

The Inclusion of the Environmental Dimension of Sustainability in Studying Informal Settlements Using the INDI System

The Case Study of Bousaada City, Algeria

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Abstract-The phenomenon of informal settlements is considered one of the most common global issues that have negative effects on several life aspects. All Algerian cities face this problem, including the city of Bousaada and the neighborhood of Sidi Slimane, which is considered one of the largest informal settlements in the city. Although the neighborhood has benefited from the Vulnerable Housing Absorption Program funded by the International Bank for Reconstruction and Development, the latter did not achieve the set goals. Therefore, it has become necessary to think about the use of modern and effective criteria for assessing the environmental dimension of sustainability, such as the INDI system of impact indicators built into EcoQuartierGrid2011 in order to contribute to the development of these neighborhoods, to ensure a better quality of life for the residents, and achieve sustainable development in light of the environmental dimension. On this basis, the present study aims to use the INDI system to integrate the environmental dimension of sustainability in informal settlements and to investigate the environmental shortcomings that the neighborhood Sidi Slimane suffers from in order to suggest possible solutions to develop it and improve the quality of life for the residents. In pursuance of this aim, the approach of the current research is descriptive-analytical in order to design an approach that deals with the criteria of the INDI System in environmental studies. The research concludes that both INDI and EcoquartierGrid 2011 will help improve the quality of life of the population for millions of individuals and residents in Algeria and in developing countries that suffer from the problem of informal housing. A guideline based on INDI and EcoquartierGrid 2011 indicators is recommended and incorporated into environmental studies as a reference. The novelty of the current research lies in finding practical and technical solutions to the problem of squatter housing through the use of the INDI indicator system and its integration with EcoQuartierGrid2011 based on 40 topics and 318 indicators covering the economic, social, and environmental dimensions.

Keywords-environmental dimension; quality of life; indicator impact system INDI; informal settlements; Bousaada City

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I. INTRODUCTION

The phenomenon of informal settlement growth is considered one of the biggest issues that threaten cities in general [1] and Bousaada in particular. The latter is attributed to the high population density [2], rapid urban growth, and the inability of regulatory authorities to address this phenomenon. The number of individuals living in informal settlements reached 725 million in 2000, and 860 million in 2013 [2]. The inclusion of the environmental dimension of sustainability has become necessary in informal settlements as it directly affects the quality of human life and society [3]. This effect is manifested in inadequate housing, the absence of generally accepted building standards, the high occupancy rate of housing, the deterioration of basic infrastructure [4-5], the spread of pollution and epidemics, unsanitary living conditions [6], in addition to the deterioration of living conditions such as the lack of necessary public facilities and equipment, the deterioration of the road network and the sewage network [7], the lack of green and public spaces, and poverty and social exclusion [8].

Informal settlements are characterized by the deterioration of their physical conditions. They are usually built with reinforced concrete, which is economical [9] and the impact of associated risks [10] is neglected, along with the risks regarding the quality of housing [11] and the construction of public projects [12]. These poor conditions clearly and directly impede the achievement of sustainable development in its environmental dimension. The environmental dimension of sustainability aims to improve the management of natural resources, protect biodiversity, and provide a healthy and livable human environment [13], while consuming renewable resources [14, 15].

II. RESEARCH METHODOLOGY AND TOOLS

A. Research Tools

The current research paper follows the descriptive-analytical approach and the INDI evaluation system in order to

assess the Sidi Slimane informal settlement. The study’s aim is to help achieve the environmental dimension of sustainability and improve the quality of life of the residents. In addition to that, field investigation has been conducted.

B. Procedures of the Case Study

This study revolves around Bousaada, an Algerian city. It is located at a distance of 250km from the capital, with an estimated population density of 614 inhabitants/km² in 2014. Furthermore, it is characterized by its strategic location and its natural, cultural and historical characteristics [18-19]. The district of Sidi Slimane was chosen as a case study, as it is one of the largest informal settlements in the city. The latter has grown in the '80's due to the absence of the concerned authorities and the increase in population growth and rural migration towards the center of Bousaada. Sidi Slimane is estimated to be 115 hectares, with a population of 45,000 people. [20]. The Sidi Slimane informal settlement is evaluated by merging the evaluation program INDI with EcoQuartierGrid2011 that consists of 40 topics and 318 indicators that include economic, social and environmental dimensions [16-17], see Table I.

