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A Mathematical Framework for Identifying Suitable Locations for Green Hydrogen Infrastructure: Two Case Studies of Energy-Intensive Industries

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The transition to low-carbon energy systems has intensified interest in green hydrogen as a strategic energy vector. This paper, using a mathematical model, proposes a quantitative framework for assessing the feasibility of Green Hydrogen Infrastructure (GHI) in urban areas. Technical, economic, environmental, and social criteria are structured hierarchically and weighted through the Analytic Hierarchy Process (AHP), ensuring consistency in pairwise comparisons. The resulting weights are integrated within a Geographic Information System (GIS) to generate suitability maps via weighted spatial overlay. The methodology is applied to the "Italcementi plant" in Matera and the "Cementeria Costantinopoli plant" in Barile (Basilicata, Italy). Spatial indicators describing renewable energy potential, infrastructure accessibility, and hydrogen demand are parameterized within the decision model. The resulting suitability surfaces identify optimal locations while demonstrating the robustness and reproducibility of the proposed AHP–GIS framework for sustainable energy infrastructure planning

Keywords and phrases: Analytic Hierarchy Process (AHP), Geographic Information System (GIS), Energy-Intensive Industries; Green Hydrogen Infrastructure (GHI).

AMS subject classification: 68W20, 05A05.

1 Introduction

The transition to low-carbon energy systems poses complex decision-making problems involving technological, environmental, economic and spatial variables [1]. In industrial contexts, particularly in energy-intensive sectors, the decarbonisation process requires the identification of optimal infrastructure configurations capable of ensuring efficiency, sustainability and resilience. The growing urgency of climate change mitigation policies has accelerated the adoption of renewable energy sources (RES) and stimulated interest in alternative energy carriers capable of supporting sectors where direct electrification is not feasible [2].

Among these alternatives, green hydrogen has emerged as a strategic energy carrier [3]. Produced through electrolysis powered by renewable electricity, it enables a low-emission energy cycle and offers significant potential for hard-to-decarbonise industries and heavy transport systems. However, the deployment of hydrogen infrastructure involves multidimensional constraints, including spatial accessibility, energy availability and proximity to demand centres.

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These factors require structured decision support methodologies capable of integrating heterogeneous criteria.

This study elaborates the location of green hydrogen infrastructure (GHI) as a spatial multi-criteria decision analysis (MCDA) problem. The decision-making framework is structured hierarchically, defining criteria and sub-criteria belonging to the technical, economic and environmental domains. The analytical hierarchy process (AHP) is used to derive priority weights through pairwise comparison matrices, eigenvector estimation and consistency checks. The resulting normalised weights are incorporated into a geographic information system (GIS), where spatial datasets are standardised and combined using weighted linear aggregation to produce suitability functions for the study area using highly symmetric generalized circulant permutation matrices [4]. The result is the development of suitability maps representing the spatial distribution of optimal locations for hydrogen production, storage and distribution facilities. The proposed framework is applied to two industries in Basilicata (Italy), focusing on the cement plants: "Italcementi" in Matera and "Cementeria Costantinopoli" in Barile. The integration of AHP-based weighting with GIS spatial modelling provides a reproducible and mathematically sound decision support tool for infrastructure optimisation in industrial decarbonisation pathways.

The rest of the paper is organised as follows. Section 2 presents the methodological formulation of the MCDA-GIS framework. Section 3 describes its application. Section 4 discusses the results and implications for industrial energy system planning.

2 Methodology

The land suitability evaluation for Green Hydrogen Infrastructure (GHI) siting can be formulated as a spatial decision problem, requiring the simultaneous consideration of heterogeneous criteria defined over a geographic domain [5, 6, 7]. A critical step in this process is the formal identification and hierarchical structuring of decision criteria, as the selection of variables and their relative influence directly affects the stability and reliability of the suitability function.

Multi-Criteria Decision-Making (MCDM) methods provide a mathematical framework [4] for solving decision problems involving both quantitative and qualitative variables. Within this class of methods, the Analytic Hierarchy Process (AHP) is widely adopted due to its ability to decompose complex decisions into hierarchical levels and to derive a priority weight vector through pairwise comparison matrices, eigenvector estimation, and consistency ratio verification.

