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Quantifying Architectural and Urban Quality: A Model Applied to the Case of Biskra, Algeria

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Abstract

Architectural and urban quality, or spatial quality, is inherently difficult to objectify due to its subjective nature. Traditional surveys can identify general trends but lack numerical precision. This study proposes a "qualitative quantification" model that transforms subjective judgments into measurable values and tracks their evolution throughout the production process. Based on evaluation criteria decomposition and Hanrot's MATEA framework, the model measures a large set of indicators related to the spatial quality of the built environment, including accessibility, density, visual comfort, functionality, maintenance and several other aspects. It generates a conceptual and graphical radar evaluation scheme, integrating production stages with quantified indicators. Applied to the outdoor spaces of 40 collective housing estates in Biskra, southeastern Algeria, the model objectively confirms the poor spatial quality perceived subjectively by residents and other stakeholders. Results reveal negative evaluations in design, construction, use and maintenance reflecting systemic deficiencies and governance challenges. This approach contributes to post-occupancy evaluation and sustainable urban development assessment, providing a reproducible framework for quantifying and visualizing spatial quality throughout architectural and urban production, enabling planners and designers to identify weaknesses and monitor improvements over time.

Keywords: architectural quality; qualitative quantification; spatial quality analysis and evaluation model; objective evaluation of spatial quality; continuous quality improvement; production process

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1. Introduction

Extending prior research on objective architectural-urban quality assessment [1] which established a multi-stakeholder evaluation framework integrating inputs from project owners, designers, contractors, and users, significant questions remain regarding the mathematization of these assessments [2,3] in architecture and urban planning [4]. Can evaluations be made more objective by prioritizing quantitative data over subjective and variable opinion-based comments? Furthermore, is it possible to develop a more Cartesian approach to spatial qualities and their variations over time and in relation to stakeholders' points of view?

Given the recurrence of such questioning, this paper seeks to contribute to the development of a scientific strategy aimed at reducing evaluative subjectivities [5] and, ultimately, helping to grasp the complexity of spatial quality and its pursuit of objective assessment [6],

monitoring, and instantly correcting the quality of the object under analysis. Using the example of spatial quality assessment, it attempts to prove that it is, in fact, possible to "quantify" subjective opinions [7,8], assign quantitative measures to them, and monitor their variations in accordance with the various events that punctuate the life cycle of the object being assessed [9]. Purposely, this research aims to achieve effective participation in the continuous improvement of the built environment [10].

Many previous works, such as those by [11–14] and evaluation methods, have tackled this theme, starting with the POE initiated by PREISER in the 1960s [15–19], followed by those dedicated to sustainable development (MEDDs, MEBDs: BREAM, LEED, HQE, SBTOOL, etc.), and currently arriving at integrated management systems (IMS), which are constantly evolving [20,21]. The method is part of the proliferation of these systems and is designed to meet the objectives of continuous improvement in architectural quality. It takes up and develops the MATEA method (models for architectural analysis, theory, and experimentation) initiated by Professor Hanrot S. [22], in terms of graphic representation and epistemology [23]. This method is based on the relativity of points of view and the temporal dimension through which opinions are likely to change according to the context and events that arise in the life of the object being evaluated. It proposes an evaluative approach that attempts to achieve objectivity in the assessment of spatial quality. This approach is based on the relativity of qualitative assessment in relation to the viewpoints of the actors (architects, project managers, and others) and the different temporalities the spatial object goes through in its life cycle. It is a relativistic and comparative approach. It differs from the human sciences, which study knowledge gathered from social or ethnological phenomena, and is not aimed at standardization of the ISO type or others. It also differs from research carried out in the field of quality in architecture and is based on social surveys that use the "questionnaire" as a data-gathering instrument. This approach is not isolated from the context in which these studies proliferate, and is intimately linked to them. It does, however, attempt to place itself in the specific field of architecture, and to produce knowledge about the objects that interest it: built objects.

This method has been the subject of several experiments, both theoretical and practical. It has been tested by the author himself in real-world work at the level of the architectural firm (Hanrot and Rault) on the occasion of realization projects and university research projects: evaluation of the Aven bridge over the Orb in different temporalities, evaluation of the VCSA (Virtual conception space in architecture) and Lcs2A (Laboratory of Computer Science Applied to Architecture) research teams. Within the framework of PUCA (French Research Programme in Urban Planning, Construction and Architecture) and as part of his research for this ministerial institution, the author has conducted research on the evaluation of the integration of points of view into project management in France, ref. [24]. These models have also been applied in several university research projects supervised by the author [25–29]. Other university research projects (magister and master of research) have used this method and have been led by other researchers [23,30–32], and others that have not been cited due to their large number.

Nevertheless, analysis of the examples applied by MATEA reveals two fundamental criticisms that this investigation endeavors to correct:

1. The definition of the sampling representing the different corpora remains at the level of the presentation of the method, and in these examples, is poorly defined, particularly when a large population is involved. This would alter the representativeness and, therefore, the generalization and reproduction of results in similar cases.
2. The nuance between indicators and dimensions or sub-dimensions. A question that remains vague in the presentation of the approach. Their high degree of abstraction and low number diminish the clarity of the method. The aspects on which the assessment is made are called upon to be broken down into the indicators that are to be measured.

Despite the abundance of existing evaluation frameworks, a gap remains: how can subjective perceptions of space be translated into robust, quantifiable, and comparable indicators? Current approaches, whether post-occupancy evaluation (POE) or sustainability assessment systems, often tend to remain descriptive or overly prescriptive. They struggle to fully capture the dynamic and multifaceted nature of spatial quality assessment, which necessarily involves a diversity of actors.

It is precisely in this area that our research is situated. We propose a model aimed at integrating, within a unified evaluation framework, the perspectives of stakeholders, the temporal evolution of places, and measurable indicators.

This approach is guided by three central questions:

1. How can subjective judgments about the quality of a space be transformed into actionable quantitative values?
2. How can the evolution of these values be tracked throughout the lifecycle of architectural and urban projects?
3. To what extent can such a model inform decision-making processes and contribute to continuous quality improvement?

Our central hypothesis is as follows: by refining the granularity of indicators and structuring them within an evaluation system designed for the long term, it becomes possible to understand spatial quality in a way that is both more objective and operational assessment of spatial quality.

With a view to improving clarity and understanding, the methodological approach adopted is presented in the following paragraphs according to a structured and thoughtful organization, beginning with the presentation of the case study.

Case Study Presentation

Any space object, from the smallest to the most complex, can make a case study for the application of the methodology developed in this research. The outdoor spaces of collective housing in Biskra (a city in south-eastern Algeria) formed this case study because of their scale and their representation in the city, and also the ease of accessibility. Poor quality is well recognized by professionals and specialists, by their inhabitants and citizens. But this subjective, unanimous statement calls the scientific mind to prove it with informed methodologies. This research focuses on this issue, which is objectivity in evaluating the spatial quality. The study corpus consists of 40 collective housing complexes, representing approximately 90% of this type of housing in the city during the study period (Figure 1). By 'corpus', we refer to these 40 collective housing complexes analyzed in the city of Biskra. The definition of the case study is fundamentally linked to the methodological approach adopted, which is the subject of the following paragraphs.

