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'Integration of sig and hierarchical analysis multicriteria planning aid urban developmen'
Case study of bejaia

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Abstract: *Urban planning plays an important role in the use of the 3Rs of sustainability: reduce, reuse, and recycle. The problem frequently encountered in urban renewal is the lack of a quantitative approach to assessing the suitability and compatibility of land for reuse; thus defining urban planning. The aim of the present article is to address this particular problem by developing an analytical framework centered around the integration of geographic information systems (GIS) as well as the fuzzy analytical hierarchy process (FAHP).In the process of developing this article, we have defined the main factors influencing decision-making on the priority of land for reuse (recycling) in urban renewal planning. These factors are identified and quantitatively examined under four visions of soil attributes: environmental, technical soil aspect, accessibility, and socio-economic. Sub-criteria were developed for value generation, assessing the priority of soils for reuse, designed and constructing an analysis grid. The proposed model was tested in the city of Bejaïa. The proposed framework proved to be a useful alternative for developing a decision-support tool for analyzing the spatial-functional capacities of existing land and facilitating decision-making to optimize the implementation of urban projects as well as guaranteeing the morphological recycling of the city. The results show that the FAHP method is an effective and reliable decision-making tool for recycling urban spaces and identifying priority land for urban renewal and acting as a valuable tool for both practitioners and researchers involved in sustainable development and urban renewal.*

Keywords: *Urban planning; multi-criteria analysis; GIS; fuzzy AHP.wasteland, land*

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Introduction:

The primary focus currently in urban discussions is urban renewal which is considered a long standing approach to urban transformation (Badariotti.D 2006.)

For several decades, specialists in urban planning (both practitioners and researchers) have been searching for methods to reduce the harmful consequences of urban sprawl, which is responsible in particular for increasing land consumption.

We have developed an analysis grid based on 4 pillars to define the suitability and compatibility of soils for rational planning and the prioritization of soils for reuse for sustainable urban renewal.

Cities are places of economic development and cultural transformation. However, since the beginning of the 21st century, the future of our cities has been at stake. This is due to increasing urbanization and globalization are driving major changes in our metropolises, creating environmental, social, political, and economic imbalances Additionally, the phenomena of metropolization in our cities, critical global issues like water shortages, environmental damage, and poverty, alongside climate change are hazards to the future of humanity.

Our aim is to develop a multi-scale concept for returning to the city; inspired by fractal geometry, which proposes (a reconstruction of the city upon the city) to manage the city without dilution and urban sprawl. Identification and valorization of free urban spaces (wasteland) as intra-urban potential. Evaluation and spatio-temporal characterization of urban space dynamics.

The emergence of a desire for integrated urban planning has given rise to new requirements for rationalizing land resources and enhancing the economic value of urban and rural positions in the conurbation, in order to respond to economic and social issues and environmental challenges. This desire is currently a strategic issue of local and national governance and remains a priority that also leads to a genuine opportunity for investment and wealth creation. However, taking into account the concept of sustainable development requires a multi-dimensional analysis of the project to mobilize and manage land for urbanization purposes.

Nowadays, the vast majority of world cities are characterized by dispersed urbanization, generating increased travel, abundant land consumption, social disparities, and infrastructure costs that are unsustainable in the long term. Faced with this situation, most countries are now aiming to limit urban sprawl by promoting the densification of existing built-up areas. (maria perez all 2013).

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The city is by definition an assemblage of individuals whose effects on the environment and society as a whole are detrimental by their very nature: consuming land and space, causing pollution of every sort, splintering society, etc.

This assemblage of human beings is constantly evolving, and cities are becoming increasingly diluted. Urban dilution is a term used to describe the intense, discontinuous sprawl of urban development (c. Enault 2004). Cities are spreading out anarchically; human activities are constantly expanding and relocating, leaving hybrid empty spaces indoors (OSWALT Philippe 2000, E Rey 2015). Cities have become fragile - an alarming and exasperating situation that is leading to the fragmentation of the city. This issue of expansion in urban space is on the agenda in many countries around the world.

Cities are built and rebuilt, and this way of occupying space has serious economic, environmental, and social consequences in terms of excessive land consumption. The demand for land, in all its forms and uses, is being abused, outstripping available land resources. (Ozcan, Cetin and Diker 2013). Soil is a non-renewable natural resource that mankind needs immediately, and it will have to be bequeath through its regeneration/reuse.(J ballet 2007, A Bispo et all 2008). *"Urban soil cannot be studied independently of the production of built space*" (Schteingart, 1986).

Anarchic urbanization and population growth are the catalysts of spatial fragmentation; and faced with the scarcity or even shortage of urban land, these parameters have made land-use planning 0important and urgent but also very difficult for urban redevelopment in relation to the concept of sustainable development.(E Rey 2015, S. M. EL AMRAOUI and all 2016).

Since the dawn of time, man has created a conflict with the earth (H WANG ET ALL 2013).

Rebuilding the city upon the city is one of the main challenges faced by most countries when it comes to limiting urban sprawl; despite this, the practice of urban planning, i.e. urban renewal through urban planning documents set up to define land use, still suffers from many practical shortcomings encountered by urban planners and local decision-makers, putting them in a situation involving a complex decision (Witlox 2005. CHTOUKI, 2011). Nevertheless, solely establishing expanding operations in the still-accessible urban wastelands and interstices is unlikely to be sufficient to accomplish the aforementioned objective. Instead, it involves densifying current neighborhoods.

This offers an opportunity to simultaneously integrate socio-cultural, economic, and environmental criteria with a view to sustainable urban development.(Maria Perez 2013).

Essentially, urban land renewal involves several factors and impacts: local authorities, residents, and land allocations (private, public...) (Blokhuis et al. 2012; Ho et al. 2012; H

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WANG et al. 2015). Faced with the complexity of urban systems and the vast amount of information and geospatial data, urban planners find themselves in need of new decision-support tools that meet the growing demands of economics, social equity, and environmental protection. (Katpatal and Rama Rao 2011; Coppola et al. 2013; H Wang 2015).

Like other cities in the world, Bejaia is no exception to this problem, having developed through anarchic expansion and an unbalanced layout. Stumbling on the slopes of Mount GOURAYA, Bejaia is characterized by a mix of entities and urban fabrics, with an old colonial fabric and a post-colonial fabric disjointed from one another.

These urban planning methods have put the soil to the test, and urban renewal through wasteland is an issue that has interested many researchers.

A sustainable land use planning system (SARD) is a set of software tools that supports and participates in the elaboration of a medium- to long-term urban land use plan (Vonk et al. 2007). When geospatial data are involved in urban land use planning, the elaboration of a SARD is carried out with the help of geographic information systems (GIS). To fill the gaps found above our work is based on the use of a combination of methods: analytic hierarchy process (AHP), and GIS (the aim of the combination of these methods). In order to facilitate the task of decision-makers and planners in terms of evaluation and elaboration of plans for the sustainable renewal of urban soils qualified as wasteland. Bejaia, like other Algerian cities, is currently experiencing an increase in urbanization brought on by a soaring population, which has caused it to expand into undeveloped areas that are frequently less advantageous than those that are already urbanized.

1.1 Research tools

This brief review aims to introduce the techniques employed in this study and to justify their application. The first section concerns geographic information systems (GIS), used to acquire, organize, manage, process, and render geographic data in the form of digital maps and plans. The second section concerns the MCDA, which is needed to analyze the needs of the population according to various criteria. Particular attention is paid to the analytical hierarchy process (AHP) (Saaty, 1977, 2008) and reasoning maps (Montibeller, Belton, Ackermann, and Ensslin, 2008). The combination of GIS and multi-criteria analysis methods constitutes a privileged and unavoidable path for evolving GIS into genuine decision support systems (Sidi Mohamed .l 2017).

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1.1.1 SIG:

According to Clarke (1995), geographic information systems (GIS) are "systems for the automated capture, storage, retrieval, analysis, and display of spatial data". GIS provides simple analysis tools that allow information to be visualized on a suitable medium. A Geographic Information System (GIS) is a computer program capable of organizing and presenting spatially referenced alphanumeric data. This system is particularly well-suited to combining the various resources available: databases, know-how, and processing capacity, depending on the applications required. According to

C. DADOUCHI et al (2016) in their GIS literature review, Hernandez (2007) explains that geovisualization seeks to transform large quantities of heterogeneous data into information (interpreted data) and subsequently, knowledge (understanding derived from the information). Our study focuses on the use and exploitation of this tool for transforming data into knowledge with ease, with a view to aiding informed decision-making.

1.1.2 AHP:

Various projects have been developed based on the selection, extension, and deepening of a list of proposed indicators. A basic analysis of the literature on positioning, which encompasses several multicriteria and decision-support methods, is presented below. Farahani et al (2010) reviewed the literature on multi-criteria location problems in three main categories, including bi-objective, multi-objective, and multi-attribute problems. Standard MCDM techniques are commonly used in the positioning literature. Vaidya, O. S et al (2006). Developed a literature review on applications of the Analytic Hierarchy Process (AHP). Tavana et al (2017) presented a group decision support system based on the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) for the evaluation of alternative layouts. Similarly, Madjid Tavana et al (2017) used the fuzzy AHP (Analytic Hierarchy Process) method to focus on the specific problem of positioning during the construction of solar power plants. Jelena Kili'c et al (2019) used a Land Fragmentation Assessment method in Sustainable Urban Renewal planning. Wang et al (2015) present a Geographic Information System (GIS)-based decision support tool (called LUDS) to quantitatively assess the suitability of land use for site redevelopment in urban renewal areas**.**
Alternative techniques to the standard multicriteria can be found in the literature; Dogan (2012) proposed an integrated approach combining Bayesian networks and the total cost of ownership to cope with the complexities of selecting an international facility for a manufacturing plant. G. Polat et al, (2019) developed a comparative study on the selection of urban renewal projects using different MADM methods.