The integration of AHP within a Geographic Information System (GIS) enables the formulation of a Spatial Multi-Criteria Analysis in which standardized spatial indicators are combined through weighted linear aggregation to produce continuous suitability surfaces. This hybrid AHP–GIS framework is well established in the literature [8, 9, 10, 11, 12] as a robust decision-support tool for renewable energy siting problems.

Nevertheless, applications specifically addressing GHI localization remain limited [11, 12]. This is primarily due to the methodological challenges associated with defining an appropriate criteria set, constructing consistent comparison matrices, and deriving reliable weight vectors capable of representing complex spatial and industrial constraints.

2.1 Analytic hierarchy process

The Analytic Hierarchy Process (AHP), originally developed by Thomas Saaty in the 1980s [13] and later formalized as an axiomatic decision theory [14], is a measurement methodology based on ratio scales that enables the evaluation and ranking of alternatives with respect to defined criteria and sub-criteria [15]. Through pairwise comparisons, AHP reduces the complexity of decision problems by structuring them into a hierarchical framework.

The method begins with the identification of the overall objective (goal), followed by the definition of criteria, sub-criteria, and decision alternatives. This decomposition phase transforms the decision problem into a multi-level hierarchical structure, allowing the relationships among variables to be systematically organized. By partitioning the problem into component elements and reassembling them hierarchically, the decision-maker can evaluate each component according to its contribution to the overall objective.

Within the hierarchy, higher levels conceptually dominate lower levels. Elements belonging to the same level are compared pairwise with respect to an element at the immediately superior level using a reciprocal ratio scale. The decision-maker is required to express a preference between elements; indifference is permitted, whereas undefined or infinite preference is not. This assumption ensures the comparability of elements and supports the derivation of consistent priority measures.

The outcome of each pairwise comparison is the dominance coefficient c_{ij}, which expresses the relative importance of element i with respect to element j at the same hierarchical level. When quantitative evaluation is not feasible, qualitative judgments may be expressed using Saaty's semantic scale (Table 1), which associates the first nine integers with levels of relative importance [16]. This scale enables the conversion of qualitative assessments into quantitative values suitable for matrix-based computation.

Score	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Judgment slightly favors one activity over another
5	Strong importance	Judgment strongly favors one activity over another
7	Very strong importance	An activity is favored very strongly over another
9	Extreme importance	Favoring one activity over another is of the highest affirmation
2,4,6,8	Intermediate values	A compromise is needed

Table 1: Saaty semantic scale.

The pairwise comparisons are organized into a comparison matrix C_x, whose structure is shown in Equation (1):

$$C_x = \begin{bmatrix} C_{11} & \cdots & C_{1n} \\ & & \ddots \\ C_{n1} & \cdots & C_{nn} \end{bmatrix} \tag{1}$$

The matrix is square of order n, where n represents the number of compared elements. Each element C_{ij} expresses the relative importance of criterion C_i over C_j. The comparison matrix satisfies the following properties [4]:

a) square structure, with dimension equal to the number of criteria or sub-criteria;

b) positivity, $C_{ij} > 0$ for all i, j, with unity along the main diagonal ($C_{ii} = 1$);

c) reciprocity, $C_{ij} = 1/C_{ji}$.

Once the pairwise comparison matrices have been constructed at each hierarchical level, priority weights must be derived. Weight estimation represents a fundamental step, as it quantifies the relative importance assigned by the decision-maker to each element. Weights are normalized so that their sum equals unity, ensuring comparability across criteria.

A common procedure consists of normalizing each column of the comparison matrix and computing the arithmetic mean of each row to obtain the weight vector [17]. Normalization is performed by dividing each matrix element by the sum of its column.

Judgments expressed in pairwise comparisons may introduce inconsistencies. Empirical applications have shown that inconsistency tends to increase as matrix order grows, due to the higher number of comparisons required. Within the AHP framework, the consistency of judgments is evaluated through the Consistency Ratio (CR), with an acceptable threshold conventionally set at 10%. Values exceeding this limit suggest revising the comparisons and reconstructing the matrix.