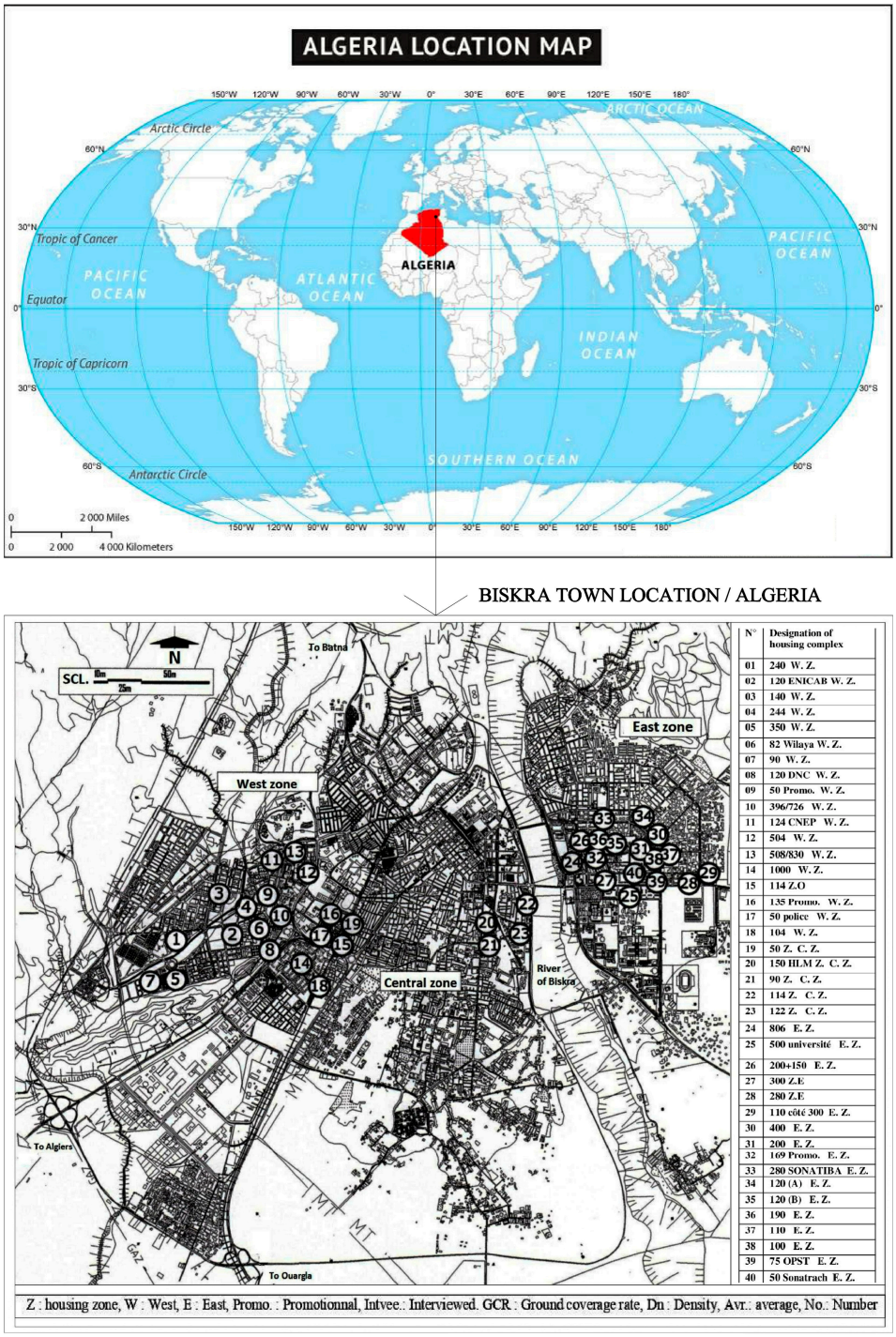


Figure 1. Geographical location of Biskra city and the study corpus.

2. Materials and Methods

2.1. Methodology

The model presented is primarily based on a conceptual analysis of the theme of spatial quality, through a production process that involves a fine-grained decomposition of the concept into dimensions, sub-dimensions, and ultimately indicators that can be measured by means of questionnaires and interviews (Figure 2). These indicators are labeled and numbered from 1 to 74 to facilitate their readability in the figures that follow, without including their full names, which could otherwise clutter them and reduce their legibility.

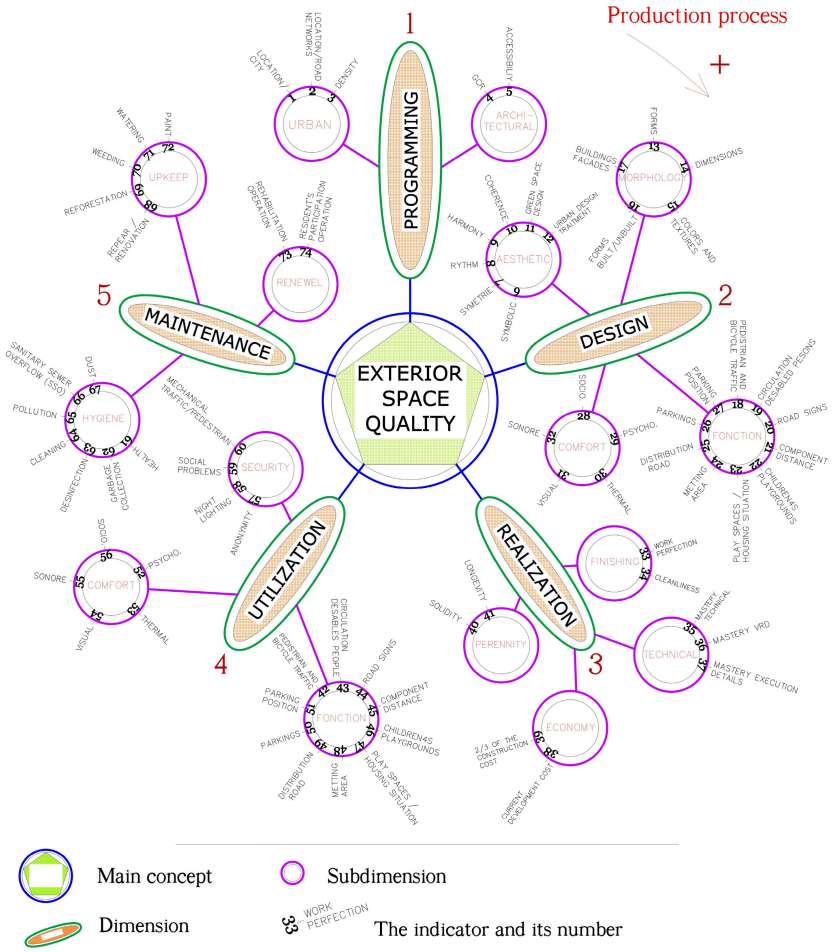


Figure 2. Conceptual breakdown of the quality of outdoor spaces in collective housing.

To ensure the scientific robustness of the proposed model, particular attention was paid to the validation and reliability of the evaluation system based on the 74 indicators. Content validity was ensured through a rigorous selection of indicators, resulting from an in-depth review of the literature and existing methods for assessing architectural and urban quality. These indicators cover the main dimensions of spatial quality (functional, perceptual, social, and environmental), thereby ensuring a comprehensive representation of the phenomenon under study. Furthermore, construct validity was examined by verifying the conceptual consistency among the dimensions, sub-dimensions, and indicators, as well as their alignment with the study's objectives.

The reliability of the system was addressed through the stability and consistency of the assessments. Consistency in the formulation of indicators and in the assessment scales was adopted to reduce interpretation bias. Furthermore, the diversity of respondents (users, architects, professionals, etc.) allows for triangulation of perspectives, thereby strengthening the robustness of the results. Where possible, the internal consistency of the responses was verified to identify any significant discrepancies.

The procedure for quantifying and processing qualitative data from subjective assessments was converted into quantitative values using standardized rating scales (Osgood scale). Each indicator was assigned a numerical value to enable its integration into an overall measurement system. The results were then processed using a comparative and aggregative approach, allowing us to:

- calculate scores by indicator,
- calculate the average of the values collected from the interviewees,

- and analyze the differences between the various stakeholders and time periods.

The first phase of the study was an attempt to demonstrate, in a more objective way, the empirical observation of the poor quality of outdoor spaces in the case study. This involved interviewing the population living in the corpus using questionnaire form instruments developed from an analysis of key concepts pertaining to outdoor spatial quality. For a better explanation of the method used, we have taken one example from among the 40 housing estates forming our study corpus, namely the 350-unit housing estate located in the western part of this town (numbered 05 on Figure 1). Then, in the second phase, the study focused on a single element of this corpus: the 500-unit collective housing estate of the University of Biskra located in the eastern part (numbered 25 on the same figure). This element was chosen for the application of our model because it presents the opportunity to receive 02 urban requalification operations: in 2007 and in 2025.

The actors involved in the act of producing architectural space: Project manager, Project owner, and Construction firm, were subjected to interview protocols with content equivalent to the questionnaire form distributed to residents. The main data collection tools inherent in the questionnaire technique for users (residents) and the research interview technique for the other stakeholders were developed in relation to five (05) dimensions: programming, design, realization, utilization, and maintenance: the logical stages of the production process in the building and housing sector. These dimensions were in turn subdivided into the seventy-four (74) observable real-world indicators measurable through clear questions [23]. It should be noted that, from one researcher to another, we have found that for the same theme, the conceptual diagnosis takes various forms of decomposition and targets different numbers of indicators. We accept that a reliable conceptual analysis is one that achieves a consequent level of finesse, enabling us to determine both the dimensions that obey the objectives previously outlined and the indicators that readily accept measurement and quantification.

Our study employs a mixed-methods approach, combining qualitative data collection (questionnaires and interviews) with quantitative analysis (statistical aggregation, averages, and graphical modeling). To construct our sample, we selected 40 multi-unit housing complexes, chosen for their representativeness (they cover approximately 90% of collective housing in the case study), their accessibility, and their diversity in terms of urban configuration (density, layout, and location). Among these housing complexes, the 500-unit university housing complex is the subject of a longitudinal study, as it has undergone several phases of intervention (2007 and 2025), which allows us to analyze its evolution over time and verify the model's reliability.

The 74 selected indicators are organized into five dimensions: planning (5 indicators), design (27 indicators), construction (9 indicators), use (19 indicators), and maintenance (14 indicators). This detailed structure helps overcome certain limitations of the MATEA model, which is often considered too abstract or lacking in granularity. All indicators are presented clearly and comprehensively in Figure 2 mentioned above. The data collection process is fully explained in the following paragraph.

