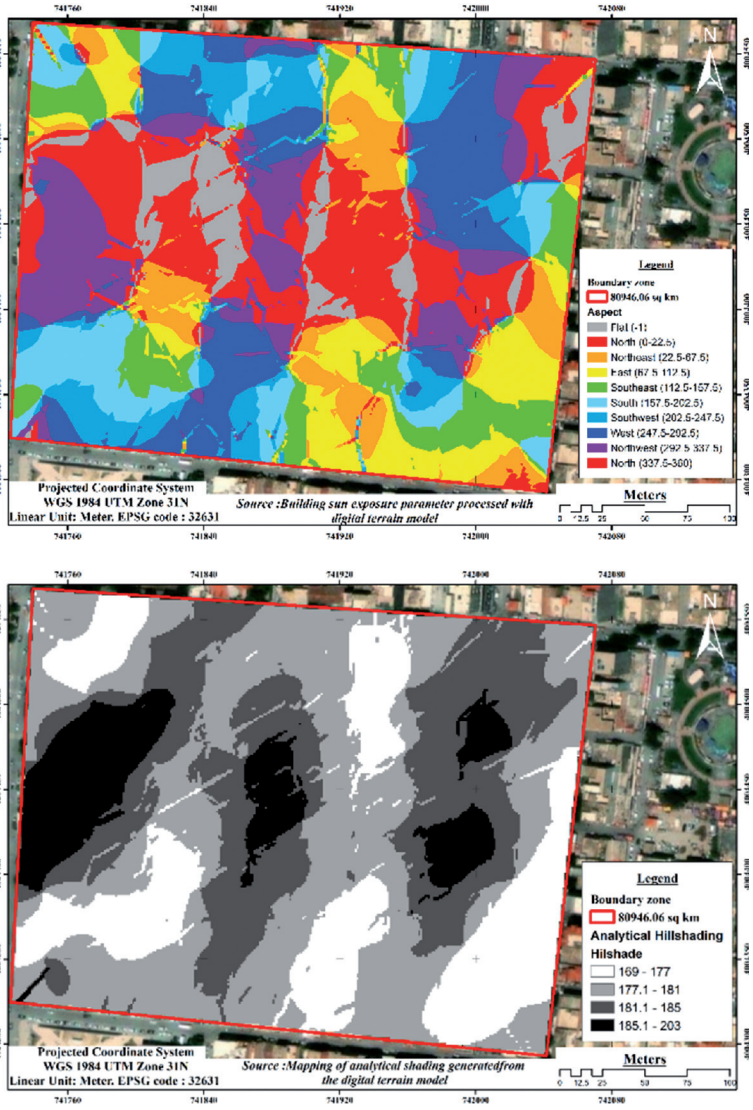
Source: Authors' own study, 2023

Fig. 11. Digital terrain model map



Source: Authors' own study, 2023

Fig. 12. Elevations (Z) of building integrated with digital terrain model map

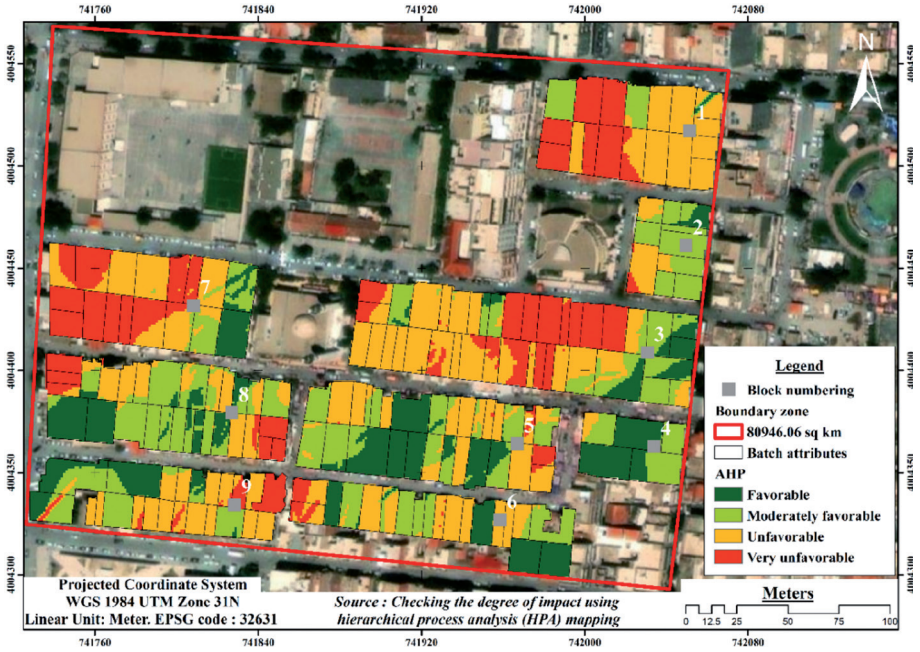


Source: Authors' own study, 2023

Fig. 13 and 14. Second assessment: zones of exogenous impact on health conditions

5.3. Third assessment: determining the affected buildings

The hierarchical analysis process yielded significant results when considering the results of the shading tool process and the criteria of other four indicators (Fig. 15). The results were analyzed for each block separately, progressing from east to west and from north to south according to block numbering, and compared with the first assessment.