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An in-depth literature review in the field of urban planning revealed that few approaches were based on analysis of (alternative) modes of "recycling" reuse of urban land, which led us to reconsider the relevance of the process for the present study.

1.2 METHODOLOGICAL APPROACH

1.2.1 PRESENTATION OF THE STUDY AREA

Bejaia (locally known as Bgayet, in French Bougie) represents one of Algeria's prominent coastal cities, located in the western portion of the southern Mediterranean geographical area, occupying the middle of the North African coastal strip. Leaning against the southern flank of Mount Gouraya, the town's overall morphology is amphitheatrically layered. The site's natural protection and defensive potential justified the establishment of this large-scale town. The Wilaya of Bejaia covers an area of 3,223.5 km, with an urban area of 12,022 hectares. The geographic coordinates of the commune at the central point of its chief town are respectively 36° 45′ 00″ North and 5° 04′ 00″ East. In 2015, the province counted nearly 187,065 inhabitants (wilaya statistical yearbook, 2015) the province is also at the crossroads of a high-capacity traffic and transportation network. It is served by a relatively dense road, motorway, and rail network. Bejaia bears the scars of history and the legacy of a heavy past, characterized by a mixed urban fabric, ancient fabric; colonial and post-colonial fabric resulting from the multitudes of civilizations that have lived there.

2 Drawing up an analysis grid:

For the construction of the method for evaluating the quality of public spaces, we have grouped together the detailed criteria from the various methods (Gaad, hqe2r, agenda 21) in order to select synthetic criteria that will facilitate the implementation of this method by local practitioners. To this end, we will have 10 synthetic criteria for evaluating the quality of public spaces (figure 3) and a series of evaluation indicators.

The method's dashboard is a general grid made up of 10 synthetic criteria defined above and 75 indicators for assessing the quality of public spaces 4, scientifically valid and able to support decision-makers in their choices, all from a sustainable development perspective (table 1).

This table summarizes the 7 criteria and 20 indicators that make up the evaluation grid for the capacity of a brownfield site to be renewed to ensure the city's sustainability.

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Criteria	Indicator	Sub-indicator
Environmental indicators		
Land use index	Topography	Slope gradient elevation Slope aspect
	geology	Land at risk of earthquakes Risk of landslides deep in bedrock
	climate	Solar access Direction of the prevailing wind
	hydrology	Depth to water table Drainage points
	Legal properties	Land ownership Administrative "limit" border easement
	Land use	Old and new land uses Use of neighbouring land
Land management	Optimizing space consumption	Urban density Surface area of available public space per inhabitant
	Redeveloping brownfields and polluted land	Surface area of fallow land in % of total surface area
	Integrating environmental concerns into urban planning documents	Number of targets covered by the regulation
Mobility	Quality of transport links	Road function International traffic Traffic volume
Economic indicators		
Economic diversity	Promoting economic activity	Number of jobs per 1,000 inhabitants
	Promoting the presence of shops	Number of shops per 1000 inhabitants
	Promoting the presence of facilities and services	Number of units less than 300m
	Diversity of housing supply	social housing %households that own their own home
Socio-cultural indicators		
Proximity	Proximity to schools Close to shops Close to leisure activities	Average distance to an elementary school Average distance to a school Secondary Ect +8

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mix	Functional mix Social mix potential	Degree of functional diversity Social diversity
heritage	heritage	Degree of historical heritage enhancement

2.1.1 GIS database collection and development: hardware and data:

The methodology employed in this study incorporate the integration of spatial data, including 1:50,000 topographic maps, satellite images, and alphanumeric data related to land, topography, demography, and land use. To facilitate this integration, appropriate hardware and software tools were utilized. The topographic maps and other data were geo-referenced using the UTM-31N projection system in the WGS84 datum, ensuring spatial accuracy and consistency across the datasets. This geospatial framework enables the assessment of areas suitable for sustainable renewal based on various parameters. The processing of the data involved the analysis of Landsat satellite images, which provide valuable information on land cover and land use patterns. Additionally, a digital terrain model was employed to derive elevation data and generate insights into the topography of the study area.

The relevant metrics were mapped and cross-referenced using the ArcGIS 10.2 software environment, and the GIS database for this study was created using the criteria and sub-criteria listed below. GIS offers geo-referenced data validation, management, processing, and spatial, thematic, and multi-thematic analysis (EL MORJANI, 2002).

Figure 1 depicts the data used and the processing performed to extract the information required for the multi-criteria analysis.

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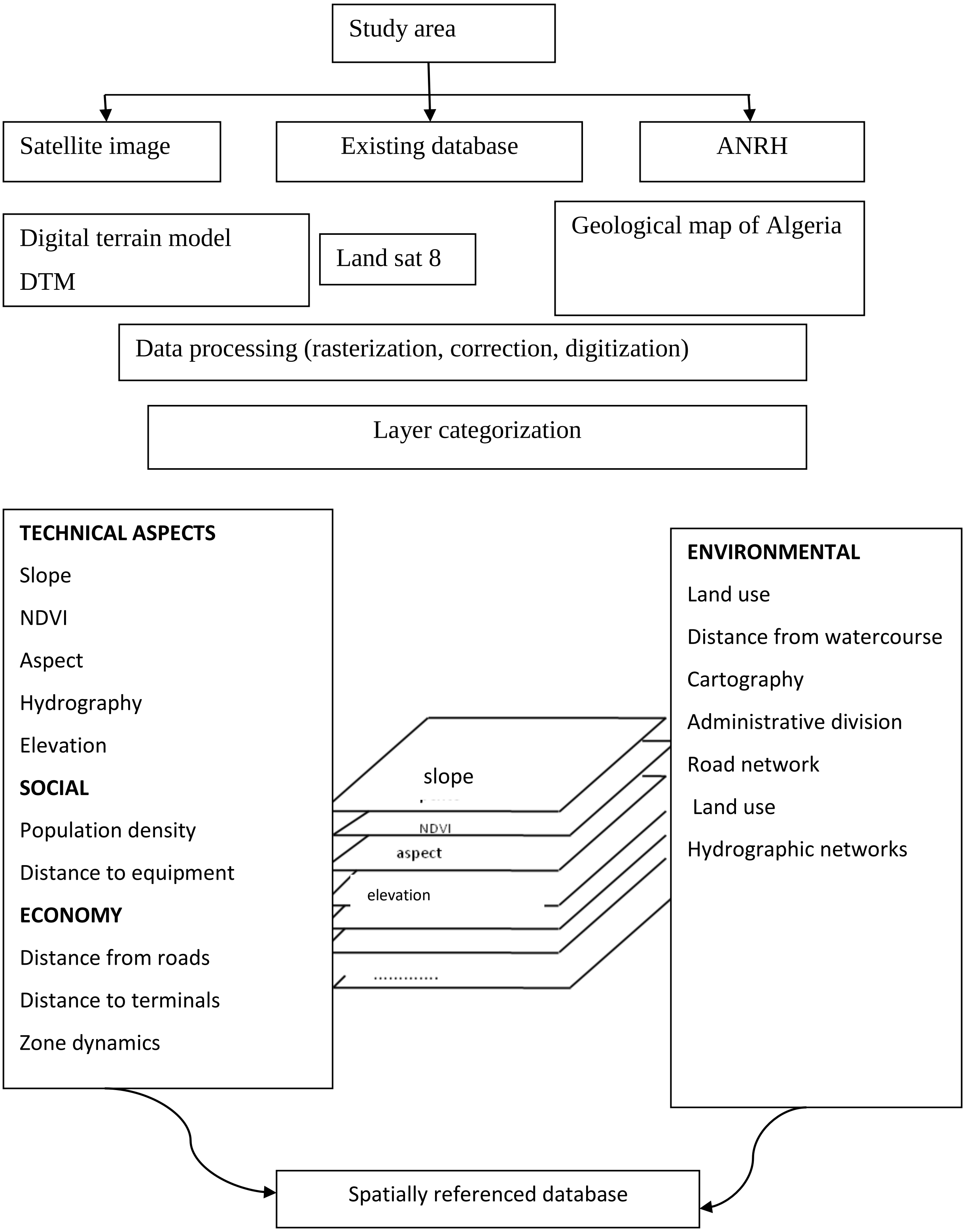

Figure 1: Data structure flow chart

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2.2 Application of hierarchical multi-criteria analysis to support sustainable urban renewal " evaluation method and selection "

The proposed method employs a systematic approach by breaking down the problem into hierarchical components, starting with the overarching objective, followed by the criteria and sub-criteria, and concluding with potential solutions. This methodology aims to emphasize urban renewal through the effective utilization of land resources, promoting sustainable urban planning, and facilitating the development of robust decision support systems. The assessment of land suitability and compatibility for regeneration is a fundamental aspect of this methodology. It relies on the utilization of Geographic Information Systems (GIS) as a tool for data integration, analysis, and visualization. In particular, the Analytic Hierarchy Process (AHP) approach, as introduced by Joerin et al. (2001), is adopted as a multi-criteria decision support analysis (MCDA) technique within the GIS framework.

