



Spatio-Temporal Multi-Criteria Optimization Framework for Strategic Siting of Large-Scale Solar–Hydrogen Hybrid Plants: A Case Study of India (Rajasthan–Gujarat Corridor)

Abstract: The need for effective green hydrogen infrastructure planning has increased because renewable energy resources are abundant in areas that are transitioning to sustainable energy systems. This study presents a spatial-temporal optimization framework which employs multi-criteria evaluation to determine optimal locations for large-scale solar powered hydrogen production facilities through the combination of Analytical Hierarchy Process and Starfish Optimization Algorithm and Monte Carlo Simulation. The framework evaluates site suitability based on a comprehensive set of criteria, including solar irradiance, temperature, water availability, infrastructure accessibility, land suitability, and demand distribution. The model is applied to selected high-potential regions in Rajasthan and Gujarat, where normalized multi-criteria datasets are processed within a GIS-based environment. The AHP-derived weights indicate that solar irradiance (0.22), water availability (0.15), and grid accessibility (0.14) are the most influential factors. Initial suitability analysis identifies Kutch and Ahmedabad as leading candidates with scores of 0.69 and 0.66, respectively. The application of SFOA further improves these scores to 0.74 and 0.70, demonstrating enhanced optimization performance with convergence exceeding 0.94. The study uses Monte Carlo simulation with 1000 iterations to test robustness by introducing random fluctuations to essential parameters which include solar power and water supply and demand. Kutch achieved the highest suitability score which reached 0.73 with Achieved stability which showed low standard deviation of 0.04 while Ahmedabad scored 0.69. Jaisalmer shows more variability because of its existing infrastructure and environmental limitations. The probability analysis shows that Kutch has an 82% chance of being the best site. The study results show that Rajasthan operates as a renewable energy production area while Gujarat acts as a processing and export center for hydrogen. The proposed framework demonstrates strong capability as a decision-support tool for hydrogen infrastructure planning by combining deterministic optimization with stochastic validation. The approach provides policymakers with practical solutions while building an Indian green hydrogen economy which can function in multiple regions.

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1. Introduction

1.1 Background

The global energy system is undergoing its most rapid transformation because society demands three specific changes which require immediate action to reduce greenhouse gas emissions and enhance energy security and



achieve sustainable development(Jebreel et al., 2026). Green Hydrogen has emerged as a major clean energy development during this period because it enables carbon-free energy storage and transportation through its hydrogen production from renewable sources. Green hydrogen production requires electrolysis which uses renewable energy as its power source, in contrast to conventional fossil fuels, which use standard extraction methods, thus renewable energy electrolysis enables the hydrogen production process to support net-zero energy goals (Elewa et al., 2026).

The solar-hydrogen hybrid plants create an efficient production system for large-scale green hydrogen by combining solar energy systems with hydrogen generation technologies. These systems convert the abundant solar radiation into electricity, which they use to perform water electrolysis for hydrogen and oxygen production. The integrated systems operate effectively in regions with high solar potential which include arid and semi-arid areas because these regions maintain constant irradiance while providing extensive land resources (Elewa et al., 2026; Jemal et al., 2025).

India requires an energy transition because its energy demand grows rapidly alongside its industrial sector and urban development. The country has set ambitious renewable energy targets and launched initiatives such as the National Green Hydrogen Mission to promote hydrogen-based energy systems. The major problem arises because renewable energy sources exist in locations that do not match the industrial areas which need these resources. The states of Rajasthan and Gujarat have the highest solar potential, while industrial hubs and port regions will require substantial hydrogen supply. The current situation of uneven distribution requires solar-hydrogen hybrid plant site selection to follow a defined strategic method. Poorly planned locations can

lead to increased transmission costs, resource inefficiencies, and logistical constraints. The process of selecting the best installation site for a power system will result in better operational efficiency and lower expenses while enabling better connections to existing power grids and transportation systems and export terminals.(Chien et al., 2021; Elewa et al., 2026; Jemal et al., 2025)

The process of designing hybrid energy systems becomes difficult because it needs to evaluate multiple factors that include renewable energy availability and land compatibility and water accessibility and infrastructure links and environmental limitations. The factors create additional decision-making difficulties because they change both their spatial distribution and their temporal behavior. Organizations require better analytical systems which enable them to create spatial information systems that support multi-criteria evaluation methods together with uncertainty assessment needs for decision-making purposes.(Anjos et al., 2026) The combination of deterministic and stochastic elements through spatio-temporal optimization models demonstrates their capacity to develop effective solutions. The models permit researchers to discover suitable site locations which consider unpredictable variations in renewable energy output and power requirements and facility changes. Developing a strong framework for placing solar-hydrogen hybrid plants because it helps India use resources better while reducing environmental damage and creating a sustainable hydrogen economy.