The Consistency Ratio is defined as the ratio between the Consistency Index (CI) and the Random Consistency Index (RCI). The CI is computed as shown in Equation (2):

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{2}$$

where $\lambda_{\max}$ denotes the principal eigenvalue of the comparison matrix in Equation (1). To estimate $\lambda_{\max}$, the priority weight vector $w$is first obtained from the pairwise comparison matrix. A new vector $y$is then derived, and the ratios between corresponding components of $y$and $w$form the Consistency Vector (CV). The principal eigenvalue is calculated as the average of the components of the Consistency Vector, as shown in Equation (3):

$$\lambda_{\max} = \frac{CV_1 + CV_2 + \cdots + CV_n}{n} \tag{3}$$

The Random Consistency Index (RCI) depends on the matrix order $n$and is reported in Table 2.

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 2: RCI values

2.2 A mathematical framework and case study application

In Spatial Multi-Criteria Analysis (SMCA) i.e. our mathematical framework [4], the hierarchical decision structure is operationalized at the levels of criteria and sub-criteria, which are represented as geographically referenced variables [18]. Within this framework, the Analytic Hierarchy Process (AHP) can be fully integrated into a Geographic Information System (GIS), enabling the simultaneous management of priority weights and spatial datasets. Each criterion is translated into a thematic map describing the spatial distribution of its values across the study area.

Decision alternatives are therefore represented explicitly in geographic space. Spatial information may be encoded either as raster layers covering the entire domain or as vector features (points, lines, or polygons), depending on data structure and analytical requirements. After standardization of the cartographic layers, the corresponding criterion weights derived from AHP are applied through map algebra procedures. This weighted linear combination produces a composite suitability function that assigns an overall score to each spatial unit. This integrated procedure is commonly referred to as the Spatial AHP approach [18].

The proposed SMCA framework is applied to identify suitable locations for Green Hydrogen Infrastructure (GHI) serving energy-intensive industrial facilities in the Basilicata region (Italy). The methodological workflow, summarized in Figure 1, includes study area analysis, identification of criteria and constraints, weight derivation, spatial overlay, and generation of land suitability maps. The resulting suitability surfaces support the identification of optimal siting solutions consistent with spatial constraints and industrial energy demand.

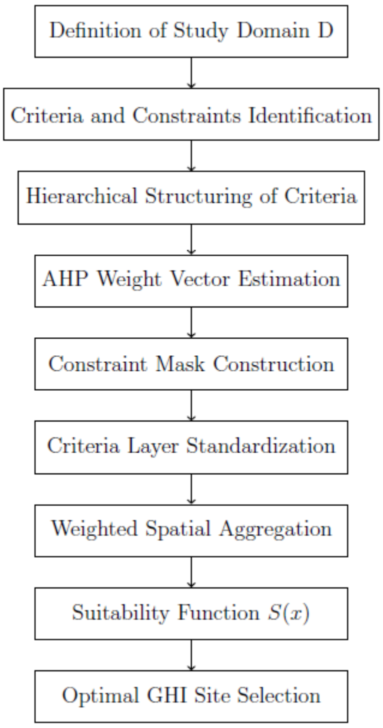

Figure 1: Workflow of the Spatial Multi-Criteria Analysis.

3 Case studies

3.1 Application of the methodology for industry "Italcementi"

The first case study is "Italcementi S.p.A.", a company that has been part of the HeidelbergCement Group since 2016 and a leader in Italy and in the world for building materials. Today it has about 40 offices throughout the nation, but its origin is in Scanzo in the second half of the 19th century with the aim of producing cement and hydraulic lime. The first firing was ground by a miller in a water mill, producing hydraulic cement with extraordinary properties. From the beginning, Italcementi expressed a propensity towards technical progress, with the conception of new products and towards sustainable development. The energy-intensive industry examined for this work is located in Basilicata, precisely in the municipality of Matera. To carry out a more detailed analysis, for the identification of sites suitable for the installation of GHI systems, it was also necessary to include the neighboring municipalities, both Lucanian and Apulian: Altamura, Ginosa, Gravina in Puglia, Grottole, Irsina, Laterza, Miglionico, Montescaglioso and Santeramo in Colle. The study area show extends for 2328 km^2. Constraint criteria were identified through a review of the scientific literature [19, 20, 21, 22, 23] and an analysis of regulatory and environmental restrictions present within the area. This process resulted in a spatial mask distinguishing constrained zones from areas potentially suitable for infrastructure development. Following the procedure adopted in previous studies, restricted areas were separated from available land according to legal, environmental, and protection constraints. Urbanized zones were also classified as restricted and therefore excluded from the analysis. The selection of criteria and sub-criteria represents a critical step in determining the reliability of the final suitability assessment. Their identification was informed by literature review and consultation with domain experts. Three primary criteria were adopted - technical, economic, and environmental - as summarized in Table 3.