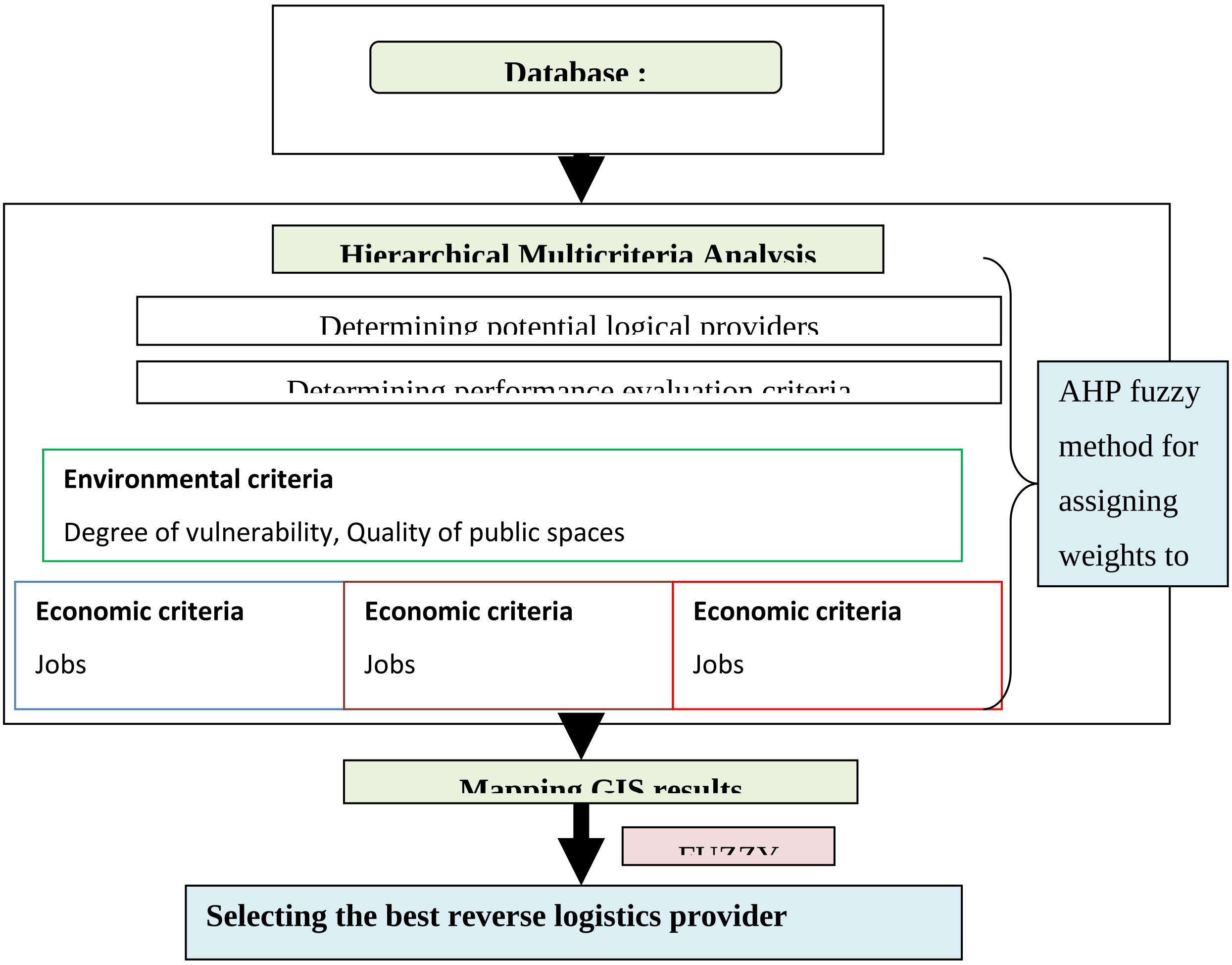

Figure 2: Architecture of the proposed methodology source: author

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We have leveraged the capabilities provided by Geographic Information Systems (GIS) to organize and integrate data, perform spatial analysis, and establish relationships among various thematic layers. Additionally, we have incorporated the Analytic Hierarchy Process (AHP), a hierarchical multicriteria analysis approach developed by Saaty (1980), which adheres to several axioms including the reciprocity axiom, homogeneity axiom, dependency axiom, and expectation axiom (Saaty, 1986). Any modifications made to the hierarchy structure necessitate a recalculation of priorities within the revised hierarchy (Željko Stević et al., 2016). The AHP methodology enables the consolidation of numerous decision criteria into a unified model, facilitating the comparative assessment of each criterion pair and determining their respective weights for evaluating each option with respect to individual sub-criteria. This comprehensive approach culminates in the creation of a synthesis map that identifies suitable land reuse opportunities for urbanization.

The achievement of land regeneration for sustainable urban renewal involves several key stages: problem identification and definition, representation and modeling of spatially referenced data, hierarchical multi-criteria analysis, criteria aggregation, and presentation of results through decision maps. The process employed to determine potential areas for urbanization (city-on-city renewal) is illustrated in Figure 2.

The experts responsible for establishing the fragmentation index model utilized the AHP method to determine the Triangular Fuzzy Numbers (TFNs). The decision to employ a fuzzy AHP (FAHP) approach, rather than the standard AHP method, was made in order to mitigate the subjectivity and uncertainty associated with defining the weights. Instead of assigning a single weight value, a triangular range of values is defined for each criterion weight. Table 6 presents the linguistic scale of importance and the triangular fuzzy scale, with lower (l), middle (m), and upper (u) values. This strategy entails deconstructing the problem, beginning with the objective, then the criteria and sub-criteria, and ultimately the viable solutions as represented in Figure 3.

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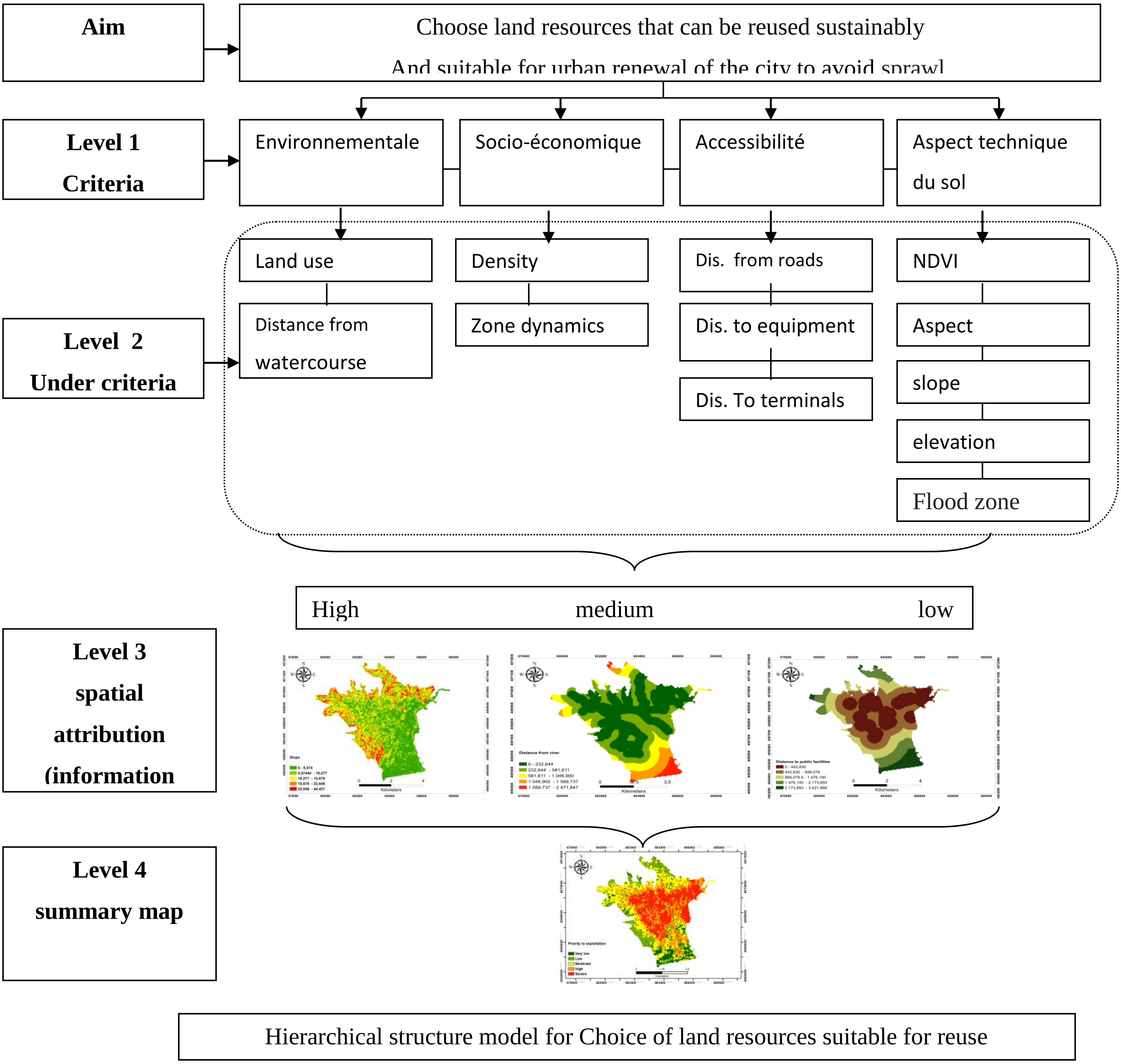

Figure3:GIS AND AHP COMBINATION flowchart

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2.2.1 Hierarchical multi-criteria formulation and elaboration of the various criteria

Our study is based on the objective of the sustainable urban renewal of undeveloped land" "towards sustainable urban planning.

AHP is the rational planning process (Banai-Kashani, 1989) for prioritizing land for reuse for sustainable urban renewal in the case under study. It is based on a decomposition of a complex system into a hierarchical structure where each level is made up of specific indicators (elementary and aggregated). This hierarchical structure highlights the indicators that will have the greatest impact on the final decision.[1]

Based on the literature review and expert opinion, we have identified 12 factors considered most influential in the sustainable urban renewal of brownfield land. Figure 3 shows the criteria and sub-criteria taken into account in the analysis of soil suitability and compatibility to create a synthesis map (thematic) prioritizing soils to be reused for sustainable city reconstruction, using the ArcGIS 10.2 spatial analysis tool.