1) INDI and EcoQuartierGrid2011

INDI is a program that aims to evaluate and develop all existing residential neighborhoods, and is used in projects that include rehabilitation, urban renewal, and urban expansion and works to achieve sustainable development and improve participation between urban actors and residents. EcoQuartierGrid2011 has been incorporated into this system as an important part of the development of the INDI index database.

The INDI rating system helps stakeholders, architects and urban planners improve the quality of life of residents and users. It is also the only tool among the global assessment systems that aims to assess the neighborhood before and after its improvement [16], moreover, EcoQuartierGrid2011 focuses on assessing the environmental dimension more and helps old and new neighborhoods integrate the environmental dimension of sustainability [17].

2) Stepwise Methods Executed to Achieve the Objectives

Three gradual methods have been followed in order to achieve the goal of the study, which is to integrate the environmental dimension of sustainability in the Sidi Slimane neighborhood in order to improve the quality of life of the residents:

- The stage of data collection: it is represented in collecting the initial information (documents, urban plans, site visits).
- Evaluation stage: By entering data into the integrated INDI program database and evaluating it, it contributes to identifying deficiencies and how to enhance them.
- Data review stage: It is the output of the evaluation process and is represented in two parts: a section for the outputs of the INDI program and a section for the outputs of EcoQuartier 2011 Grid, both in the form of graphs and tables.

TABLE I. TOPICS OF INDI AND ECOQUARTIER 2011 INDICATORS

Dimensions of Sustainability	Topics of the INDI Indicator Impact System	Topics of EcoQuartier Grid2011
Environmental	Energy management in project design	Good location and familiarity with the project
	Energy management in buildings	Comfortable and healthy living environment
	Optical comfort	Preserving biodiversity and enhancing nature in the city
	Mobility management	Use of non-renewable resources and waste
	Field consumption	Water Saving Department
	Biodiversity	Rationalization of energy needs
	Sustainable water management	Reduced greenhouse gas emissions
	Managing sustainable and natural resources	Valuing the agricultural environment and forests
	Quality of housing, population and private spaces	
	Quality of public spaces and green spaces	Regulating transportation and reducing car use
Economic	Security and health risks and pollution reduction	Alternative and sustainable transport
	Fighting poverty and social exclusion (work and housing)	Dense neighborhood and/or context adapted
	New ways of thinking and acting	Dynamics of local development Financial and legal feasibility
Social	Access to high-quality public facilities and utilities	Maintaining continuity of approach Monitoring and consultation
	Sharing the collective effort and integrating the neighborhood into the city	Solidarity and the responsibility to live
	Solidarity and the politics of social cohesion	Coexistence promotion
	Culture, education and training	Learning management and evaluation
	Evaluation and value as a method of education	
	Participation	Promoting heritage and identity
Involvement of residents and users		

3) Rating Values of the INDI System

The evaluation results are classified according to the evaluation field (0,1,2,3,4,5) according to five classifications, see Table II.

TABLE II. INDI RATING EVALUATION

Values	Evaluation
0	Absence of evaluation
1	Very insufficient
2	Somewhat insufficient
3	Average
4	Somewhat satisfying
5	Very satisfying

4) The Evaluation Process

The evaluation process is carried out according to the explanatory scheme of Figure 1.