Main Criteria	**Sub-Criteria**
Technical	Slope
	Solar radiation
Economic	Distance of roads
	Distance of industry
	Distance of RES
	Distance of GAS pipelines
Environmental	Land use

Table 3: Identification of criteria and sub-criteria.

The application of AHP as described in section 2.1 resulted in the matrix of comparisons shown in Table 4. The last column of which represents the vector of weights of the individual sub-criteria.

The consistency check is satisfied, as shown in Table 5.

To support the identification of suitable locations for green hydrogen infrastructure, a spatial analysis was conducted by overlaying normalized datasets associated with the defined criteria within a GIS environment. Each sub-criterion was represented as an individual thematic layer, resulting in seven levels of spatial analysis. These layers included solar radiation, slope, distance from highways, proximity to industrial demand nodes (Italcementi), availability of renewable energy sources (RES), proximity to gas pipeline networks, and land use characteristics. Table

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	w_i (%)
C_1	1,00	0,20	0,50	0,14	0,25	0,33	0,20	3
C_2	6,00	1,00	5,00	0,50	3,00	4,00	2,00	24
C_3	2,00	0,20	1,00	0,17	0,33	0,50	0,25	5
C_4	7,00	2,00	6,00	1,00	4,00	5,00	3,00	34
C_5	4,00	0,33	3,00	0,25	1,00	2,00	0,50	11
C_6	3,00	0,25	2,00	0,20	0,50	1,00	0,33	7
C_7	5,00	0,50	4,00	0,33	2,00	3,00	1,00	16

Table 4: Pairwise comparison matrix and weights of sub-criteria.

$\lambda_{\max}$	N	CI	RCI	CR	CR (%)
7,61	7	0,10	1,32	0,08	7,70

Table 5: Consistency check.

6 summarizes the type, description, and data source associated with each sub-criterion.

Sub-Criteria	**Data**	**Type of layer**	**Source**
Slope	Digital Terrain Model (DTM)	Raster	Regional Spatial Data Infrastructure of Basilicata (RSDI)
Solar radiation	Digital Terrain Model (DTM)	Raster	RSDI
Distance of roads	Road network	Vector	RSDI
Distance of industry	Industrial lots	Vector	RSDI
Distance of RES	Industrial lots	Vector	RSDI
Distance of GAS pipelines	GAS distribution network	Vector	RSDI
Land use	Corine Land Cover	Vector	European Union, Copernicus Land Monitoring Service 2018, European Environment Agency (EEA)

Table 6: Data collection and their sources.

The selected sub-criteria were modelled as spatial variables representing the technical feasibility, economic accessibility, and environmental compatibility of potential locations for Green Hydrogen Infrastructure (GHI). Among the technical factors, solar irradiance was considered the primary indicator of renewable energy availability, as solar power represents the energy source assumed for hydrogen production in this study. Spatial variability in solar radiation was derived from terrain morphology, enabling the assessment of energy potential across the study domain. Higher irradiance values indicate greater suitability due to increased renewable energy yield.

Terrain slope constitutes the second technical variable. This parameter influences both the installation efficiency of photovoltaic systems and infrastructure deployment. Areas characterized by low slope values are preferred, as they facilitate plant construction, transport logistics, and pipeline routing.

Economic criteria were represented through accessibility and infrastructure proximity indicators. Road accessibility was modelled through travel-time analysis, reflecting the efficiency of hydrogen transport by heavy vehicles. Accessibility to industrial demand nodes was similarly evaluated to ensure proximity between production sites and end-use facilities. In addition, proximity to gas pipeline networks was considered to support future hydrogen blending and distribution. Distance from renewable energy sources was also incorporated, reflecting the need to ensure reliable and continuous energy supply for electrolysis processes.

Environmental compatibility was assessed through land-use classification. After excluding legally constrained areas, available land was categorized according to suitability levels. Industrial areas and brownfield sites were considered highly suitable, while agricultural and green areas were assigned lower suitability levels in order to minimize environmental impact. Each sub-criterion was represented as a spatial variable $c_i(x)$, normalized to ensure comparability and integrated within the decision framework through AHP-derived weights. The resulting set of standardized variables constitutes the input for the computation of the land suitability function.