2.2. Data Collection Tools

The construction of the question forms and interview schedules as the main data collection tools required for the analysis was based on the research indicators obtained through the conceptual analysis. Sampling of users (residents of collective housing estates in the city of Biskra) was designed to be non-probabilistic and accidental, not only because of the absence of a list drawn up during the period of investigation, but also for reasons of speed and efficiency [33]. To this end, 408 question forms were distributed in proportion to the size of the different areas studied, which together total 54,174 inhabitants.

A percentage of 0.75 to 0.76% of the number of inhabitants is assumed to be valid for determining our sample, which will not be too large for ease of data processing. Several interview schemes (05 per category of actor) involved various project managers (design architects), project owners (DLEP: Directorate of Housing and Public Equipment, DUC: Directorate of Urban Planning and Construction, OPGI Real Estate Promotion and Management Agency, APC: Municipal People's Assembly), and construction firms, all involved in the production process of the object of research. This study collects evaluative judgments from residents regarding their diverse perspectives on various aspects of outdoor space quality. We have observed that interviewees tend to perceive and report on individual physical elements rather than intangible concepts such as comfort or aesthetics [34]. The specialized nature of certain questions about these spatial features could potentially exceed residents' comprehension. Consequently, we deliberately avoided self-administered questionnaires in favor of interviewer-administered surveys, where researchers verbally pose questions with appropriate explanations and simultaneously record responses. The interview form, in which the interviewer asks the questions, is the appropriate instrument for the questionnaire. It is based on multiple-choice, closed-ended questions, with only one response among 07 corresponding to the graduations of the differential semantic value scale (Osgood) used [33]. The use of this scale is explained in the following paragraph. The structure of the interview form corresponds exactly to the structure resulting from the conceptual analysis of this research. That is to say, the indicators resulting from the fine breakdown of concepts, dimensions, and sub-dimensions shown in Figure 2.

To ensure the robustness of the measurement system, we verified the internal consistency of the indicators within each dimension by analyzing and comparing response trends and standard deviations. Although a comprehensive statistical reliability test (such as Cronbach's alpha) was not initially conducted, the large sample size (408 respondents) and the convergence of trends observed among the various stakeholders support the validity of the results obtained. Future research will build on this work by incorporating formal reliability tests.

Without a clear definition of the measurement scale to be used in measuring the indicators, the relevance and reliability of the results cannot be established. The following subsection explains the adopted scale in detail.

2.3. Measurement Scale

This research is based on the target population's assessment of the quality of the case study. These subjective assessments will undergo systematic analysis. The two qualitative ordinal scales (Likert and Osgood) appear most suitable for this study as they: accommodate closed-ended questions and enable identification of intention reflecting attitudes or opinions. They enable us to transform the qualitative and subjective information gathered into more operational quantified data [35]. These two scales are very similar in construction and definition. However, in the human sciences, each scale is adapted to a particular character. The Likert scale is used to express the degree of satisfaction through the respondent's attitude [36]. On the other hand, the Osgood scale, also known as the semantic differential scale, is used to position opinion on a bipolar scale relative to two opposing adjectives, such as good-bad or weak-strong [37]. Both scales can contain up to seven rungs. We chose the Osgood scale as it seemed the most appropriate for the specificities of this study, which attempts to bring together opinions on the quality of the object being evaluated into a resulting average.

The elements necessary for the presentation of the methodological approach: case study, data collection instrument, and measurement scale are now clarified, thus the analysis and interpretation of the results can be stated in the following paragraphs.

3. Results and Discussion

3.1. Evaluative Objectivity and Absence of Quality in the Corpus

This article synthesizes evaluative data from both users and stakeholders involved in the production and lived experience of inhabited spaces. While users are not domain experts, their perspectives carry significant weight as they align with a critical phase of the architectural and urban lifecycle: the usage stage [13]. A comprehensive Excel database summarizes all the dimensions, sub-dimensions, and indicators measured under ordered headings for each of the collective housing complexes studied. This refers to the lifecycle stages of the object under study. The rows represent the targeted users (numbered), and the columns list all evaluation scores they assign to specific indicators. These scores range from 0 to 6, where a value of 0 means no quality assessment at all, a value of 3 means average quality, and a value of 6 means excellent quality.

The results were compiled into an Excel spreadsheet, with rows representing the ratings provided by the interviewees. These ratings range from 0 to 6, and the columns represent the 74 indicators distributed across the sub-dimensions and dimensions. This data was processed in Excel using a graphical format known as a "radar chart." Subsequently, this configuration was thoroughly revised conceptually and graphically using appropriate CAD and CAM tools for each element of the dataset. It is presented here as an example in (Figure 3), illustrating the results obtained for the 350-unit multi-family housing complex numbered 05 in (Figure 1).

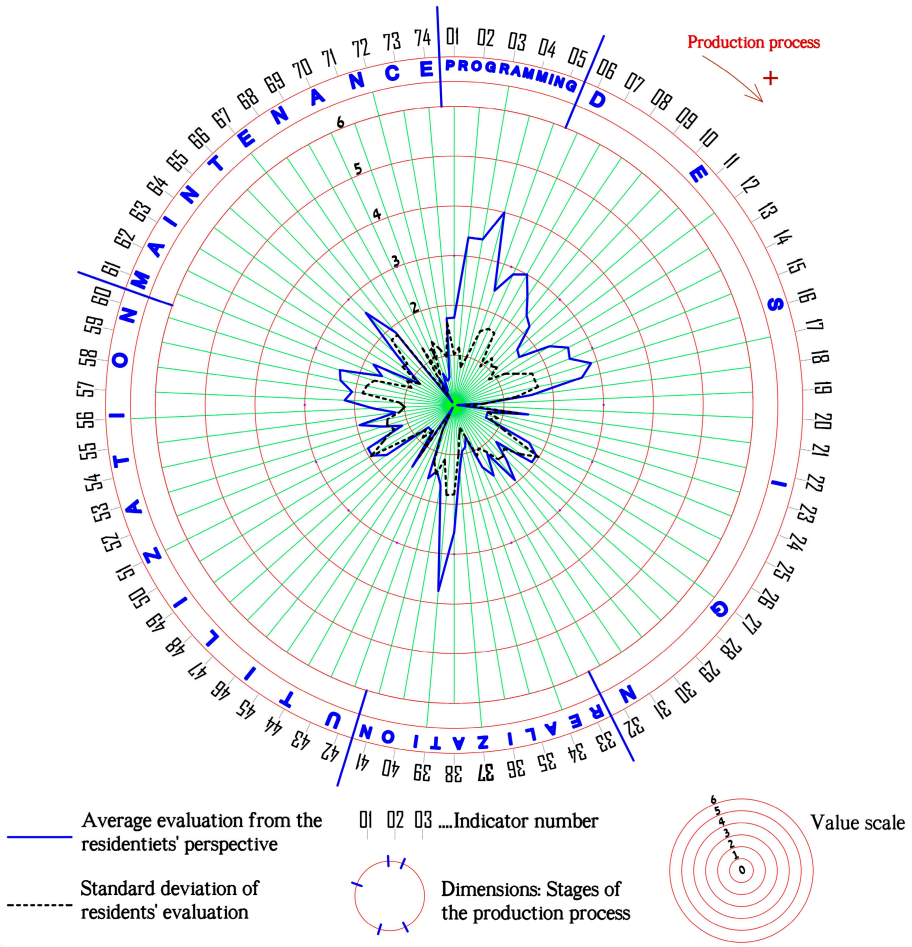


Figure 3. Radar diagram visualizing aggregated user evaluations of the outdoor spaces. Case of a 350-unit collective housing estate.

The graph shows the average ratings of the various stakeholders and the standard deviations between these ratings. Averages and standard deviations are results that give important indications of the pattern of interviewees' judgments for each indicator (the negativity or positivity of the average evaluation between interviewees, the convergence of points of view, their coherence and homogeneity) [25]. The radar diagram representation of all this data enables us to describe all the variations in evaluation throughout the production process of the object under study. Oriented clockwise, this diagram is designed based on concentric circles, the last four of which group together the dimensions, sub-dimensions, and indicators (74 in number) gravitating around the last outer circle. Thick line segments delimit each dimension, indicating its beginning and end. Evaluation values are represented by numbered, concentric circles with uniform graduations ranging from value 0 (center of circles), indicating zero quality, to value 3, indicating average quality (third circle from center), to value 6 (sixth circle from center), indicating excellent quality. This basic configuration forms the body of the radar diagram on which the graphs illustrating the variations in the various functions, i.e., evaluation averages and standard deviations, are plotted. The graphs representing interviewees' evaluation averages or standard deviations are drawn point by point and obtained by intersecting the radius corresponding to the indicator in question with the evaluation value on the radio concentric graduated scale. The points drawn are connected by clockwise segments. With this configuration, the diagram gives direct and simultaneous readings of the interviewees' judgments and their standard deviations in relation to the various stages in the life cycle of the object under study. The thick, continuous graph represents an average negative assessment of the quality given by the interviewees to the exterior spaces of this housing complex. This assessment is remarkable for all the indicators, which are assigned evaluation values of less than three. Except for 03 indicators for the planning dimension (location in relation to main road networks, density, ground coverage ratio, and just one for the realization dimension (2/3 of the construction cost indicator numbered 39), these are slightly above the 03 average.