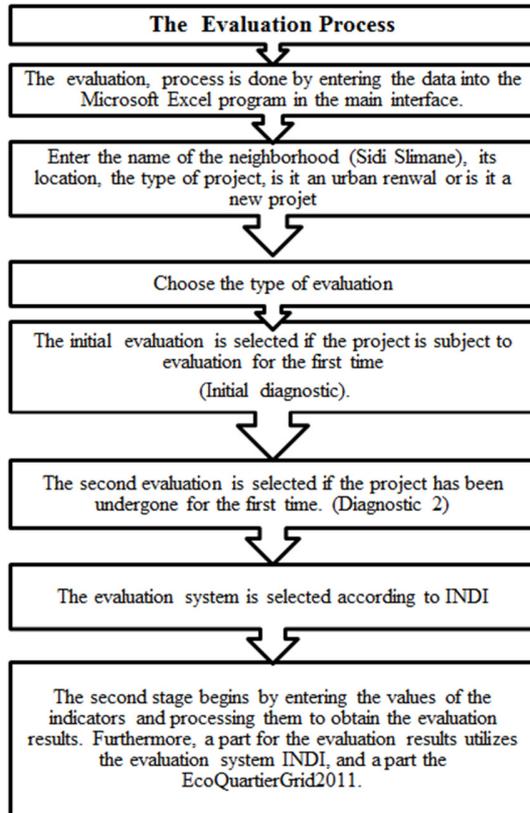


Fig. 1. The evaluation process.

III. RESULTS AND DISCUSSION

Sidi Slimane informal settlement was evaluated with the use of the INDI and with EcoQuartierGrid2011, see Tables III-IV and Figures 2-3. The aim of this study is to explore the shortcomings and insufficiencies in order to address the problem of substandard housing and to improve the quality of life for the population in the studied area.

TABLE III. ASSESSMENT RESULTS OF SIDI SLIMANE ACCORDING TO THE INDI SYSTEM

Assessment results of Sidi Slimane using the INDI Indicator Impact System	Initial evaluation
Energy management in project design	0.3
Energy management in buildings	0.3
Optical comfort	1
Mobility management	0.3
Field consumption	3
Biodiversity	0.5
Sustainable water management	0.5
Managing sustainable and natural resources	0.5
Fighting poverty and social exclusion (work and housing)	0.8
Access to high-quality services and facilities	1.8
Quality of residential buildings, residences, and private spaces	0.6
Quality of public spaces and green spaces	0.4
Security and health risks and noise reduction	0.3
Contribute to the collective effort and the integration of neighborhoods in the city	0.9
Solidarity and politics of social cohesion	0.2
Culture, education and training	0.2
A new way of thinking and acting	0.3
Evaluation and capitalization as a pathway to learning and improvement	0.7
Partnership	0.5
Involvement of residents and users	0.2

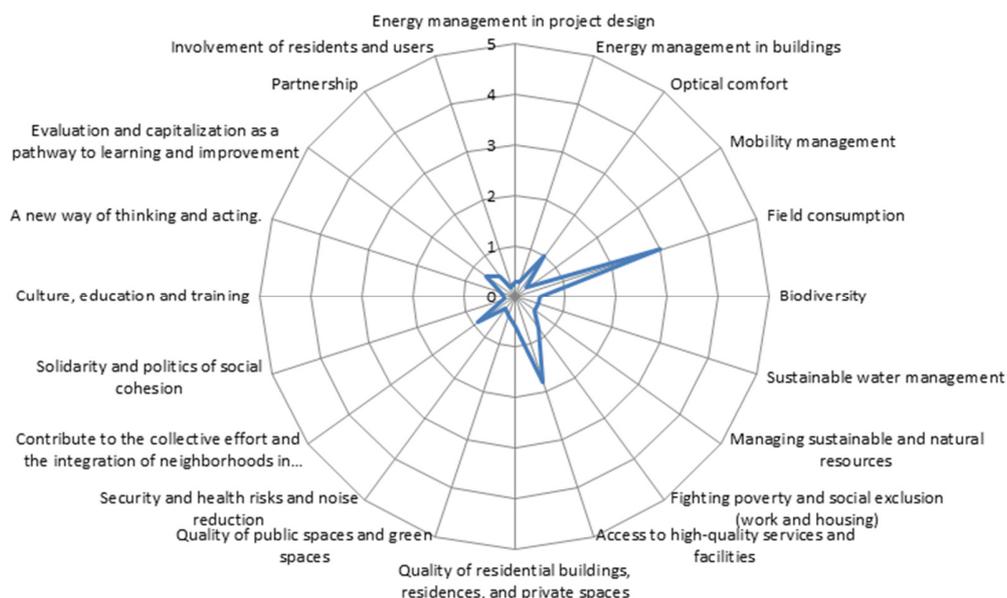


Fig. 2. Circuit diagram of the results of the assessment of the Sidi Slimane neighborhood according to the INDI assessment program.