Factor and parameter weights were calculated using MsExcel and MATLAB.

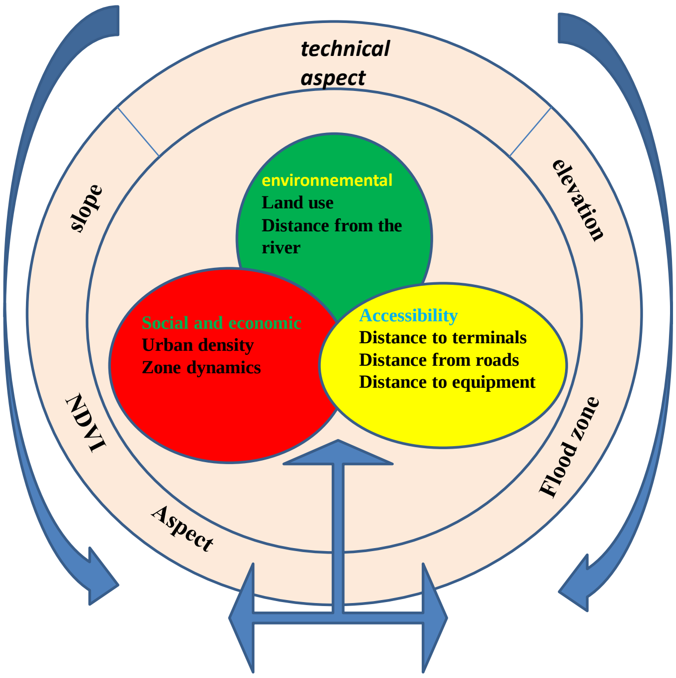

Figure 4: Flow chart of evaluation criteria

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In the following paragraphs, we aim to explain the four research criteria, namely the soil technical aspect, the environmental aspect, the accessibility aspect, and the socioeconomic aspect, in addition to the 12 sub-criteria.

2.2.1.1 Environment index

2.2.1.1.1 **Land use and land cover:**

According to the FAO (1998), land cover refers to "the bio-physical cover of the land surface", which plays an essential role in urban planning. Land use/land cover, therefore, refers to changes in the environment as a whole (the type of use (or non-use) of land by man). This said changes in vegetation cover refer to the conversion and modification of vegetation, changes in biodiversity, soil quality, runoff, erosion, sedimentation, and soil productivity, including the sustainability of different land uses. In other words, the artificialization of land through increased concreting causes a momentous change in the landscape of use ((Braun Von & Mirzabaev, 2016, Rajcaniova et al., 2014, Vink, 1991) and land cover. (landscape, land cover, and land use)[2]

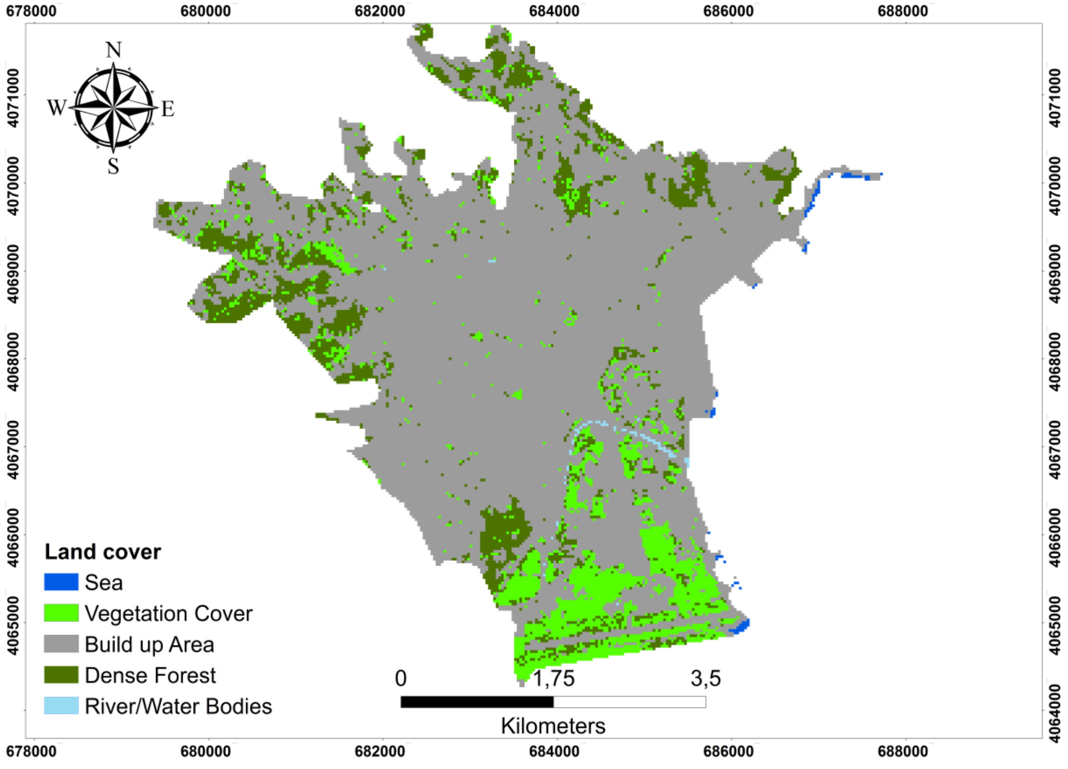

Figure 5: the result of the land use criterion

Analysis of the distribution of areas classified according to: "green space", "forest space" and "artificial/constructed space" shows that in the city of Bejaia, there is a spread of "artificial space", which is distributed over the entire surface area of the city. Fragments of "green space" and "forest space" can also be seen, distributed unevenly throughout the city. The further one moves away from the city center (which is characterized by the presence of green

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spaces defined by squares and squares), the greater the proportion of green space (figure 1). Within the artificialized or built-up area, there are also "undeveloped areas" in the form of uncultivated islands, which can be used as an alternative for future construction to limit the over-consumption of virgin land.

The figure shows how the metropolis instills a culture of soil artificialization A Decoville, (2023) and devours every free piece of green land.

2.2.1.1.2 Distance from the river:

Distance from the watercourse is one of the most important factors in assessing vulnerability, since the overflow of a watercourse into its major bed, following episodes of heavy rainfall or the failure of a civil engineering structure, will have serious consequences for local residents, largely due to non-compliance with instructions or ignorance of the risk. For this reason, land use must respect an easement that is a sufficient distance from the watercourse to classify the land as urbanized or as a not to build zone.

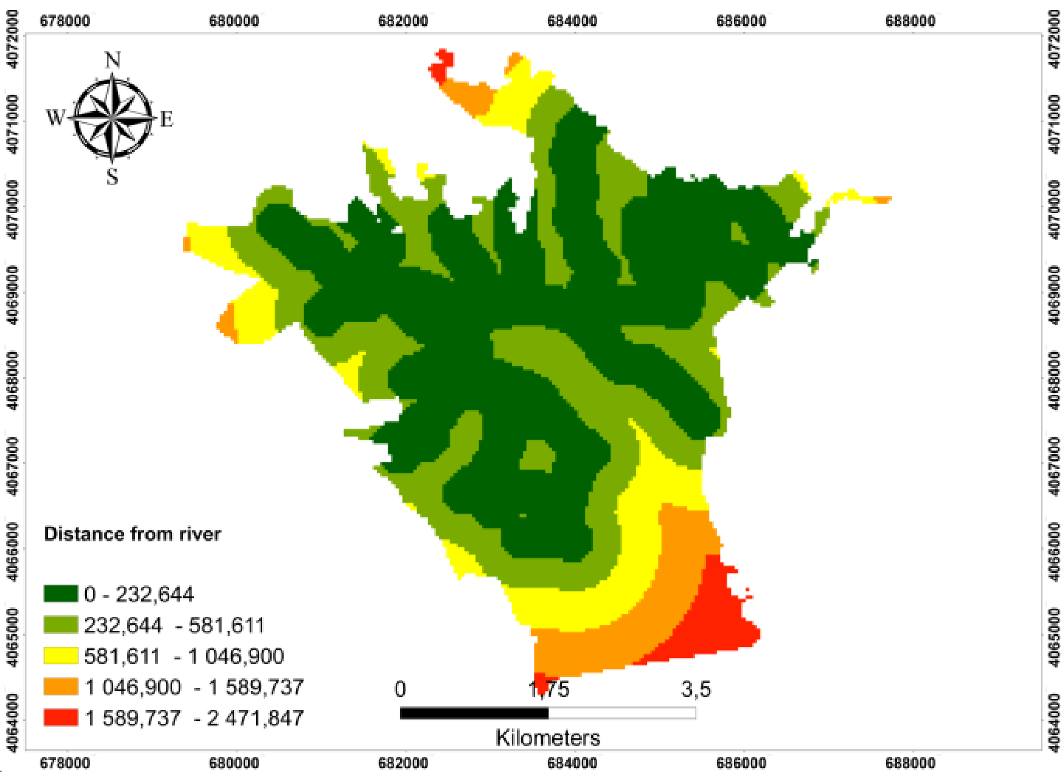

Figure oresult of the distance to watercourses criterion

2.2.1.2 Index of the technical aspect of the soil

These clues can be deduced from ***geological*** maps***, which*** provide a wealth of important ***geological*** information in an easy-to-read form.

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2.2.1.2.1 Slope:

is a very important criterion in urban planning, as it determines a site's predisposition to instability (relief, geological nature of the terrain, etc.) and determines the configuration of the land and its slope. Relief is the most important and necessary indicator for understanding land use events.