The quantitative analysis reveals systemic deficiencies across all measured dimensions of outdoor space quality in the 350-unit collective housing estate: design, realization, utilization, and maintenance from the point of view of the residents. This result is probably due to shortcomings in the management and control of the project during design and realization, as well as a lack of effective management of the post-occupancy phase. In the programming stage, the location of the project site in relation to the main road networks, the choice of the ground coverage ratio, and the density were eventually well programmed. This graph also shows the heterogeneity of interviewees' opinions on the various indicators. Overall, they are negative, but very different from one another. This heterogeneity can also be seen in the graph, with its thick, broken line representing the standard deviations between interviewees' evaluations. It is true that there is convergence overall on the negativity of the quality of outdoor spaces in this collective housing complex, but in the range of values below the average, there is a divergence of opinions relative to the indicators. We can also note the existence of accentuated negative peaks tending towards zero values for the maintenance dimension and for some indicators of the dimensions inherent in design, realization, and utilization.

This work was systematically applied to the 40 collective housing complexes representing the corpus of the study (Figure 4). The mean composite score, summarizing the overall evaluation of outdoor spaces in collective housing across the entire city of Biskra, based on assessments from both residents and other stakeholders, revealed a negative assessment, indicating generally poor quality. (Figures 5 and 6).

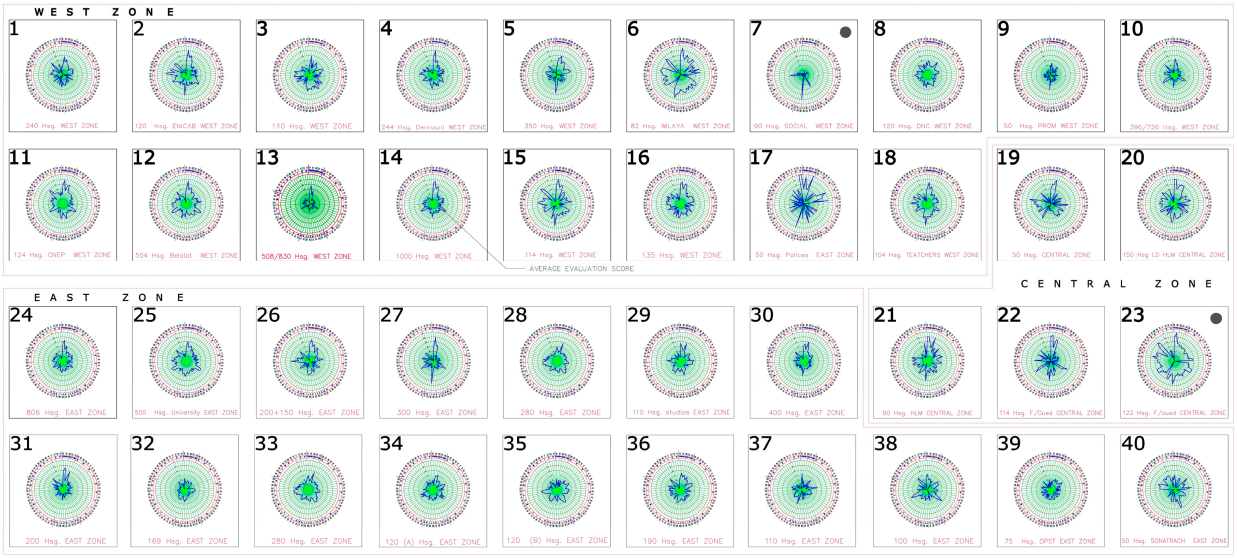


Figure 4. Mapping user perceptions of outdoor space quality in Biskra's collective housing.

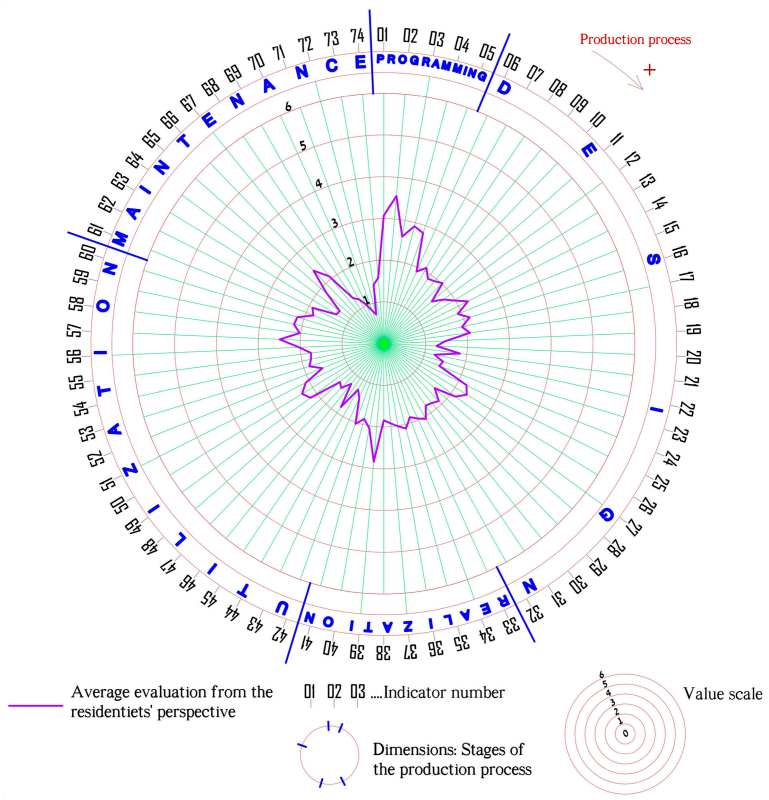


Figure 5. Mean negative perception of outdoor space quality by residents in the 40 collective housing complexes of the case study.

Synchronically superimposing the opinions of all the actors, we can see that only seven (07) indicators out of seventy-four (74) positively evaluate the quality of the corpus with an average higher than 3. These are:

- All the 05 indicators of programming dimension: location/city, location/main road networks, density, GCR (ground coverage ratio), and accessibility to outdoor spaces.
- 01 design dimension indicator: distribution road, numbered 25;
- 01 economic indicator: 2/3 of the construction cost, numbered 39;

- No realization dimension indicators;
- No utilization dimension indicator: distribution road, numbered 49;
- No maintenance indicators.

The analysis demonstrates that the studied corpus exhibits systemic deficiencies across all phases of its production process, pertaining to the construction, management, and operationalization of the building stock. Regarding maintenance, empirical data from stakeholder interviews—including residents, project managers, owners, and contractors—reveals a consensus on the neglect of built assets post-occupation, particularly concerning the exterior spaces of collective housing developments.