Fig. 3. Circuit diagram of the results of the assessment of the Sidi Slimane neighborhood according to EcoQuartierGrid2011.

It is shown in Figure 2 that the field consumption index obtained the highest value (3), which is an average rating, explaining the increase of the informal settlement at the expense of natural areas and trees, the absence of oversight by the concerned authorities, and the weak application of laws aimed at reducing squatter housing. Most indicators of the environmental dimension of sustainability obtained a rating value around 0, which shows that the study area was randomly built without taking into account the appropriate orientation of the neighborhood to benefit as much as possible from the sunrays, and not taking into account climatic factors (such as wind direction, air currents, and shade) in addition to the lack of a network electricity and gas in the studied area, and failure to preserve natural areas, local trees, and plants when building. Furthermore, Figure 2 shows that the light comfort index obtained a value of 1, a very insufficient rating, and this explains the absence of public lighting in most of the streets of the study field. Finally, the indicator of obtaining high-quality public facilities and utilities obtained a value of 1.8, a very insufficient rating, and this explains the lack of the necessary equipment and facilities and their distance from housing, and that these facilities do not consider persons with disabilities.

It is displayed in Figure 3 that the dense and/or context-adapted living indicator has the highest value (2.3), corresponding to a somewhat insufficient rating and this explains the consumption of the urban area in the field of study. The Figure also shows that the functional blending index obtained a very insufficient rating (1.7), due to the absence of diversification in urban functions at the level of neighborhoods, residential islands, and housing units. As a conclusion, most of the indicators of the environmental dimension of sustainability got a value of 0 rating. This is explained by the absence of energy-saving buildings, the absence of a culture of preserving the environment and biodiversity, and the absence of a culture of reducing the volume and quantity of solid and household waste.

TABLE IV. ASSESSMENT RESULTS OF SIDI SLIMANE ACCORDING TO ECOQUARTIER2011

Assessment results of Sidi Slimane using Ecoquartier 2011	Initial evaluation
Good location and familiarity with the project	0.3
Monitoring and consultation	0.6
Financial and legal feasibility	0.5
Learn how to manage and evaluate	0.6
Maintain continuity of approach	0.1
Promote coexistence	0.6
Solidarity and responsibility to live	0.5
Comfortable and healthy living environment	0.7
Valuing heritage and identity	0.5
Dense neighborhood / or context adapted	2.3
Functional blending	1.7
Regulating transportation and reducing car use	0.3
Alternative and sustainable transport	0.2
Dynamism and local development	0.6
Valorization of the agricultural and forestry field	0.7
Reduce greenhouse gas emissions	0
Rationalization of energy needs	0.2
Water Saving Department	0.2
Use of non-renewable resources and waste	0.1
Preserving biodiversity and enhancing nature in the city	0.5

The research gap appears by referring to previous studies, The author in [21] believes that the absence of the principle of participation and the absence of negotiation to limit the informal settlement of the studied area (the Hanna Nassif Community Managed Settlement Upgrading pilot project) with the authorities and government agencies negatively affect the quality of life of the residents. A two-pronged approach was used: forward-looking proactive strategies to contain new urban populations and slum upgrading to address the needs of the people currently living in slums. Authors in [22] believe that improving the quality of life of their case study (slum-improvement projects in India) dwellers in India is linked to the development of a comprehensive legal framework that enables governmental and non-governmental agencies to deal quickly

with the structuring and implementation of slum improvement projects, promoting participation, transparency, and cooperation between governmental and non-governmental entities to support financial governance and facilitating land tenure. There is no method or evaluation program that was followed in this study, but direct suggestions were made. Authors in [23] argue that improving the quality of life of individuals of their case study, which includes providing basic needs such as adequate housing, sanitation, and waste management, especially with the Covid-19 pandemic, requires improving medical care for slum dwellers and working to improve the economic situation. The proposed actions are the establishment of emergency planning committees in the informal settlements, the application of the strategy of solid waste management and collection, and the provision of food aid. No method or evaluation program were followed in this study, but direct suggestions were made.