3.2 Land suitability map

Following normalization and weighting, the spatial variables were aggregated through the suitability function $S(x)$, producing a continuous surface that identifies the locations most suitable for the deployment of green hydrogen infrastructure. The resulting suitability map (Figure 2) represents the spatial distribution of areas that best satisfy the technical, economic, and environmental requirements for green hydrogen production and distribution facilities.

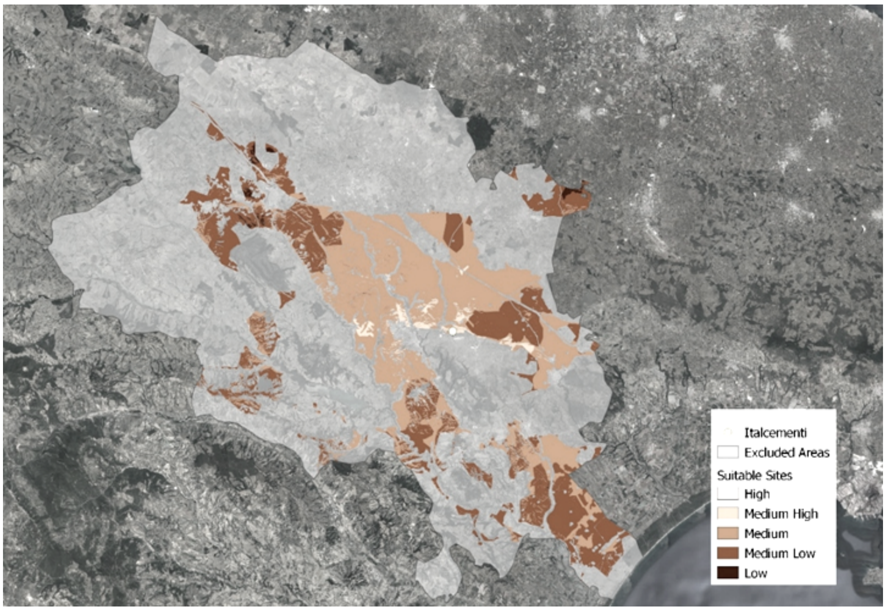

Figure 2: Land suitability map.

The suitability distribution indicates that a large portion of the study domain falls within the medium suitability class, while areas classified as medium–high suitability are primarily concentrated in proximity to the Italcementi plant. Approximately 54% of the available land is categorized as moderately suitable, compared with about 43% classified as low to moderately suitable. These results confirm the significant influence of the selected criteria in determining spatial suitability patterns.

High-suitability areas adjacent to the Italcementi facility extend over approximately 160 hectares, representing a spatial extent adequate for the potential installation of green hydrogen production and distribution systems.

3.3 Application of the methodology for the industry "Cementeria Costantinopoli"

The second case study is "Cementeria Costantinopoli", the company, officially established in 1990, began its evolution starting from the business activity of cultivation of pozzolana started in the early sixties. The increasingly consistent demand for pozzolan coming from the cement industries, in fact, has led to the creation of the latest generation plants for the production of clinker and cement. To improve the environmental impact, the company adopts an integrated management system functional both to improve product performance and to maintain environmentally compatible standards. The excellence of the raw materials, the continuous monitoring, and the constant control of the production process allow us to produce cement with constant yields in a sustainable way. In this case, the industry site is located in the Basilicata region and precisely in Barile municipality. Like previous cases, in aim to do a comprehensive study, we consider also the surrounding municipalities of Barilis inith it which are seven municipality as follow (Figure 29), Melfi, Rapolla,Venosa, Ginestra, Ripacandida, Atella and Rionero in Vulture. The study area covers 584 km^2. The first step in spatial analysis is to create the exclude map like two previous cases. Also, here we considered three main lands as excluded areas, which are mainly urban areas, areas that are restricted by laws, and protected areas. Compare to other cases, the percentage of restricted areas is noticeably less, so there is more possibility to implement the GHI. The last column of Table 7 is contain the weights of each sub-criteria. As the industrial site in Barile is the end user of green hydrogen, so the highest value is dedicated to C4 which is the distance from the industrial site. Secondly, the technical criteria (C1, C2) take the higher percentages regarding the aim of sustainability of this work, as the main source of producing hydrogen is photovoltaic, the solar radiation and slope are crucial factors in producing green energy source.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	w_i (%)
C_1	1,00	2,00	5,00	0,50	5,00	6,00	3,00	24
C_2	0,50	1,00	5,00	0,33	0,25	5,00	2,00	13
C_3	0,20	0,20	1,00	0,17	0,50	0,50	0,25	4
C_4	2,00	3,00	6,00	1,00	5,00	7,00	4,00	34
C_5	0,20	4,00	2,00	0,20	1,00	2,00	0,50	11
C_6	0,17	0,20	2,00	0,14	0,50	1,00	0,33	4
C_7	0,33	0,50	4,00	0,25	2,00	3,00	1,00	10