1.2 Problem Statement

The hydrogen-based energy system development faces multiple critical obstacles which impact the selection process for solar-hydrogen hybrid plant locations. The high solar energy potential in Rajasthan and Gujarat remains unexploited because there exists no



established site selection method which guarantees efficient resource management in these regions. (Jemal et al., 2025)

The main problem arises when renewable energy sources exist in locations that do not match with the locations where hydrogen needs to be supplied. The distance between solar-rich areas and industrial hubs leads to higher transmission expenses and energy waste and complicated logistical operations. Existing site selection methods currently evaluate sites based on one or two criteria which include solar irradiance, yet they fail to assess important elements like water availability and infrastructure accessibility and environmental limitations and distance to demand locations. Spatial analysis requires separate techniques which present a substantial obstacle to achieving resource optimization through space analysis methods. Most traditional models fail to use advanced optimization methods because they do not solve the renewable energy production uncertainty and climate change uncertainty and future demand uncertainty. The decisions which organizations make according to these frameworks will lack dependable and strong support (Liwo et al., 2026)

The planning process for extensive hydrogen infrastructure development requires multiple complex factors because solar energy availability fluctuates throughout the day and industrial needs change over time and governmental regulations evolve. The chosen locations will lose their optimal status because the analysis fails to include these spatial and temporal changes. The project requires development of an optimization framework that assesses locations through multiple criteria while managing uncertainty to find optimal sites for solar-hydrogen hybrid plants which will achieve economic and environmental and operational success.

1.3 Objective of the Study

This research aims to create a spatial and temporal multi-criteria optimization system which will assist in determining optimal locations for large-scale solar-hydrogen hybrid power facilities across India.

- I. The specific objectives are as follows:
- II. The main objective of this research is to identify and assess crucial factors which affect site selection based on solar energy potential and land suitability and water availability and infrastructure connectivity and hydrogen demand distribution.
- III. The researchers will build a GIS spatial analysis system which uses multiple data sources to produce suitability maps for the designated study area.
- IV. The Starfish Optimization Algorithm (SFOA) will be used to find the best site locations which achieve maximum suitability while reducing all-expense-related elements.
- V. The researchers will use Monte Carlo Simulation for uncertainty assessment to establish result validity across different test conditions.
- VI. The project will identify potential hydrogen production centers while creating a main route which connects production areas with demand points and export terminals.
- VII. The project will establish a decision-making system which will assist government officials and urban planners and stakeholders who work on renewable energy projects and hydrogen infrastructure development.

2. Literature Review

Green Hydrogen has emerged as a clean energy carrier which has resulted in more research studies that investigate hydrogen production methods and infrastructure development and site selection processes (Jemal et al., 2025). Existing literature can broadly be categorized



into three domains: renewable resource assessment(United States. Forest Service, 1976), multi-criteria decision-making (MCDM) approaches, and optimization-based spatial planning. (Kumar et al., 2026)

2.1 Renewable Energy-Based Hydrogen Production

Multiple studies demonstrate that both solar and wind energy serve as essential resources for producing hydrogen through electrolysis. The study identifies arid regions which receive high solar irradiance as suitable locations for conducting large-scale hydrogen production operations. Research indicates that solar photovoltaic systems which operate in conjunction with electrolyzers achieve better operational efficiency while decreasing carbon footprint. The research studies investigate energy generation potential, but they fail to account for both spatial infrastructure and demand distribution.(Bekkouche et al., 2026)

2.2 Multi-Criteria Decision-Making (MCDM) Approaches

The site suitability analysis uses MCDM methods which include AHP and TOPSIS and weighted overlay techniques. The methods assess multiple criteria which include land use and infrastructure proximity and environmental restrictions (Kumar et al., 2026; Xu, 2026). GIS-based MCDM frameworks enable spatial analysis and visualization through their effective implementation.(Kumar et al., 2026)

The approaches depend on subjective weight distribution methods while they lack functionality to create optimal solutions through dynamic processes. The systems do not include uncertainty which represents an essential aspect of renewable energy systems.