The research contribution of the current study lies in finding practical and technical solutions to the problem of informal settlement through the use of the INDI Indicator Impact System and its integration with EcoQuartierGrid 2011 with the aim of achieving the environmental dimension of sustainability and improving the quality of life in the Sidi Slimane informal settlement.

IV. CONCLUSION

This research aims to use the Indicator Impact System INDI to integrate the environmental dimension of sustainability and the environmental shortcomings that the neighborhood Sidi Slimane suffers from in order to suggest possible solutions to improve the quality of life of the residents. The results showed strong absence of the indicators of the environmental dimension of sustainability, stronger than the economic and social ones.

This study has many advantages over the previous ones since it differs in the methods and the results. While there is no method or evaluation program that was followed in previous studies, and directly suggestions and recommendations were made, the current study focuses on the process of evaluation which is based on 40 topics and 318 indicators covering the

economic, social, and environmental dimensions. This is what enables us to provide comprehensive, accurate, and practical solutions according to the study's results. In addition, the utilized techniques were used for the first time to address the problem of informal settlement. The previous studies took into account only 9 indicators at most to investigate the quality of life of the residents in informal settlements, which is insufficient and not comprehensive to address the problem, which faces several environmental, economic, and social challenges, which were studied without the utilization of programs or evaluation systems. The current study provides a starting point to understand and address the problem of informal settlement using the INDI technology integrated into EcoquartierGrid 2011 in developing countries, specifically in Algeria. These techniques are very useful in extracting deficiencies at the level of social and economic dimensions, especially environmental dimensions, and thus addressing the problem of informal settlement.

The implication of these findings is that these new technologies will be available to decision-makers and urban planners and will increase profitability, enhance the economy of the cities and improve environmental sustainability in informal settlements. The INDI and EcoquartierGrid 2011 may become a form of sustainable urban development that requires coordination, cooperation and realization of the principle of participation between the different urban actors, i.e. local and governmental authorities, the private sector, civil society, and the population.

Both the evaluation systems, INDI and EcoquartierGrid 2011 will help improve the quality of life of the population for millions of residents in Algeria and in developing countries that suffer from the problem of informal housing, and help in rationalizing energy consumption, protecting the environment, reducing pollution, and promoting development. As a conclusion, a guideline to improve the quality of life in an informal settlement in the city of Bousaada, based on INDI and EcoquartierGrid 2011 criteria and indicators should be developed, and it should be integrated into environmental studies as a reference, taking into account the recommendations shown in Table V.

TABLE V. A GUIDELINE FOR IMPROVING THE QUALITY OF LIFE IN SIDI SLIMANE BASED ON INDI AND ECOQUARTIER2011 CRITERIA AND INDICATORS

Indicators	Recommendations
Energy management in project design	<ul style="list-style-type: none"> -It is necessary to provide all housing in the slum of Sidi Slimane with electricity, gas, and sewage facilities. -There is a need to take into account the appropriate orientation of the building to benefit as much as possible from sunlight and climatic factors (such as wind direction, air currents, shade) when designing the building. -The establishment of housing units within the field of study that achieves self-sufficiency in energy needs so as to produce and use clean energy efficiently and effectively is proposed.
Energy management in the building	<ul style="list-style-type: none"> -Energy efficiency can be achieved by reducing the use of electricity and gas, heating, ventilation, cooling, artificial lighting, and making use of natural lighting as much as possible. -Local and sustainable building materials that enhance heat gain must be utilized.
Optical comfort	<ul style="list-style-type: none"> -All primary and secondary roads in the field of study must be equipped with public lighting.
Mobility management	<ul style="list-style-type: none"> -The development of an integrated and sustainable transportation system that takes into account quality, pricing, security and safety, and provides common public transportation such as buses is suggested. -The use of bicycles and allocating areas for pedestrians must be encouraged. -The necessity of providing car parking, taking into account the distance of less than 300m between the dwelling and the stopping station is underlined. -The provision of public transportation at all times and at the end of the week must be taken into account. -Lanes for bicycles must be allocated. -The necessity of enabling persons with disabilities to have easy access to public transportation is underlined.