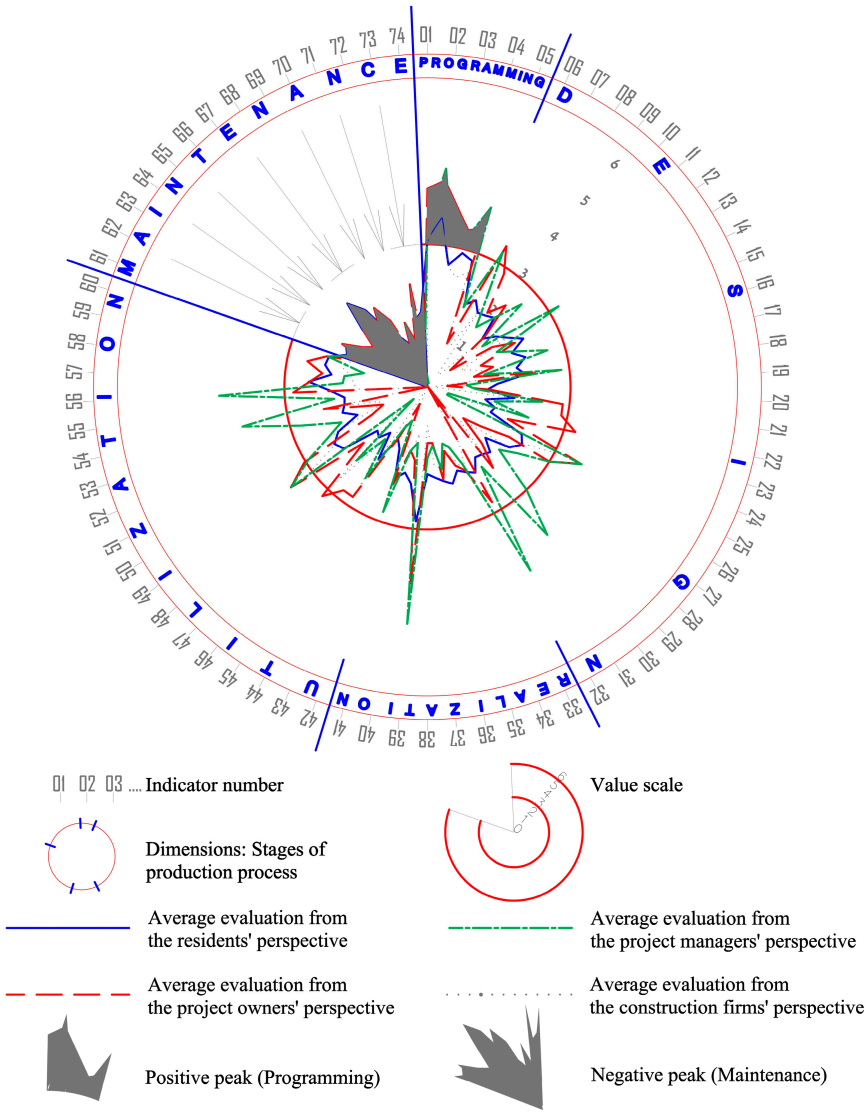


Figure 6. Synchronic evaluation of outdoor spaces in Biskra's collective housing: consistently negative assessments by all stakeholders involved in their implementation.

A synchronic evaluation reveals that while operational stakeholders and residents broadly concur on the substandard quality of the studied corpus, the former assign systematically higher ratings than the latter. This disparity underscores a pronounced perceptual divide between occupants of collective housing and other process participants, particularly architects (project managers). The divergence is most acute for indicators related to visual and social comfort, as well as the perceived aesthetics and form of outdoor spaces.

This misalignment arises from two primary determinants: first, the marginalization of residents in the decision-making processes shaping built environments, second, the

fragmented coordination and inadequate synthesis of technical expertise across operational stakeholders—namely, architects, project owners, and contractors.

These findings confirm what other studies have already highlighted: there is often a gap between the intended urban quality and that actually perceived by users (see, for example, refs. [37,38]. However, our research goes further. It shows that the gaps observed are not merely a matter of perception. They are, in fact, structurally embedded at every stage of the production process, particularly during the construction and maintenance of urban facilities.

This study has also demonstrated that, compared to previous studies, it offers the ability to instantly analyze and monitor the quality of architectural and urban objects throughout their production process. The continuous improvement of the quality of the analyzed object becomes its primary objective. This will be explained in the following sections.

3.2. Testing Qualitative Quantification

As mentioned above, the 500-unit housing complex is one of the 40 housing complexes included in the study. The average rating of its outdoor spaces, as assessed by its residents in November 2008, is shown in Figure 7.

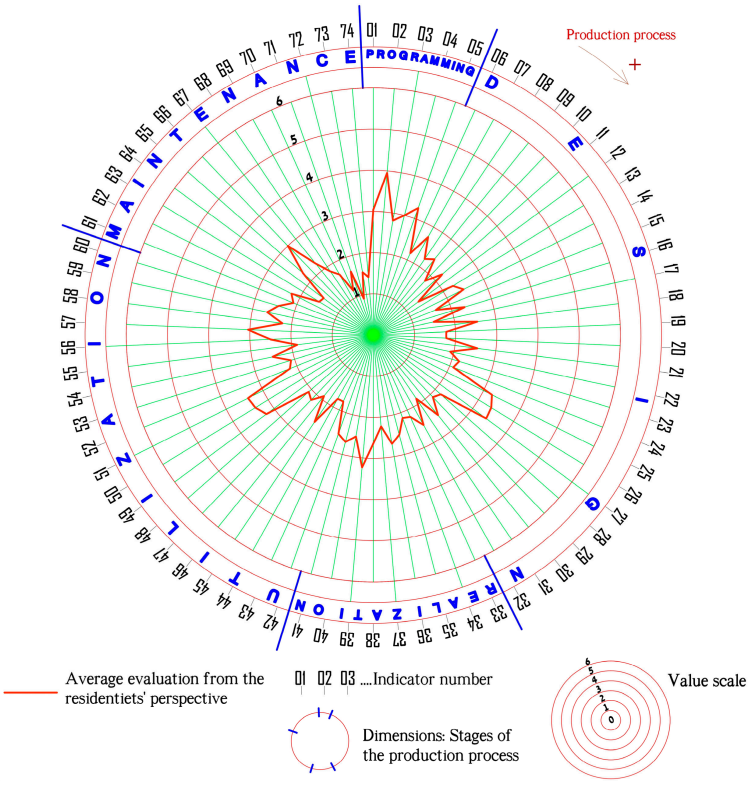


Figure 7. Average assessment of exterior space quality based on user perceptions: case: 500-unit housing estate of Biskra University.

The graph represents an average negative assessment of the quality given by the residents to the outdoor spaces of this housing estate. This assessment is remarkable for all the indicators, which are assigned evaluation values of less than three. With the exception of four indicators in the programming dimension (location/main, location/road networks, ground coverage ratio and accessibility), three in the design dimension (distribution road, parking and parking position), only one of the realization dimension (2/3 of the construction cost) and four other indicators of the use dimension (distribution road, parking, parking position and anonymity) are slightly above the 03 average. The findings reveal deficiencies in the outdoor space quality of the 500-unit housing complex across all

processes except programming, as perceived by residents. This is probably due to shortcomings in the management and control during design and construction, as well as a lack of effective management of the project's post-occupancy phase. In the programming stage, the location of the project site in relation to the city and the main road networks, the choice of the ground coverage ratio, and accessibility to the various blocks of this housing complex were eventually well programmed. The graph also shows the heterogeneity of interviewees' opinions on the various indicators. We can also note the existence of accentuated negative peaks tending towards zero values for the maintenance dimension and for some indicators of the dimensions inherent in design, realization, and utilization.

Drawing upon a comprehensive analysis, the following section systematically presents the preliminary sketches of the model developed in this study.

3.2.1. The Share Approach

A more in-depth comparative analysis focuses on comparing the importance of the dimensions in the overall evaluation. This study proposes the identification of evaluation by an indicator. With no weighting established between indicators, and considering the conceptual analysis relating to the general concept of "quality of outdoor spaces in collective housing", the importance of the dimension is a function of the number of indicators it contains [39,40]. A study of the weighting between indicators can be the subject of research, offering greater precision on the objective evaluation of spatial quality [13,27]. Thus, the dimensions: design, utilization, maintenance, realization, and programming, classified according to their importance in the overall assessment of the quality of outdoor spaces, present proportions ranging from 36%, 26%, 19%, 12%, to 7%, respectively. These proportions represent the evaluation of the entire dimensions in relation to the overall evaluation. For a given dimension, the assessment of any given actor can be read in relation to the overall assessment (Figure 8). These comparative analyses provide granular insights into quality assessment, while highlighting the potential for developing quantitative metrics of spatial quality derived from multi-stakeholder evaluations [41,42].

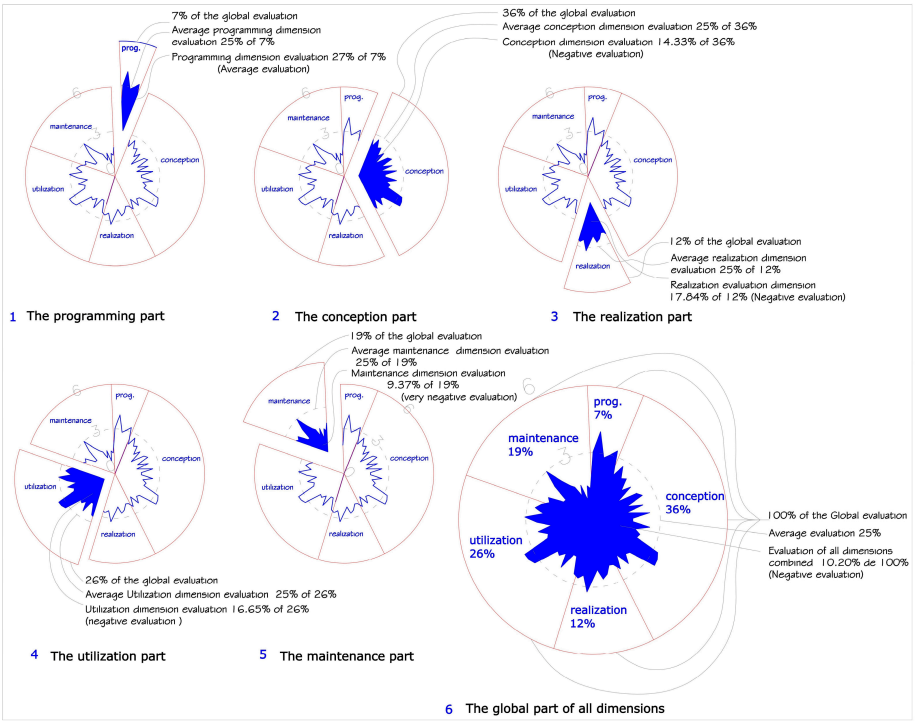


Figure 8. The significance of quality assessment in relation to production process phases for outdoor spaces in a 500-unit housing estate of Biskra University (resident-based evaluation).