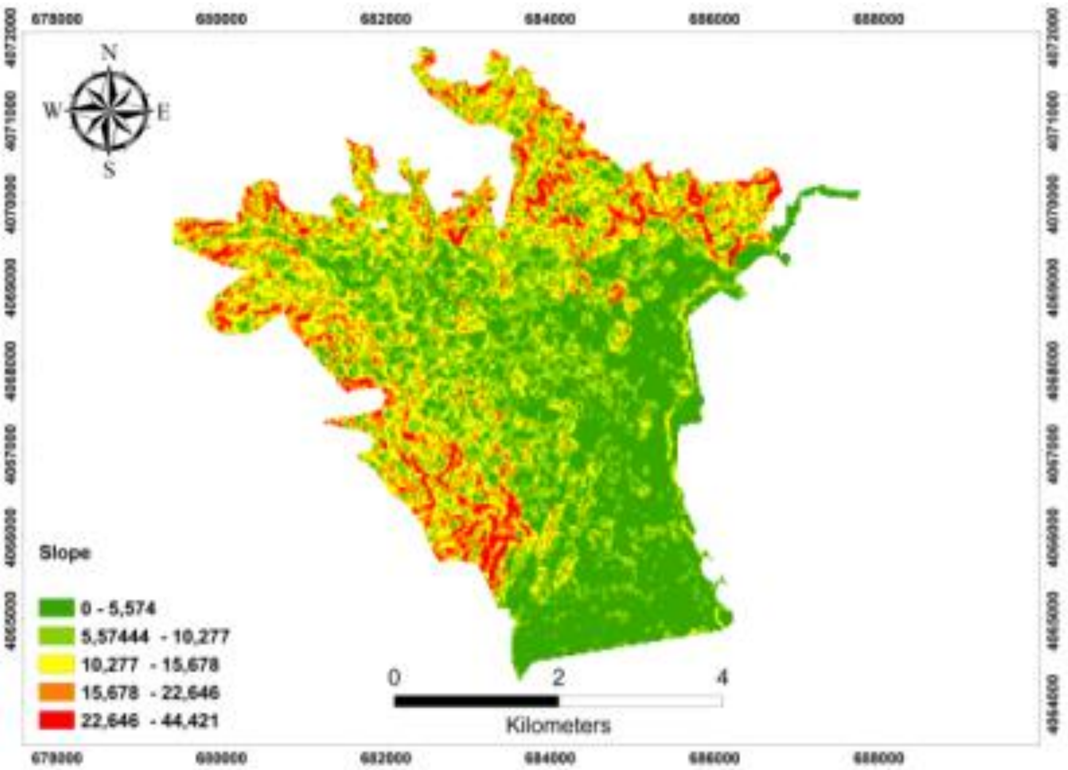

Figure 6: slope criterion result

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2.2.1.2.2 Elevation:

Elevation is a very useful parameter for classifying relief and locating points of minimum and maximum height (Li et al. (2012) a factor that determines building height. Regulates the height of buildings that can be erected in the various zones making up the municipal territory.

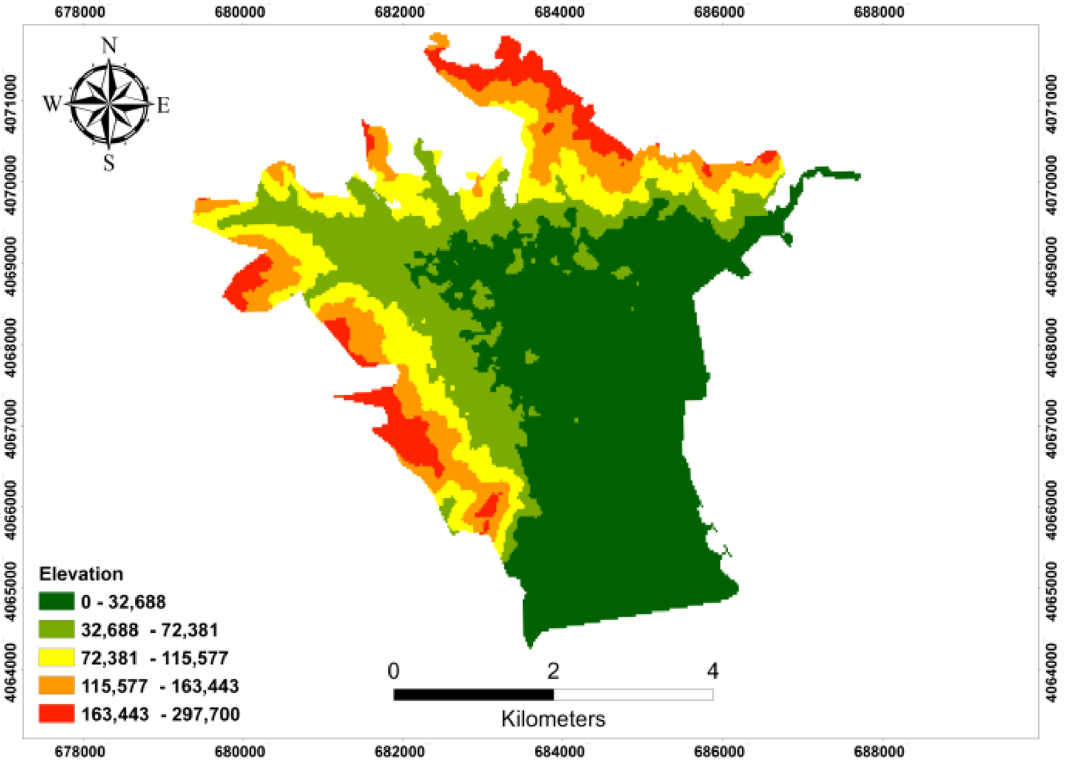

Figure 7 Elevation criterion result

2.2.1.2.3 Flood zone:

The type of soil in flood-prone areas is an important criterion, as it can amplify/mitigate the intensity of flooding. Soils with a small particle size fraction are areas with low infiltration potential. On the contrary, permeable soils, such as sand, favor water infiltration through runoff and underground drainage. To be utilized with the goal of minimizing the susceptibility of property and persons to floods, which should not be equated with the inconstructibility or freezing of vulnerable areas (Alexandre Brun and Félix Adisson 2011)

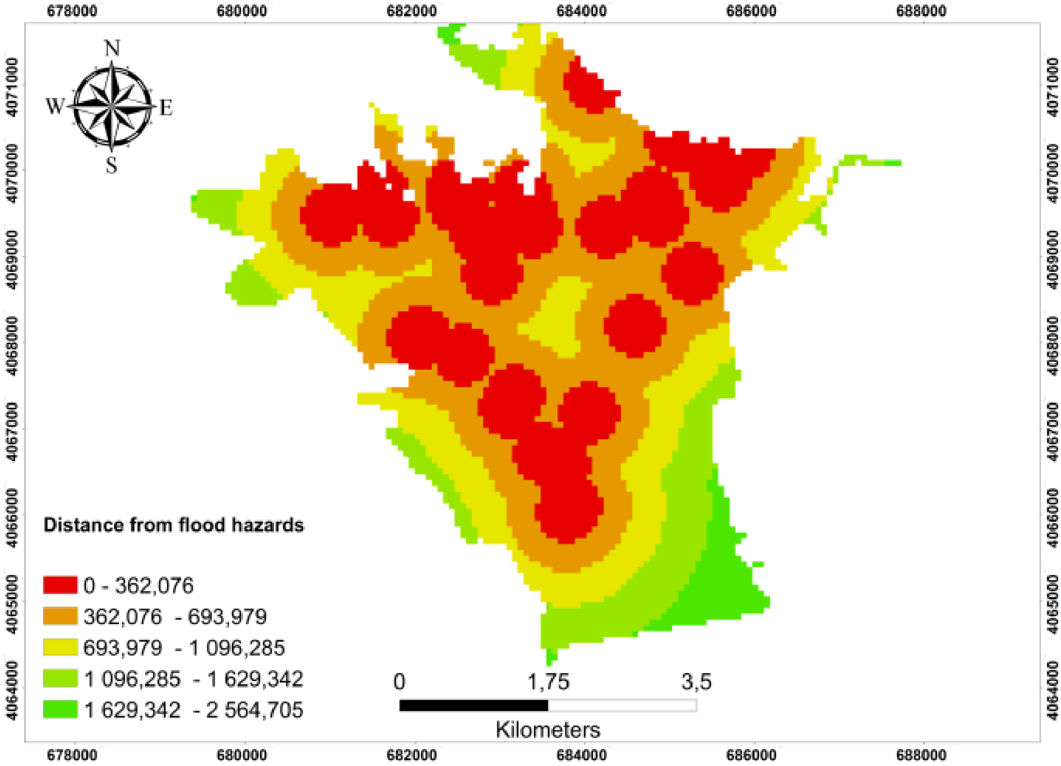

Figure 8 Result of the flood zone distance criterion

2.2.1.2.4 Aspect (orientation):

In architecture and urban planning, orientation is the arrangement of a building's plans relative to the points of the compass based on a variety of variables such as site topography, property rights-of-way, safety considerations, and so on.