Field consumption	-There is a need to protect and preserve agricultural areas, forests, and trees. -Tightening of supervision by the concerned authorities and the application of laws that limit random housing that consumes the urban space excessively is suggested.
Biodiversity	-The preservation of natural areas when initiating the processes of preparing the neighborhood must be taken into account. -The continuity of natural areas should be preserved. -There is a need to take proactive measures aimed at preserving trees when constructing buildings. -Different types of native plants must be cultivated.
Sustainable water management	-There is a necessity of providing all housing units in the study area with potable water, rationalizing the consumption of domestic drinking water. -The quality of potable water must be ensured (taking into account sanitary, physical and chemical conditions and compliance with water quality standards). -Water leakage can be reduced by repairing and renovating old channels. -Work has to be done in order to establish separate rainwater and greywater treatment centers.
Sustainable management of natural resources and materials	-There is a necessity of using local building materials and energy-saving conservation techniques.
Fighting poverty and social exclusion (work and housing)	-There is a necessity of providing equitable employment and housing positions for all segments of society. -There is a necessity of reducing squatter housing because it negatively affects the economy.
Access to high-quality services and facilities	-There is a necessity of increasing the number of health, security, and educational equipment in the studied neighborhood, as it is insufficient. -There is a necessity of taking into account the proximity of the housing in the case of the area to public facilities (shops, school, mail, health centers, etc.) within a range of 300m. -Public facilities and facilities must provide access to persons with disabilities.
Quality of residential buildings, residences, and private spaces	-The quality of housing must be improved. -Work has to be done in order to achieve quality in public roads, common spaces between residences, private spaces, and stairs, and secure access. -The privacy of the dwellings and the interfaces between private and public spaces must be taken into account. -There is a necessity of furnishing the streets and general lighting at the level of the studied neighborhood in order to serve the residents.
Quality of public and green spaces	-There is a necessity of providing public spaces and green spaces within the field of study. Abandoned and unbuilt spaces can be exploited. -The population has to be informed and sensitized to the preservation of green spaces and natural areas. -There is a need to take into account the hierarchy of spaces and ease of reading in the design of green and public spaces.
Security and health risks and noise reduction	-There is a necessity of preparing a preventive plan for the natural disasters that the studied area suffers from (the danger of falling stones and floods). -Strict instructions must be established to reduce the risk of accidents in construction workshops. -The construction waste must be disposed of immediately after the completion of the construction process.
Contribute to the collective effort and the integration of neighborhoods in the city	-There is a necessity of diversification in urban functions at the neighborhood level, residential islands, and housing units to achieve functional blending.
Solidarity and politics of social cohesion	-The studied area contains only individual housing, so it is necessary to diversify the housing style through the establishment of social housing to enhance interaction between residents and achieve social diversity.
Culture, education, and training	-There is a necessity of valuing heritage and local identity is underlined. -Awareness-raising and media campaigns at the level of the studied neighborhood on protecting the environment and preserving green spaces and natural areas must be carried out.
A new way of thinking and acting: Approaches, methods, and tools	-Programs of training and educating workers and engineers of governmental and non-governmental agencies, private sector, associations, civil society, and the population can be carried out. -There is a necessity of calculating the project budget and the total cost of the initialization operations.
Evaluation and capitalization as a path to action and improvement	-There is a need for continuous adaptation and improvement of the project.
Partners	-The preparation of a charter for the project of environmentally sustainable residential neighborhoods that include the various actors and partners in the project, is proposed.
Involvement of residents and users	-Consultation and involving residents and users in evaluating the project's stages and planning for the establishment of public facilities, public spaces and green spaces is suggested.

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