Table 7: Pairwise comparison matrix and weights of sub-criteria.

Table 8 shows that the consistency check is also satisfied for this case study, as CR is less than 10%.

The criteria and sub-criteria were evaluated following the same methodological framework adopted for the first case study. The Spatial Multi-Criteria Analysis procedure was applied to process and standardize the relevant spatial variables, ensuring methodological consistency and comparability between the two applications.

$\lambda_{\max}$	N	CI	RCI	CR	CR (%)
7,80	7	0,12	1,32	0,09	8,71

Table 8: Consistency check.

Solar irradiance was evaluated as the primary technical indicator of renewable energy availability. The spatial analysis shows high solar exposure across the study domain, supported by the relatively flat terrain, which reduces shading effects and enhances photovoltaic performance. This condition strengthens the feasibility of solar-powered hydrogen production. Terrain slope was considered to assess both photovoltaic installation efficiency and infrastructure deployment. The prevalence of moderate to low slope values indicates favorable conditions for solar panel placement and facilitates construction and transport operations.

Economic feasibility was represented through accessibility and infrastructure proximity indicators. Road accessibility analysis shows that most locations can be reached by heavy vehicles within a short travel time, ensuring efficient transport logistics. Proximity to the cement plant indicates medium to high accessibility, supporting efficient connection between production and industrial demand.

Distance to renewable energy sources was included to ensure reliable and cost-effective energy supply for electrolysis processes. The study area exhibits high coverage of renewable energy nodes, supporting energy availability and minimizing transmission losses. Proximity to gas pipeline infrastructure was evaluated to support potential hydrogen blending and distribution. The dense pipeline network within the region suggests favorable conditions for future hydrogen transport.

Environmental compatibility was assessed through land-use analysis to ensure that infrastructure deployment minimizes conflicts with existing land uses. Available land was classified according to suitability levels, with industrial and previously disturbed areas considered more appropriate for development. Each sub-criterion was modeled as a spatial variable $c_i(x)$, normalized and integrated within the decision framework.

Following normalization and weighting, the spatial variables were aggregated through the suitability function $S(x)$, producing a continuous surface that identifies the most suitable locations for green hydrogen infrastructure. The resulting land suitability map (Figure 3) shows that a substantial portion of the study area falls within the medium to medium–high suitability classes, confirming the overall spatial feasibility of green hydrogen infrastructure deployment. Figure 3 represents the primary outcome of the analysis, aimed at identifying optimal locations for the implementation of green hydrogen infrastructure. The suitability surface was obtained by aggregating the normalized spatial variables through weighted overlay, using the priority weights derived from the Analytic Hierarchy Process (AHP).

The assessment indicates that no areas reached the highest suitability class. Instead, approximately 69% of the study domain is characterized by moderate suitability, suggesting that the territory presents generally favourable - though not optimal - conditions for infrastructure development.

4 Discussion and conclusion

Finally, this study proposed a spatial multi-criteria decision framework for the identification of suitable locations for Green Hydrogen Infrastructure (GHI) in industrial contexts. By integrat-