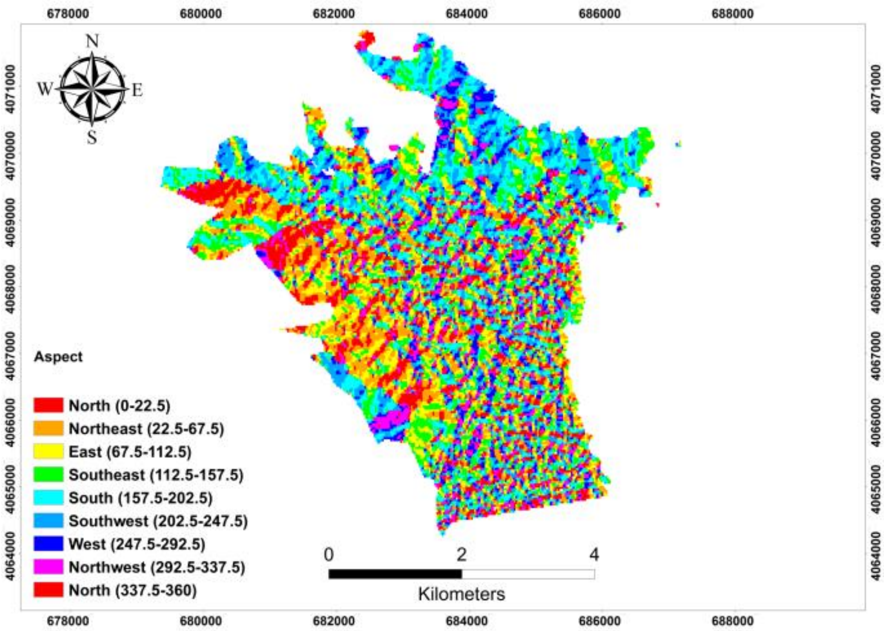

Figure 9: Aspect criterion result

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2.2.1.2.5 NDVI (Normalized Difference Vegetation Index):

The Normalized Difference Vegetation Index (NDVI) (Rouse and Haas, 1973; Tucker, 1979) is a measure of the density of vegetation in an urban environment. The Normalized Difference Vegetation Index (NDVI) is a measure of vegetation cover-abundance. This measure is represented by standardized values from -1 to 1. ***It*** is constructed from the red (R) and near-infrared (PIR) channels. The NDVI index is a standardized index used to generate an image displaying vegetation cover (relative biomass) and calculating greenness (vegetation quantity). It compensates for changes in lighting conditions, surface slope, exposure and other exogenous factors (Lillesand 2004).

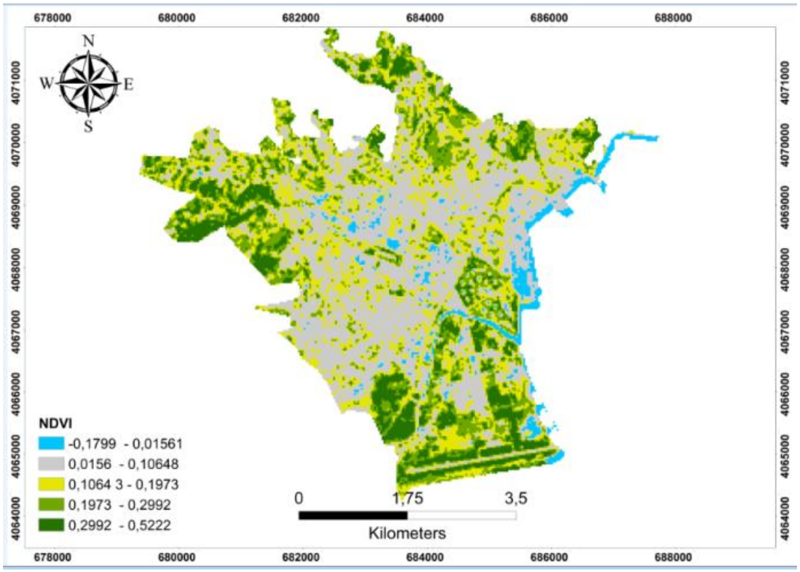

Figure 10: NDVI criterion results

2.2.1.3 Accessibility index

Preserving land resources helps to limit urban sprawl, to make the most of existing services, and, above all, to reallocate land that has already been urbanized, both on an urban scale and on an architectural scale, by encouraging building density. respect for the well-being of users and environmental constraints (reduction of local emissions of atmospheric pollutants and traffic noise), implies the need to restrict the use of private cars.

This corresponds to the large expansion of public transportation or shared services, which is contingent upon the conurbation of financial resources.

2.2.1.3.1 Distance to terminals:

Proximity criteria are assessed by measuring the distance separating the nearest equipment from the main entrances of apartment buildings to the terminals (bus stops). From a sustainable development point of view, this proximity also contributes to indirectly reducing

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car dependency, by offering the possibility of walking to meet the needs of children and students. Reference values are calculated on the basis of average travel time, taking into account an average walking speed of 1 meter per second (Bridel 1998).

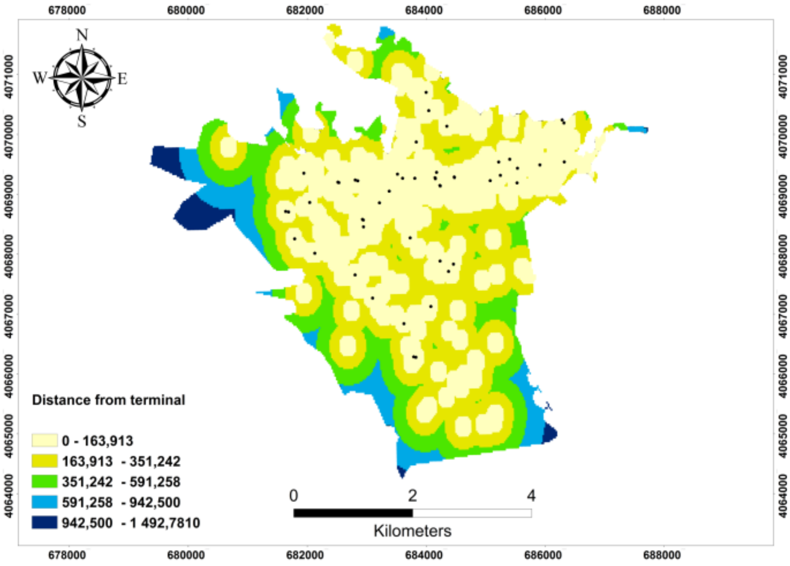

Figure 11: results of distance to terminal criterion

2.2.1.3.2 Distance from roads:

3 Urban renewal and brownfield redevelopment projects have the potential to contribute to the reduction of energy consumption associated with transportation, as they are integral parts of a coordinated strategy that combines urban development with the enhancement of sustainable mobility networks. The objective is to decrease reliance on private vehicles and promote alternative modes of transportation. A key aspect of this strategy involves establishing effective public transportation systems and improving connectivity within urban areas.

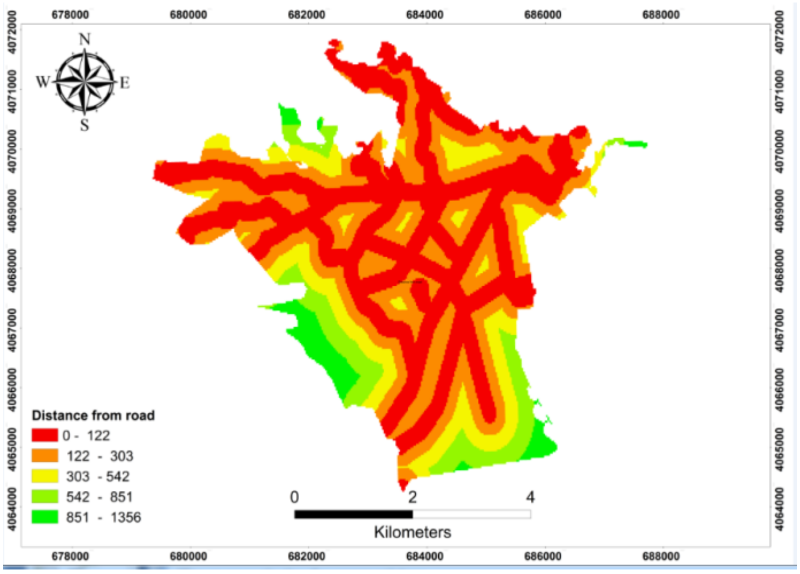

Figure 12: Results of the distance-to-roads criterion

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3.1.1.1.1 Distance to equipment:

An integral part of the elements that contribute to the quality of life in an urban environment, as they promote rapid access to facilities that enable city dwellers to recharge their batteries and access services that meet their daily needs. The locations under consideration encompass various public amenities, including parks, forests, and lakes, as well as cultural establishments such as museums, theaters, and sports facilities.

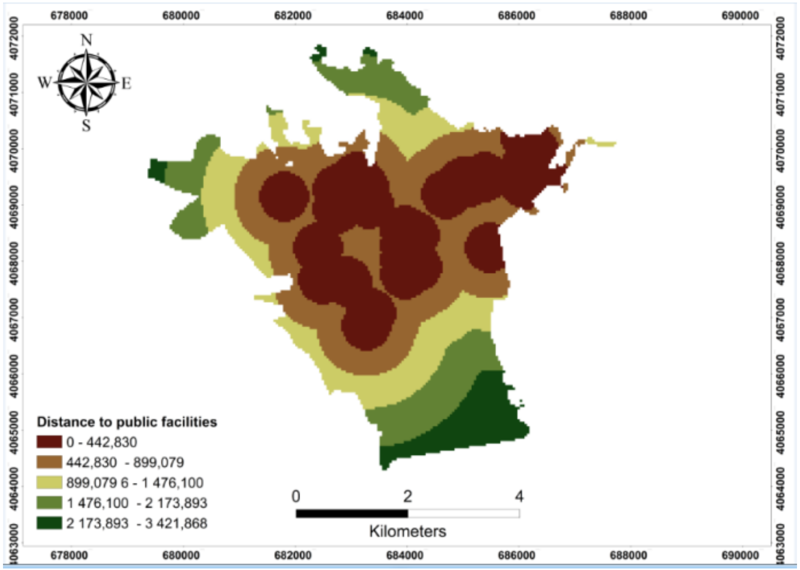

Figure 13:result of distance-to-equipment criterion

3.1.1.2 Social and economic index

3.1.1.2.1 Urban density

The consideration of human resources is also crucial in the context of sustainable urban development. A high population density often signifies a significant demand for land resources for the effective implementation of urban development initiatives.