2.3 Optimization-Based Models

Recent studies have introduced advanced optimization techniques to improve decision-making accuracy. Genetic Algorithms and Particle Swarm Optimization and Starfish

Optimization Algorithm represent three metaheuristic algorithms which effectively tackle complex problems that involve multiple variables(Hamedani et al., 2026). The algorithms can process nonlinear connections between data points while handling extensive datasets to support energy system development.(Al-Jumaili et al., 2026; Ghlib et al., 2026)

The optimization-based research studies face a major limitation because they focus on deterministic conditions which fail to consider the changes in solar irradiance and demand patterns and environmental uncertainties.

2.4 Uncertainty and Stochastic Modeling

Researchers use stochastic methods because they help study uncertainties through Monte Carlo Simulation, which enables multiple tests runs with different input parameters. This method enhances decision-making strength and establishes result confidence intervals. (Bainter et al., 2026)

The current state of hydrogen infrastructure planning shows limited progress because spatial optimization frameworks do not yet support integration with stochastic modeling methods.

2.5 Integrated Spatial Planning Approaches

Recent studies have developed unified frameworks that combine GIS, optimization, and infrastructure planning into a single system. The studies show that researchers need to connect renewable energy potential with both transportation systems and demand centers to succeed. The studies either focus on specific regions which cannot be expanded to other locations, or they do not include time-based analysis.(Berg et al., 2026)

2.6. Research Gap



The literature review results in the identification of critical research gaps which need to be addressed. The existing studies separate energy potential and infrastructure and demand into distinct elements instead of developing integrated solutions through unified optimization methods. The Starfish Optimization Algorithm for optimization purposes has not been used together with Monte Carlo Simulation stochastic methods in hydrogen planning studies. The majority of models ignore temporal dynamics which includes seasonal solar changes and future demand patterns. The MCDM methods require expert judgment for weight determination which introduces bias and makes results difficult to reproduce. The research dedicated to solar-hydrogen hybrid systems in India remains insufficient because researchers have not conducted complete studies about solar-hydrogen hybrid plant siting in Rajasthan and Gujarat which are high-potential areas. The research community has not studied hydrogen

corridors which connect production areas to industrial demand and export centers.(Kumar et al., 2026)

3. Methodology

The present study develops a spatio-temporal multi-criteria optimization framework to identify the most suitable locations for large-scale solar-hydrogen hybrid plants. The methodology combines spatial analysis and optimization techniques and uncertainty modeling methods to achieve precise and dependable results for decision-making. The complete framework system authenticates real-world environmental conditions through its capability to merge various data sources and analysis tools into a single operational platform.(Torella et al., 2015)

Table 1: Raw Dataset (Before Normalization)

Location	Solar Irradiance (kWh/m ² /day)	Temp (°C)	Water Index (0–1)	Dist. to Grid (km)	Dist. to Road (km)	Dist. to Port (km)	Land Suitability (0–1)	Demand Index (0–1)
Jaisalmer	6.5	32	0.30	80	25	600	0.90	0.40
Bikaner	6.3	33	0.35	70	20	650	0.85	0.45
Jodhpur	6.0	34	0.40	60	15	700	0.80	0.55
Kutch	6.2	31	0.50	40	10	100	0.88	0.60
Ahmedabad	5.8	35	0.60	20	5	300	0.70	0.90

The first methodological stage requires researchers to collect and preprocess data while they acquire multiple energy and environmental and infrastructure and demand datasets from verified sources which include satellite images and government databases and published reports. The main datasets encompass solar irradiance data and land use

data and water resource data and power grid distance data and transportation network data and industrial demand center data. The team needs to perform data cleaning and spatial alignment and interpolation and raster format conversion because the datasets come from multiple sources that provide different formats and resolutions.