3.2.2. Toward a Model for Quantifying Quality: The Numerical Transcription of Evaluative Values

This approach is fundamentally based on assigning "surface units" to quality values based on the graphically developed radar pattern. If the graph representing the evaluation averages fully takes the shape of the circle corresponding to the max value, which is 6, this will indicate a maximum and surface quality (πr^2) where r is the radius of this circle, which varies on the scale of values in the abscissa (Figure 9). Q is the desired quality value.

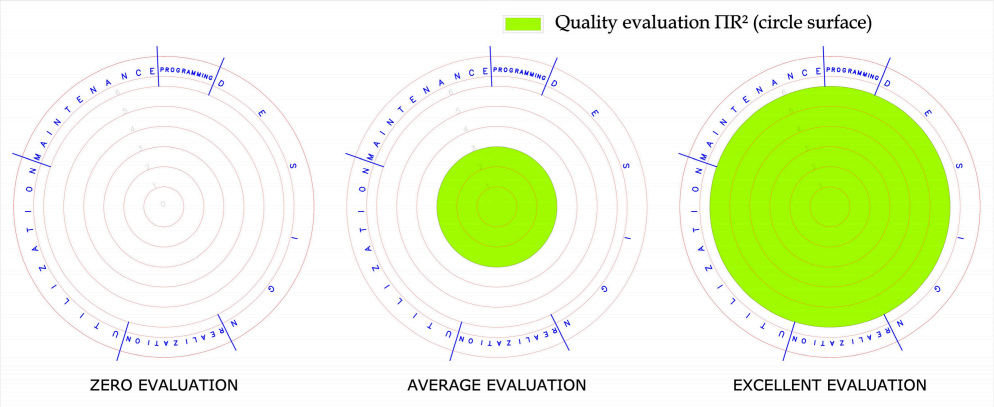


Figure 9. Spatial quality metrics: a digital quantification approach.

It corresponds to the area intercepted by the curve, designating the average of evaluations for each set.

To simplify the calculations, we have transformed the polygon with 74 indicators into a circular approximation. The underlying idea is that, with a large number of indicators, the polygon gradually approaches a circle, allowing us to use the formula $Q = \pi r^2$ as an estimate of aggregate quality. It should be noted here that r corresponds to the normalized average score, on a scale of 0 to 6, and that the resulting surface does not represent a physical area, but rather a synthetic index of spatial quality. This transformation introduces a non-linear, parabolic-type scale, where progress made at already high quality levels results in greater gains in the index. Thus, the model does not directly convert Osgood-type data into geometric values; rather, it uses geometric analogy as a tool to merge multiple assessments into a single, comparable metric.

$$Q = \pi r^2 \quad (1)$$

Is the equation of a section of the parabola (Figure 9). The quality value is now put on a "parabolic scale". It is therefore not proportional to the increment of the value scale.

Based on the information contained in (Table 1) and (Figure 10), our basic scheme for comparisons and deductions on latent concepts is constructed, mixing average point-of-view evaluations with other aspects such as densities and ground coverage ratio, in order to investigate their influence or neutrality in relation to quality Figure 11. Table 1 summarizes this knowledge, the number of which can be extended. In our study, we are talking about ground coverage ratio (GCR), density, housing type, layout shape, and shape of outdoor spaces.

It is widely recognized that pressing densification processes have negative social and ecological consequences for the population [43–45].

However, the present case study reveals that densities and GCR, which are notions intimately linked to everything unbuilt, have no influence on the quality of outdoor spaces (from the point of view of residents). This assumption is supported by studies on density, which distinguish between measured and perceived density in collective housing [46,47].

Table 1. Designation and typological characteristics of urban elements in Biskra's case study corpus.

N°	Designation of Housing Complex	No. Hsg.	Density Dn.	Avg. Dn.	GCR	Avg. GCR	Housing Type	Layout Shape	Shape of Outdoor Space	No. Interv.
01	240 W. Z.	240	91	93.1	0.273	0.249	social	Barre	Central linear	11
02	120 ENICAB W. Z.	120	40		0.173		social	Pavillon	Dispersed	5
03	140 W. Z.	140	138		0.247		social	Bar-shaped form	Central linear	6
04	244 W. Z.	244	106		0.358		social	Bar-shaped form	Linear	11
05	350 W. Z.	350	47		0.22		Co-housing	Bar-shaped form	Central linear	16
06	82 Wilaya W. Z.	82	41		0.183		Employee housing	Pavillon	Dispersed	4
07	90 W. Z.	90	74		0.218		social	Bar-shaped form	Linear	4
08	120 DNC W. Z.	120	53		0.417		Promotionnal	Bar-shaped form	Linear	6
09	50 Promo. W. Z.	50	46		0.257		Promotionnal	Bar-shaped form	Linear	2
10	396/726 W. Z.	396	61		0.175		social	Bar-shaped form	Central linear	18
11	124 CNEP W. Z.	124	85		0.349		Promotionnal	Pavillon + barre	Linear	6
12	504 W. Z.	504	61		0.161		Promotionnal	Bar-shaped form	Central linear	21
13	508/830 W. Z.	508	69		0.173		social	Pavillon + bar	Central linear	23
14	1000 W. Z.	1000	45		0.130		social	Pavillon + bar	Dispersed	44
15	114 Z.O	114	72		0.226		social	Bar-shaped form	Linear	5
16	135 Promo. W. Z.	135	79		0.679		social	Pavillon + bar	Central	6
17	50 police W. Z.	50	52		0.158		Fonction	Pavillon	Dispersed	2
18	104 W. Z.	104	68		0.217		Participatif	Bar-shaped form	Linear	5
19	50 Z. C. Z.	50	61		0.210		social	Pavillon	Dispersed	2
20	150 HLM Z. C. Z.	150	86		0.155		social	Bar-shaped form	Linear	7
21	90 Z. C. Z.	90	72		0.212		social	Pavillon	Linear	4
22	114 Z. C. Z.	114	76		0.193		Promo.	Bar-shaped form	Linear	5
23	122 Z. C. Z.	122	83		0.179		Promo.	Pavillon + barre	Central linear	6
24	806 E. Z.	806	105		0.219		social	Pavillon + barre	Central linear	35
25	500 université E. Z.	500	64		0.127		Employee housing	Pavillon + bar	Central linear	22
26	200 + 150 E. Z.	350	146		0.27		social	Pavillon + bar	Central linear	12
27	300 Z.E	300	68		0.163		social	Pavillon + bar	Central linear	14
28	280 Z.E	280	90		0.247		social	Bar-shaped form	Central linear	13
29	110 côté 300 E. Z.	110	143		0.173		social	Bar-shaped form	Dispersée	5
30	400 E. Z.	400	188		0.294		social	Pavillon + bar	Central linear	18
31	200 E. Z.	200	174		0.301		social	Bar-shaped form	Central linear	9
32	169 Promo. E. Z.	169	47		0.347		Promotionnal	Pavillon + bar	Central linear	17
33	280 SONATIBA E. Z.	280	124		0.231		social	Pavillon	Dispersed	12
34	120 (A) E. Z.	120	163		0.321		social	Bar-shaped form	Central linear	5
35	120 (B) E. Z.	120	142		0.226		social	Bar-shaped form	Central linear	5
36	190 E. Z.	190	178		0.246		social	Bar-shaped form	Central linear	8
37	110 E. Z.	110	237		0.46		social	Bar-shaped form	Central linear	5
38	100 E. Z.	100	123		0.24		Participatif	Bar-shaped form	Linear	4
39	75 OPST E. Z.	75	75		0.25		Employee housing	Courtyard form	Central	3
40	50 Sonatrach E. Z.	50	51		0.316		Promotionnal	Bar-shaped form	Linear	2

In the cloud of values attributed to the outdoor spaces of the 40 collective housing complexes studied, we note that there is a dispersion of points, which shows that elements of this corpus can have similar quality evaluations but very different densities and GCR. We can distinguish this case for project N°23, which represents the 122-unit housing estate located in the Central zone, and whose quality is the only one rated positively (above average). This housing estate has a GCR and density similar to those of housing estate N°07, representing the 90-housing estate located in the West zone, whose quality is rated as the most negative compared to the rest of the corpus.