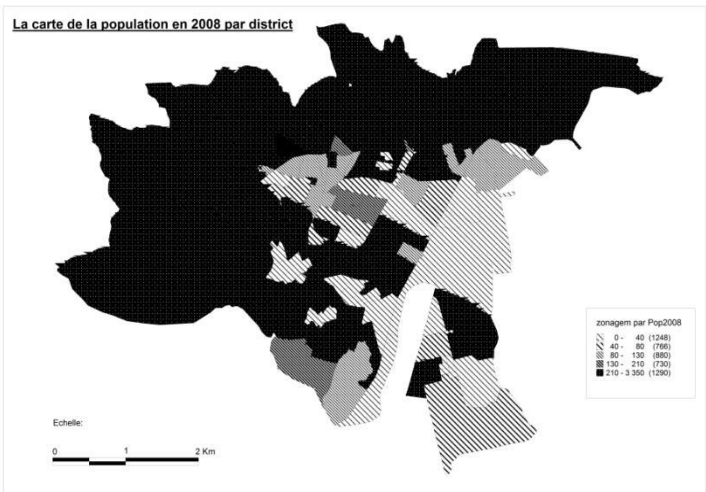

Figure 13.: Population density result

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3.1.1.2.2 Zone dynamics :

Mixed use in a neighborhood is represented by a balance between working and living spaces, better integration between different social groups, and stability in terms of social cohesion (SIA 2004a). This criterion is in line with the long-term balance objective underpinning the concept of sustainable development. The mixed-use criterion will be analyzed from two angles: functionally, by looking at it qualitatively, and by analyzing the share of different types of activity; at the same time, the evaluation will also focus on the potential for social mix, by analyzing the diversity favoring a mix of socio-professional classes, households, and generations.

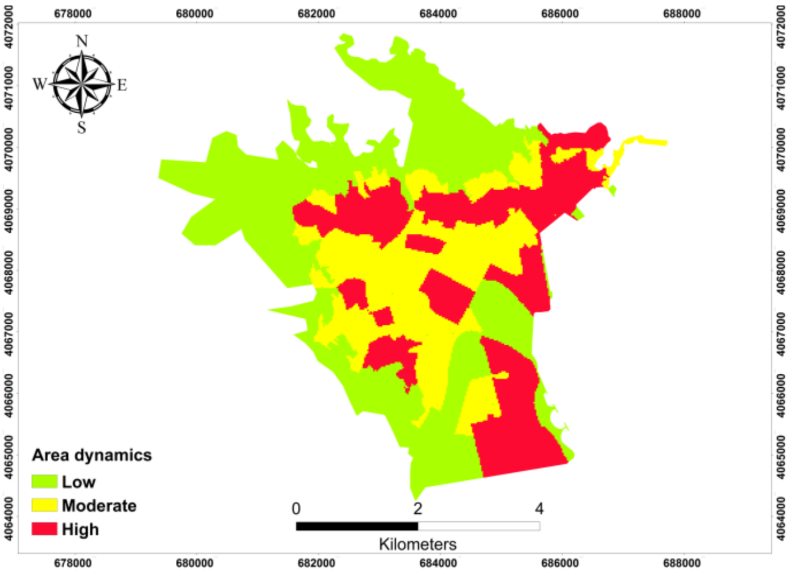

Figure 14: Results of the zone dynamics criterion

3.1.2 Categorization and standardization of assessment criteria

Standardization or normalization of criteria is the process of calculating the relative importance of each criterion (SAATY, 1984). This technique is used to translate various entrances to a decision problem onto a common scale, to be able to integrate several factors (qualitative and quantitative) into the model it is necessary to make them comparable and to overcome the incommensurability of data (Rahman et al, 2012). In this regard, the standardization of factors was established on the foundation of the concept of fuzzy logic (Fuzzylogic) in order to formulate the applicability of various elements on a common scale between 0 and 1.

The new Arcgis10.2 functionalities in the operator (Fuzzy membership) have been introduced into the spatial modeling of land apt to be reused to standardize the criteria in the same scale in order to measure them on the one hand zones favorable to urbanization and urban renewal and determine the layer of each factor that indicates the degree of suitability of each unit of space for the development of land resources. and convert the semantic description of land

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regeneration into a digital spatial prediction model on the other hand. This will result in a series of maps associated with a weighted linear combination.

3.1.3 Weighting of assessment criteria and combination of layers:

The next phase of the multi-criteria evaluation consists in comparing and assigning weights to the factors, in order to determine the importance of their contribution to solving the problem. This is done using the AHP method of (SAATY, 1980). This is the most basic method of weighing all the factors. The criteria designated in the hierarchical multi-criteria formulation determine the quality of the objective's achievement, using the various indicators linked to the land's reusability for urbanization purposes.

A matrix of pairwise comparison ratios (Saaty Matrix) is obtained by comparing these indicators and defining the importance of each for the others using the AHP (Analytical Hierarchy Process) method.

Schéma de comparaison par paire au sein de l'AHP

$$A = [r_{ij}] = \begin{bmatrix} 1 & r_{12} & \cdots & r_{1j} \\ 1/r_{12} & 1 & \cdots & r_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ 1/r_{1j} & 1/r_{2j} & \cdots & 1 \end{bmatrix}$$

Source : Matrice de comparaison de thomas SAATY (1984)

Figure 15thomas Saaty's comparison matrix

The figure above shows the pairwise comparison within the AHP. The degree of importance is determined by comparing each pair of criteria and assigning them a weighting coefficient rij according to the SAATY value scale of 1 to 9; weights are assigned for each pair of factors to obtain the ratio and degree of importance of each of the criteria. Once the weights have been determined, the CLP (Weighted Linear Combination) technique is used to combine the layers of the model, according to their weights. This technique simply involves multiplying each standardized factor by its weight, then adding them together. The sum is divided by the number of factors.

4. application of the Hierarchical Multicriteria Method (HMM) to the case study:

Table 1Results of criteria standardization

criteria	the result
C1: Distance from roads	**0.12108**
C2: Zone dynamics	0.07879
C3: distance from watercourse	0.05938
C4: NDVI	0.09802

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C5: Land use	**0.18776**
C6; Population (density)	0.06518
C7: Distance to equipment	0.10176
C8: distance to terminals	0.07879
C9: elevation	0.05587
C10: slope	0.04521
C11: appearance	0.07653
C12: flood zone	0.03157

Table 2:Pairwise comparison matrix, factor weights

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	weight	%
C1	1	1	4	3	1/3	2	1	1	6	5	3	4	**0.12108**	**12.1**
C2		1	3	2	1/3	1	1	1	5	3	2	3	0.07879	7.8
C3			1	1	1/6	1/2	1/3	1/3	2	1	1	1	0.05938	5.9
C4				1	1/5	1	1/2	1/2	3	1	1	5	0.09802	9.8
C5					1	4	3	3	8	6	6	5	**0.18776**	**18.7**
C6						1	1	1	4	2	2	3	0.06518	6.5
C7							1	1	1	4	4	6	0.10176	1.0
C8								1	5	3	2	3	0.07879	7.8
C9									1	1/2	1	1/2	0.05587	5.5
C10										1	1	1	0.04521	4.5
C11											1	1	0.07653	7.6
C12												1	0.03157	3.1

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3.1.4 Consistency check

According to Saaty's criteria, if the consistency ratio (CR) exceeds 0.1, there is inconsistency in the pairwise comparisons, necessitating a re-evaluation of the resulting comparison matrix. In our case study, we applied pairwise comparisons for the criteria and calculated the random index (IA) and the consistency ratio (CR), which yielded a CR value of < 0.1. Since the consistency ratio is less than 0.1, we can conclude that the judgments made in assessing the criteria were consistent.

Table 3:Random index as a function of the number of criteria

N	5	6	7	8	9	10	11	**12**
IA	1,12	1,24	1,32	1,41	1,45	1,49	1,51	**1,54**

Source: Table of random indices by SAATY (1980)

4 Results and discussion

The use of multi-criteria analysis method (fuzzy AHP) combined with geographic information systems (GIS) provided a decision-making aid for assessing the suitability of potential land for sustainable renewal and prioritizing potential sites for sustainable renewal.

The main cartographic output of this study is a global synthesis map generated following a decision-making process that included modeling the information layers, converting the layers to raster, calculating the relative weights of the criteria using the AHP method, and integrating their weights into a GIS for aggregation. We were able to categorize the research region on a scale of 3 to 9, with a pixel having a high value referring to an optimal zone for opening up to urbanization, as a consequence of aggregating the several criteria maps according to their weights. Additionally, the AHP calculation of weights reveals that land occupation and use (in other words, the land itself) is rated by experts as the most important factor for urban renewal and land use for urbanization at 18.7%, followed by site accessibility (distance to roads, etc.) at 12.1%, NDVI at 9.8%, are dynamics and distance to terminals at 7.8% and aspect at 7.8%.

The consistency ratio calculated in pairwise comparisons is RC = 0.03 (value <0.10), indicating that the basic judgment is reasonably consistent.

On the basis of the basic weights resulting from the pairwise comparison, we can see that the hierarchy in the importance of the criteria established by this approach is preserved as far as possible. We can therefore see that the most important criteria remain land use and occupancy as an environmental index, and accessibility and mobility. The next most important factors are

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the technical aspects of the land, i.e. its natural and topographical characteristics. Distances to infrastructure: facilities and terminals, and the urban density and dynamics of the area.