Source: Authors' own study, 2023

Fig. 15. Third assessment: determining the affected buildings

In the first block, the condition of the buildings was classified as unfavorable in the east and very unfavorable in the west, indication a worse situation than in the first assessment.

In the second block, the condition of all buildings has improved to some extent.

The third block is noteworthy because the buildings on the north-eastern side have partially preserved their condition, while those on the south-eastern side have improved. However, the situation is different for the rest of the buildings, with a deterioration observed even for those that were classified as favorable in the first assessment.

The fourth block showed an evident improvement in the buildings located to the east – the favorable buildings maintained their conditions.

As for the fifth block, it is worth noting that the neighboring buildings to the north and south maintained their favorable conditions, while those located on its west changed from a favorable to a moderately favorable, similar to what happened to the buildings located in the north-east.

Moving on to the sixth block, we find that the buildings to the east have also improved to some degree, and the favorable buildings have maintained their conditions.

The condition of the seventh block is considered the worst in the entire allotment. The buildings located in the north, initially classified as favorable in the first assess-

ment, transitioned into the very unfavorable and unfavorable status. The same applies to the buildings located to the south, as their unfavorable conditions have exacerbated.

Regarding the eighth block, the unfavorable status of the buildings on its eastern and western sides has not changed, while it has changed drastically in its middle. Consequently, the status of the southern buildings has improved, and that of the northern buildings has partially improved.

We end the analysis with the ninth block, where the unfavorable buildings remained partly unchanged, while the favorable ones did not maintain their conditions in the west.

6. Discussion and conclusion

The multi-criteria analysis confirmed that horizontal densification through plot division, vertical densification by raising buildings, and the conversion of residential functions to mixed-use, predominantly incorporating commerce on the ground floors, reducing or eliminating courtyards, led to adverse health effects endogenous to the building.

The shading tool highlighted areas of shadow propagation in the environment of the Bellala residential allotment, thus identifying the zones of exogenous impact on health conditions.

The hierarchical analysis process demonstrated that when the damage originates from scattered or few buildings within the block, it is isolated and does not spread to neighboring buildings. Consequently, dwellings maintain their favorable state, even the buildings described as having endogenously adverse health conditions may not reach the extremely unfavorable state.

It also confirmed that when buildings described as endogenously adverse are clustered together, not only do they worsen their own unfavorable conditions, but they also extend the deterioration to buildings that were initially unaffected within the same block, rendering them unfavorable. This effect extends to multiple cases in adjacent areas, exacerbating the bad situation, especially if the affected buildings are situated to the south or west.

However, when buildings in a favorable state are surrounded by two or more sides, either within the same block or neighboring areas, their status is characterized as extremely unfavorable, or they may partially lose their favorable status, at the very least.

The noteworthy observation is that buildings resulting from subdivision, which did not exceed two floors above the ground floor, were able to maintain their favorable status relatively. Similarly, buildings initially classified as unfavorable in the first assessment but improved in the third assessment after considering the shadow effect in the analysis matrix, provide scope for further studies that may take into account the spatial organization within dwellings, especially the dimensions of courtyards.

A more comprehensive understanding may emerge when the desire to fulfill various human needs within extended families takes precedence over the consideration of maintaining the health conditions of evolving constructions. In such cases, individuals

often resort to gradual, step-by-sted changes without seeking the expertise of an architect, since most of these interventions are not allowed under residential urban planning regulations.

However, the situation differs with regard to new buildings that have scored extremely poorly in the first assessment. These buildings are supposed to be designed by a certified architect approved by the municipal technical administration. This raises questions about the underlying reasons and leads us to consider it as a potential subject for future studies.

The outcomes of our investigation pave the way for the assessment of similar residential allotments facing comparable challenges.

The methods and tools we employed to address this issue can be regarded as preliminary diagnostic tools, specifically tailored for examining the condition of residential allotments similar to our case study.

This enables the stakeholders in the city to make appropriate decisions related to air quality, solar radiation levels, and natural lighting. Professionals can work on technical solutions to restore the health conditions of the dwelling, and thus of the urban environment of residential allotment.

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