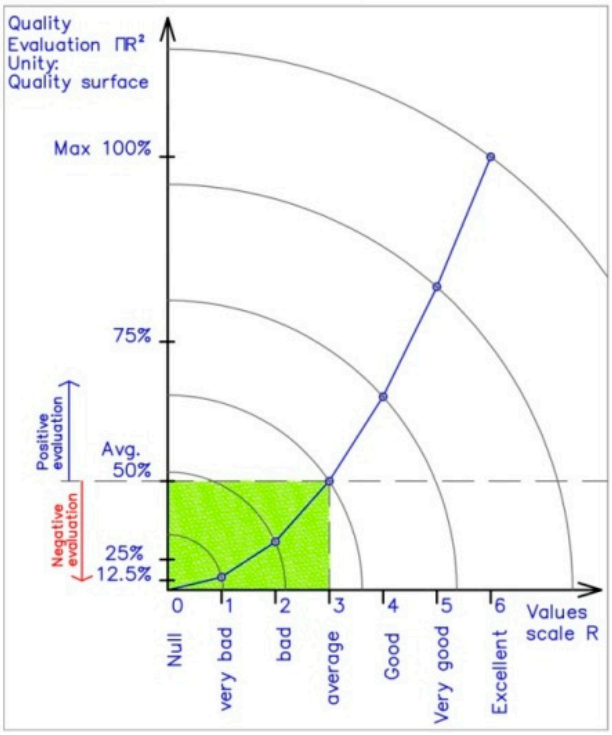


Figure 10. Radial Variation in Surface Quality Indicators.

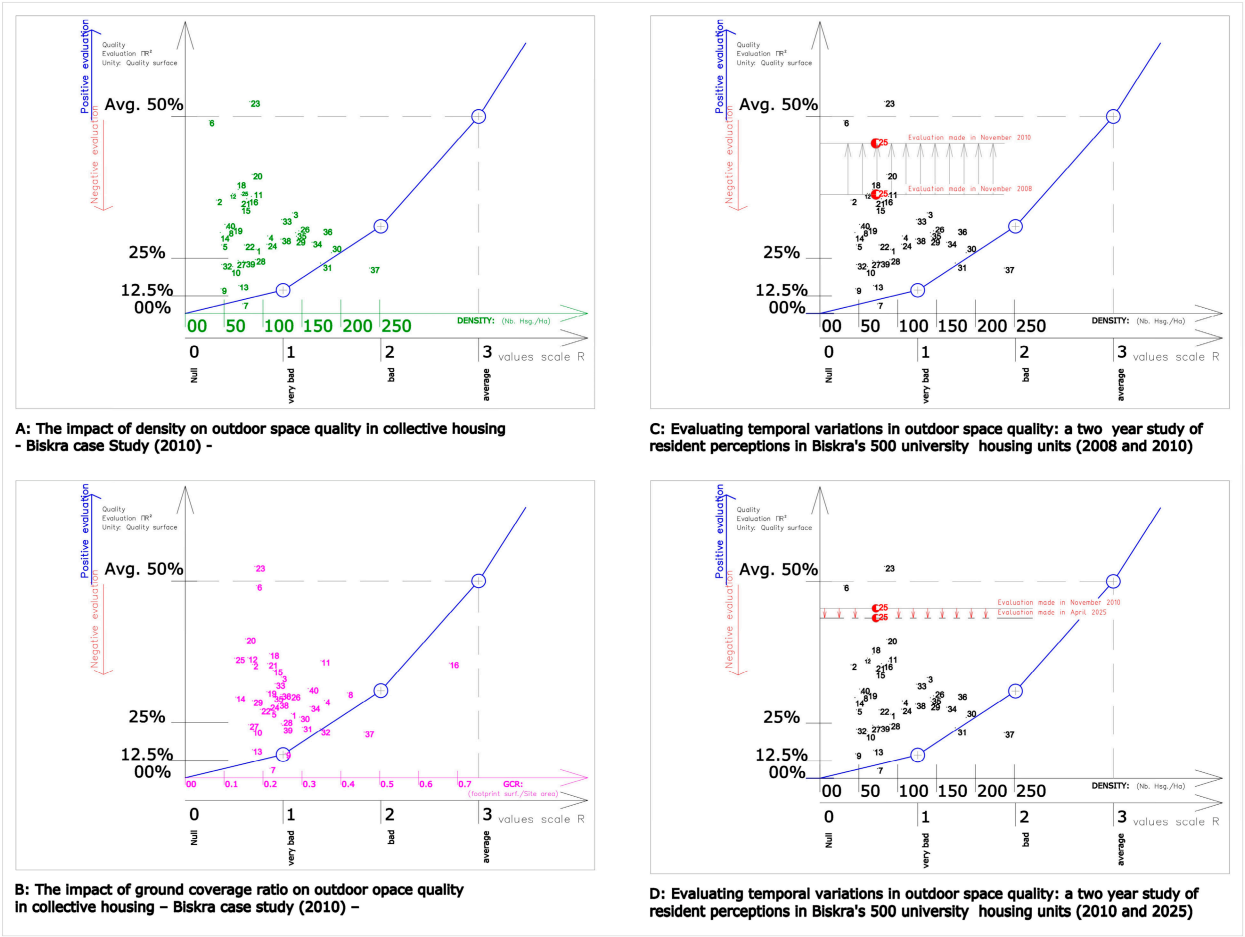


Figure 11. Multidimensional analysis of outdoor space quality in Biskra's collective housing: density, GCR, and evolving resident perceptions (2008–2025).

GCR and densities are important parameters in analyses of everything to do with open spaces or outdoor areas, particularly in collective housing [48]. But they are not the only ones. Other factors can influence the quality of these spaces, such as the urban and social forms of the type of housing, the shape of these spaces, and the layout of buildings in relation to outdoor spaces [49], their components and distribution [50]. This reflection opens avenues for future research to examine their influence on the quality of architectural and urban objects.

3.3. Essay on Monitoring and Managing the Quality of Post-Occupied Objects

The fundamentalist concept of the relativity of spatial quality assessment in relation to time enables us to move forward with an operational research approach. During its existence, and with a view to acceptable longevity, the architectural or urban object is subject to development, redevelopment, requalification, even restructuring or renovation operations. With its open architecture, the present model, further developed by the present research, extends its contribution to the objectivity of spatial quality assessment to the analysis and evaluation of urban and architectural intervention approaches and operations that post-occupied objects undergo [51].

To test this theoretical vision, the same sociological survey was repeated on a non-probabilistic accidental sample at the 500-unit university housing estate in Biskra's Est zone. The selected case study is a public housing complex that underwent urban renewal in November 2007 and again in January 2025 (focusing on north-side exterior space rehabilitation along Arris's primary access boulevard (town to the north-east of Biskra) (Figure 11).

This example provides an opportunity to analyze the relative assessment before and after the intervention while shedding light on the examination and evaluation of the approaches taken by the involved stakeholders. This figure compares the average evaluation of the views of the residents of this apartment block between the opinion recorded in November 2008 and November 2010 (after the new landscaping had been completed). The graph in Figure 12 shows a clear positive evolution in users' point of view compared to the initial assessment, particularly regarding the programming and design dimensions, and to a lesser extent, about the realization, utilization, and maintenance dimensions. Although progressing positively, this assessment still falls short of the population's aspirations, as it is below the average represented by the value 3 and thus marks an assessment of the quality of the outdoor spaces in this complex that is still negative.

This figure emphasizes the recognition and classification of the most diminished cases in the city, where intervention becomes a matter of urgency compared to others. For example, clusters 7, 9, 13, 10, 37, and 31 are, in this order, the poorest-quality clusters in the city of Biskra, requiring immediate requalification. (Figures 11 and 12) also shows the new position of the 500-unit housing estate represented by number 25 in (Table 1), in red, circumscribed by a solid black circle) In relation to the other estates in the city of Biskra, in terms of the quality of outdoor spaces as perceived by residents.