To confirm our findings in our case study, the analysis must show the degree to which this classification of land suitability is caused by discrete elements or whether it confirms the overall concordance of the parameters and weightings used. From this point of view, multi-criteria evaluation with spatial reference has helped us to highlight the territorial entities on which we should focus our efforts to ensure the rational development and use of land resources.

In the area studied, the multi-criteria aggregation (weighted sum method), based on the calculated weights of the twelve sub-criteria according to the SAATY method, enabled us to distinguish five differentiated spatial units shown on the overall summary map (figure 6). The classification was carried out according to expert opinion, after overlaying with previously collected basic thematic data, including Bejaia's land-use master plan (PDAU), and also after reconciliation with the reality on the ground by juxtaposition with Google Earth images, which brought out five index class categories (medium to high).

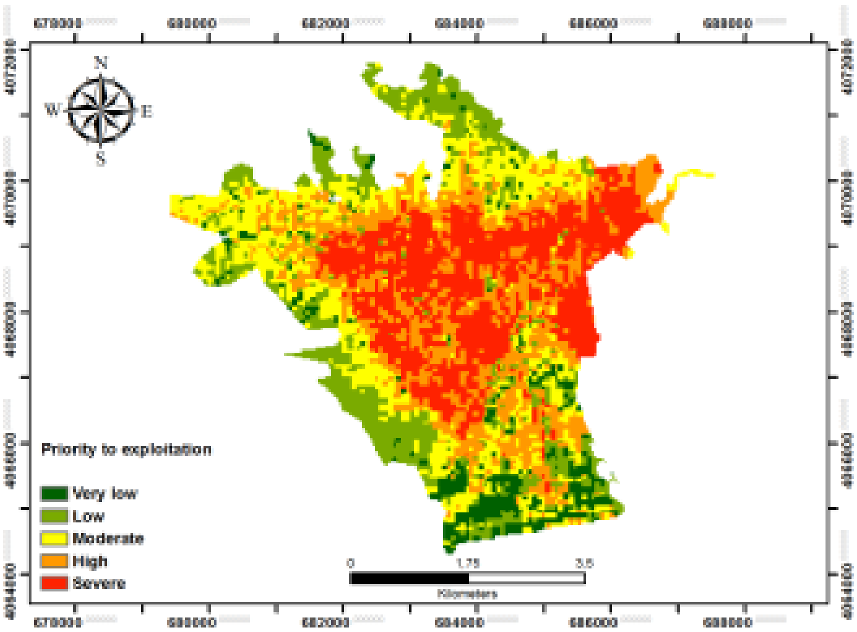

Figure 16:map summarizing the superposition of the various criteria

The legend on the resulting synthesis map shows the values of the aggregated different parameters, organized into five classes ranging from the first rank to be protected or excluded from urbanization priority to the fifth rank suitable for urbanization.

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The final results obtained for the urban development priority map reveal that the potential sites for urban development and therefore sustainable urban renewal are properties characterized by urban wasteland close to infrastructure zones. This is in line with the resulting weights of the criteria after weighting by pairwise comparison.

On the overall summary map, the priority land for regeneration for sustainable urban planning is not very favorable beyond the outskirts of the centers, given the technical aspect of the soil (PNG protected zone) for land development and the distance from infrastructures that are

Most of these developments are concentrated in the urban centers and on the southern side of the city, as this is a flood zone. In addition, the PDAU guidelines do not favor urban development in this area.

The few favorable zones on the outskirts of town centers are located in reserved areas that are not urban, but rather agricultural or strategic reserves housing economic or tourist activity areas.

In order to control urbanization and maximize the utilization of untapped land resources, the summary map of priority land for urbanization created using this method can be used as a fundamental tool for prospecting regions to be endowed by urban planning or development plans. Thus ensuring an alternative to the sustainable renewal of the city on itself through the regeneration of already-used land. Of course, the combination of GIS and AHP is considered one of the best decision-making tools for regional planning.

4.1 Discussion

This research focuses on the assessment and prioritization of soil regeneration for sustainable urban renewal in small-scale urban areas.

The primary objective and scope (categories) of the evaluation criteria are indicative of this emphasis. Firstly, these identified criteria cover not only the physical and occupational attributes of the land but also the legal and cultural considerations of land use, as well as sustainability considerations. (i.e. environmental, social, and economic perspectives). Secondly, certain criteria, notably those relating to land-use accessibility and compatibility, emphasize small-scale (site-level) land-use planning for urban renewal projects. Thanks to advances in computer science, advanced systems such as GIS and MCDA can help planners manage the growing complexity of land-use decision-making. In this instance, GIS and MCDA have complemented each other very well. On the one hand, GIS technologies and processes play an important role in the analysis of decision problems. On the other hand, MCDA offers a wide range of methods and approaches for organizing decision issues and creating, ranking, and evaluating choice alternatives (Malczewski, 2006). Experimental testing indicates that the system is likely to be helpful in supporting planning decisions for

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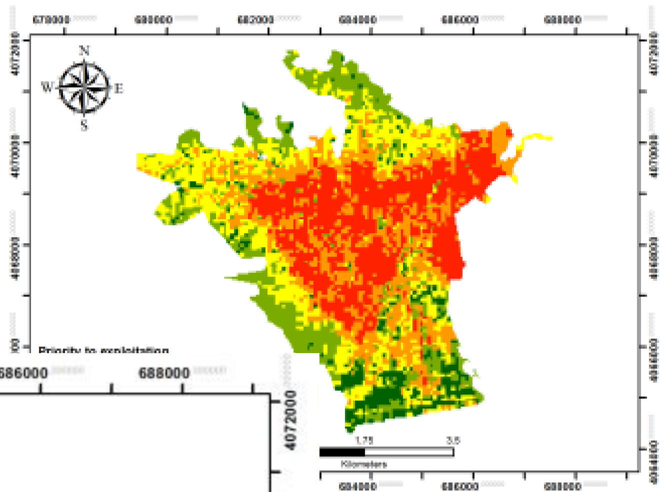
site reuse in the urban renewal process. Suitability analyses have provided planners with a quantitative and objective reference to improve their decision-making processes, which currently rely heavily on subjective and qualitative judgments. In addition, our experiment can serve as a prototype decision support system for sustainable urban renewal (rebuilding the city on itself). The Urban Regeneration Priority Soil Analysis Grid was developed using MCDA, AHP, and GIS, providing planners with a clearer, more comprehensive framework for understanding the suitability of land/sites in urban renewal areas and enabling more sustainable land use and priority decisions. In addition to furthering sustainability and its immediate application, this combination of decision-support methods enables planners to convey their ideas visually to the local community and all city stakeholders.



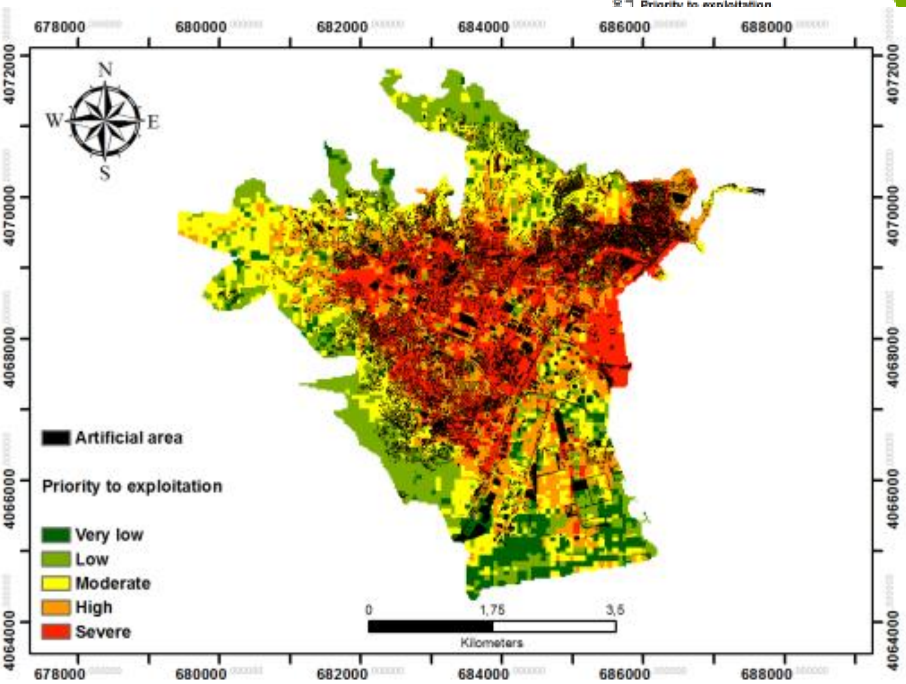


Figure 17:summary map of priority sites for reuse

Conclusion

Our contribution has made it possible to formalize an approach for building an assessment of land mobilization as part of urban planning.

This approach can be applied to issues other than the evaluation of land use according to urban planning documents. It has three main features. The first is that the model incorporates

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important factors that reflect the perception of land resource planning, in line with the method developed by SAATY. To this end, we have chosen a multi-level hierarchical model. The second distinctive feature of the approach is its use of aggregation methods, enabling us to express synergies between several criteria. In the evaluation of preferences, wherein we construct instances to get the utility vector of each vector of alternatives and then sort them in order of decreasing utility, it additionally incorporates other, more specialized elements.

These new vectors are then summed and weighted by predefined coefficients. The third particularity of the approach is the integration of a GIS for the representation of geographical data, the modeling of information by theme, and the classification of the results obtained on maps.

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