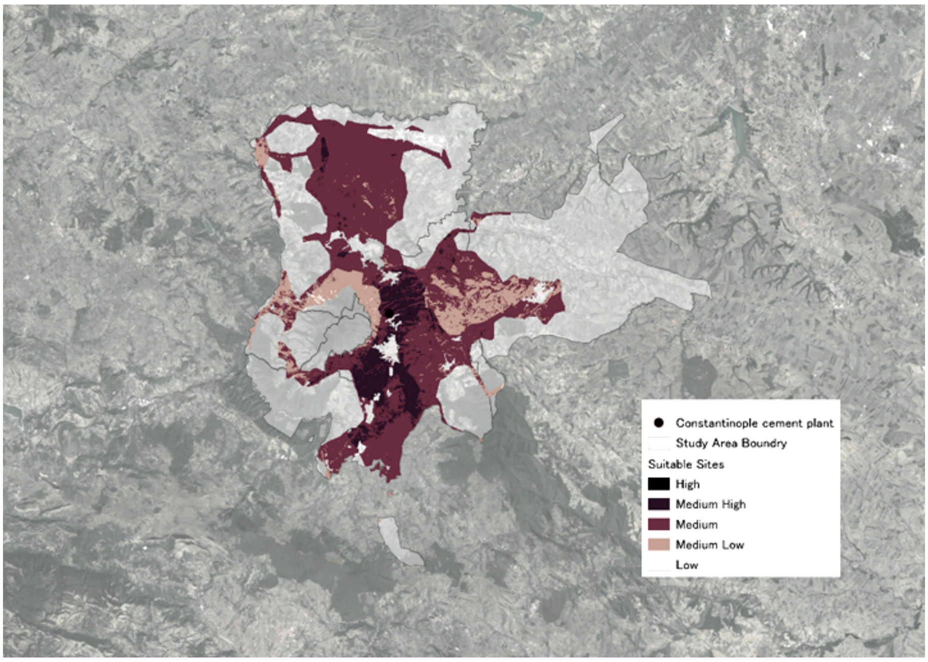

Figure 3: Land Suitability Map.

ing the Analytic Hierarchy Process (AHP) with Geographic Information System (GIS) spatial modeling, the methodology enables the aggregation of heterogeneous technical, economic, and environmental variables into a continuous suitability function $S(x)$. The resulting suitability surfaces provide a reproducible and mathematically consistent tool for infrastructure planning [4].

The application of the framework to the Italcementi plant in Matera and the Cementeria Costantinopoli plant in Barile demonstrates the robustness and adaptability of the proposed approach. In both case studies, the suitability distribution indicates generally favorable spatial conditions for hydrogen infrastructure deployment, although optimal locations are spatially constrained. For the Italcementi case, medium–high suitability areas are concentrated near the industrial demand node, confirming the relevance of proximity and accessibility factors in minimizing transport costs and improving operational efficiency. In the Barile case study, the predominance of medium suitability areas and the absence of highly suitable zones highlight the influence of spatial constraints and land-use compatibility in shaping infrastructure feasibility.

The results confirm that technical variables related to renewable energy potential and terrain morphology play a critical role in determining suitability patterns. Solar irradiance and terrain slope significantly influence energy production feasibility, while accessibility indicators and proximity to industrial demand nodes determine logistical efficiency. Infrastructure proximity, particularly to gas pipelines and renewable energy sources, further enhances the potential integration of hydrogen within existing energy systems. These findings underscore the importance of considering both energy production and distribution constraints within a unified decision framework.

From an industrial perspective, the proposed methodology supports strategic planning for the decarbonization of energy-intensive sectors. The identification of spatially feasible locations for hydrogen production and distribution facilities contributes to the development of integrated hydrogen ecosystems and may support future Hydrogen Valley initiatives. By enabling the evaluation of alternative siting scenarios, the framework provides decision-makers with a transparent and quantitative tool for sustainable infrastructure planning.

Despite its advantages, the study presents some limitations. The suitability assessment depends on the availability and resolution of spatial data, and the results may vary with the inclusion of additional criteria or updated datasets. The assumption of solar energy as the primary renewable source simplifies the energy supply model and does not account for hybrid renewable systems. Furthermore, the static nature of the analysis does not incorporate temporal variability in energy demand, renewable generation, or infrastructure development.

Future research may extend the proposed framework by integrating multiple renewable energy sources, incorporating dynamic demand scenarios, and coupling spatial suitability with optimization models for network design and energy flow. The inclusion of economic cost functions and lifecycle environmental assessments could further enhance the decision-support capability of the model.

In conclusion, the integration of AHP-based weighting with spatial multi-criteria analysis provides a mathematically grounded and operationally applicable approach for identifying suitable locations for green hydrogen infrastructure. The methodology supports industrial decarbonization strategies and offers a flexible decision-support tool adaptable to different territorial and industrial contexts.

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