This result shows that the management of the operation to redevelop the outdoor spaces of this collective housing estate is generally lacking in all its dimensions. However, some indicators are positive, as follows:



Project: 500 Hsg. of Biskra university
Site area = 77,179 m2
Number of dwellings = 500 Hsg.
Footprint of the buildings = 9,813 m2
Outdoor spaces surface = 67,366 m2

GCR = (footprint surf.) /(Site area) = 0.127
Density = (No. Hsg.) /(01 Ha) = 64 Hsg/Ha
Layout shape: Pavilion + bar-shaped form
Shapes of outdoor space: Central + linear

Mass layout plan of the 500-unit housing estate of Biskra university (April 2025)



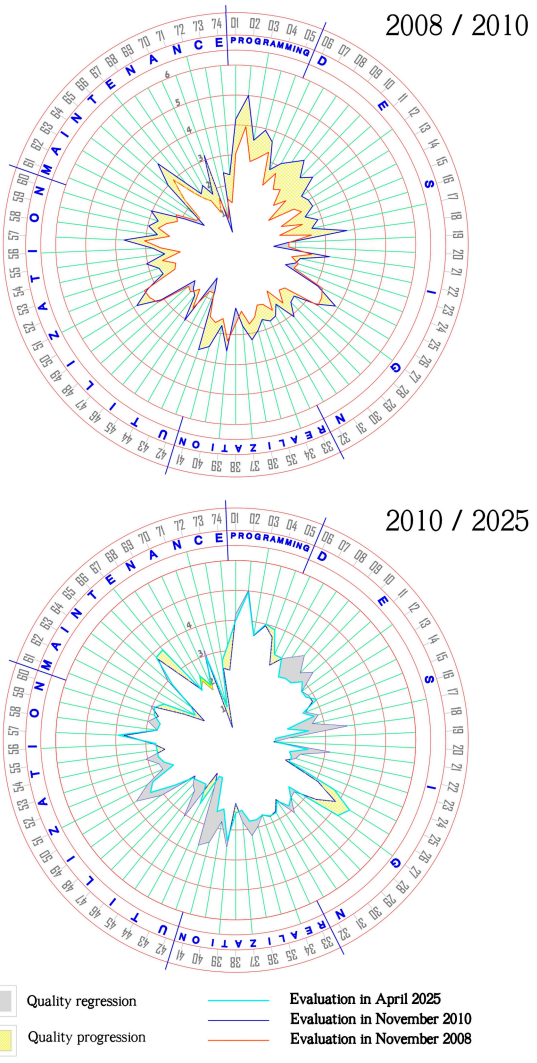
Boulevard side elevation view of the 500-unit housing estate of Biskra university (taken on November 14, 2007).



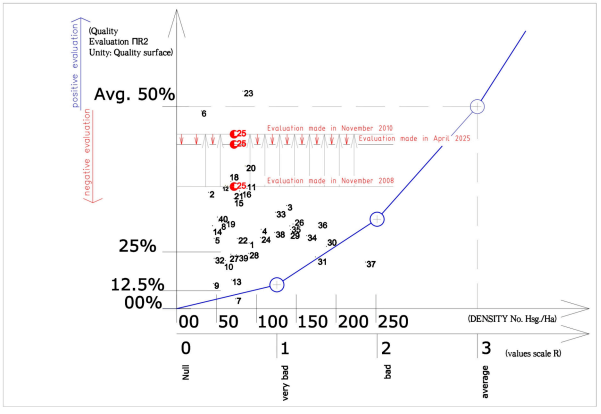
Boulevard side elevation view of the 500-unit housing estate of Biskra university after redevelopment (taken on March 14. 2010).



Boulevard side elevation view of the 500-unit housing estate of Biskra university after redevelopment (taken on April 05, 2025).



A : Temporal relativity of the quality evaluation in the outdoor spaces of 500-unit housing estate of Biskra university from inhabitants view point. (Comparaison made: in November 2008-November 2010 and November 2010-April 2025)



B: Diachronic comparaison of the outdoor spaces quality in the 500-unit housing estate of Biskra university from inhabitants view point (Evaluation made in November 2008, November 2010 and April 2025)

Figure 12. Spatial quality analysis and monitoring model. case of the 500-unit housing estate of Biskra University.

- 05 for programming (i.e., in relation to this dimension as a whole);

- 11 for the design dimension in terms of aesthetics and functionality (symmetry, rhythm, harmony, coherence, green space design, pedestrian and bicycle traffic, component distance, distribution road, parking, parking position, and visual comfort);
- 03 for the realization dimension (mastery VRD (Roads and Utilities), current development cost and longevity);
- 07 for the utilization dimension (pedestrian and bicycle traffic, component distance, distribution road, parking, parking position, visual comfort, and anonymity);
- 04 for the maintenance dimension (health, pollution, sanitary sewer overflow (SSO), and watering).

Overall, 35 out of 74 indicators were assessed as slightly positive after the redevelopment of part of the outdoor spaces of the 500-unit university complex, 11 of which were design aspects. This suggests that, from the point of view of the residents, this redevelopment seems to have been moderately mastered during the study and poorly managed during realization. After the redevelopment was completed, residents continued to rate their outdoor spaces negatively, both in terms of their utilization, management, and maintenance. Resident feedback indicates that the efforts made to redevelop the outdoor spaces have made a positive contribution to their living environment, but they are still insufficient. Deficiencies relate mainly to realization, utilization, management, and maintenance.

In terms of execution, problems of specialization, qualification, and control of the construction firm are perhaps at the root of poor finishes, fragile work, and mediocre products. The unqualified project managers in monitoring the construction work probably contribute to these shortcomings.

In terms of utilization, the experience of the redeveloped space is still poorly appreciated by local residents. The redevelopment of the housing estate's extramural area remains insufficient from the point of view of users. The outdoor space of apartment blocks between buildings seems to be more important to residents, as it reinforces the sense of ownership of the space. It is very likely that if these redevelopments also cover the areas between buildings inside the mass plan, the evaluation of residents will be positive, particularly in terms of utilization.

Regarding post-occupancy maintenance and space management, the survey results following the recent redevelopment confirmed the complete lack of serious oversight by the project owner regarding all aspects of the co-ownership related to urban public heritage.

Replicating the Model in 2025

The 500-unit university housing estate underwent a second exterior space redevelopment project in 2025. This opportunity enabled the redeployment of our evaluation model in April 2025, thereby confirming its reliability. Identical data collection procedures were implemented, as documented in (Figures 11 and 12), with supplementary photographic evidence, Photo 3.

Residents perceived the 2025 renewal of outdoor spaces in this housing complex as falling short of their expectations. Compared to their 2010 evaluations, spatial quality declined by 6% (Figure 12). Nearly all indicators in the design, realization, and utilization dimensions showed marked deterioration, while maintenance-related indicators saw marginal improvement. This suggests deficiencies in project management (both execution and oversight) during the renewal operation, coupled with increased maintenance investments. This evaluation dynamic opens the possibility of using this model as a tool not only for the objective evaluation of spatial quality, but also for analyzing and monitoring the object's quality management and lifecycle through the interfaced behaviors and actions of involved stakeholders.

The results raise important questions about the model's scope. Although Biskra's study provides a solid empirical foundation, applying it to other urban contexts will require adapting the indicator system to local sociocultural and environmental realities. Furthermore, "qualitative quantification" remains an open field of research. While this study demonstrates its operational feasibility, further work will be needed to refine the weighting systems between indicators, improve statistical validation, and integrate more advanced data analysis methods, such as multivariate analysis or machine learning.

4. Conclusions

Overall, this paper focuses on the development of a model to objectively quantify the assessment of product and process quality in the field of architecture and urban planning. As a result, it works towards the continuous improvement of spatial quality. To this end, it is taking over and improving the model MATEA in terms of graphic representation, but also in terms of quantifying the spatial and practical quality of architectural and urban projects, particularly in their post-occupancy stages.

In terms of graphic representation, we have seen that the initial radar diagram has been refined by very fine decompositions ranging from the concept in dimensions to a significant number of indicators. This decomposition is illustrated in an advanced radar diagram drawn on a professional CAD support.

For spatial quality quantification, the developed graph of the radar diagram representing the averages of the evaluations of the spatial quality of the object analyzed sheds light on the quantification of quality based on the surfaces contained in the curves representing the evaluations of the actors interviewed.

On the practical level of the project in its post-occupational stages, the tool developed in this way can accompany the spatial object, enabling the control and evaluation of operations undertaken during its production process. It also becomes an investigative tool for the development of quality control, management, and monitoring systems.

This "multi-criteria" approach can help make important decisions about the future of architectural and urban objects. Objective quality analysis and assessment can also help to anticipate and avoid design, project management, and implementation failures in new projects. The case of outdoor spaces in collective housing in Biskra is an interesting example of the application of this approach. In the absence of a retrospective analysis of this legacy, which occupies a large proportion of urban public space, the same shortcomings observed in post-occupation housing projects persist in new developments. The model thus developed becomes not only an evaluation tool, but also a self-control tool for the architectural and urban operations undertaken during the life of the object studied.

This study does more than simply propose a model; it also demonstrates its empirical applicability through concrete results, highlighting systemic shortcomings in spatial quality and the limited effectiveness of urban interventions.

Future research should focus on:

1. Developing weighting systems for indicators
2. Testing the model in different cities
3. Improving statistical validation (reliability and reproducibility)
4. Developing visualization tools for decision-makers

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Abbreviations

The following abbreviations are used in this manuscript:

GCR	Ground Coverage Ratio
MATEA	Theoretical and Experimental Architectural Analysis Model
VCSA	Virtual Conception Space in Architecture
Lcs2A	Laboratory of Computer Science Applied to Architecture
IMS	Integrated Management Systems

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