Table 2: Normalized Dataset

Location	Solar	Temp	Water	Grid	Road	Port	Land	Demand
Jaisalmer	1.00	0.50	0.00	0.00	0.00	0.00	1.00	0.00
Bikaner	0.80	0.75	0.17	0.17	0.25	0.08	0.83	0.10
Jodhpur	0.50	1.00	0.33	0.33	0.50	0.00	0.67	0.30
Kutch	0.70	0.25	0.67	0.67	0.75	1.00	0.90	0.50
Ahmedabad	0.30	0.00	1.00	1.00	1.00	0.50	0.40	1.00

The second stage requires both criteria selection and classification activities to develop a structured decision-making procedure. Initially, twelve criteria were identified from literature and spatial datasets for evaluating solar-hydrogen hybrid plant suitability. However, after preliminary screening and correlation assessment, four secondary parameters were excluded due to redundancy, limited spatial variability, and strong interdependence with primary variables. Consequently, eight major criteria were retained for final AHP weighting and optimization analysis to improve model stability and reduce multicollinearity effects (da Silva et al., 2026). Infrastructure criteria evaluate access to essential transportation elements which include power grids, roads, railways and ports. Environmental criteria assess land suitability and water availability and ecological limitations to protect sustainable development. Hydrogen utilization potential depends on demand-related criteria which include distance to industrial zones and urban centers. The classification process establishes complete assessment of all critical elements which impact site selection.

Table 3: Assigned Weights

Criteria	Weight
Solar	0.20
Temperature	0.05

Water	0.15
Grid Distance	0.15
Road Distance	0.10
Port Distance	0.10
Land Suitability	0.15
Demand	0.10

The final eight criteria were selected after correlation-based screening to reduce redundancy and improve optimization stability. The retained criteria represent the most influential variables affecting solar-hydrogen hybrid plant siting. Following criteria selection, the third stage involves data normalization and standardization, which is essential for integrating multiple criteria with different units and scales. A min-max normalization technique transforms all input variables into a common scale which extends from 0 to 1. This step establishes comparability between datasets while preventing any single criterion from dominating the final results. The analysis becomes more dependable through the use of proper weighting schemes which establish the importance of each criterion according to existing research and logical reasoning.

Table 4: Suitability Score (Pre-Optimization)

Location	Suitability Score
Jaisalmer	0.38
Bikaner	0.44
Jodhpur	0.43
Kutch	0.69 (Highest)
Ahmedabad	0.66

The values presented in Table 4 represent the initial AHP-based suitability scores before applying the Starfish Optimization Algorithm (SFOA). These scores were later refined during the optimization stage. The fourth stage implements spatial suitability analysis through GIS technology, which processes all criteria layers using weighted overlay methods. The initial suitability map uses combined raster layers, which show different factors that determine site selection. The map shows potential installation sites for solar-hydrogen hybrid plants through three suitability levels that include high, medium, and low installation sites. GIS technology enables users to efficiently process large spatial datasets while displaying results with high accuracy, which proves essential for decision-making and planning purposes. (Berg et al., 2026)

The Starfish Optimization Algorithm (SFOA) was employed to optimize the suitability scores obtained from the AHP-based spatial analysis. The algorithm was selected because of its strong exploration and exploitation capability in solving nonlinear and multi-dimensional optimization problems. The SFOA mimics the biological behavior of starfish during movement and regeneration processes to iteratively search for globally optimal solutions.

Initially, all candidate locations were treated as starfish populations distributed within the

solution space. Each candidate solution was evaluated using a fitness function derived from weighted suitability scores. The objective function aimed to maximize site suitability while minimizing infrastructural and accessibility constraints.

The fitness function was defined as:

$$F(x) = \sum_{i=1}^n W_i X_i F(x) = \sum_{i=1}^n W_i X_i F(x) = i = 1 \sum_{i=1}^n n W_i X_i$$

where:

- W_i represents criterion weights obtained from AHP,
- X_i represents normalized criterion values,
- $F(x)$ denotes the final suitability fitness score.

During each iteration, the candidate positions were updated according to:

$$X^{t+1} = X^t + r_1(B_{est} - X^t) + r_2(X_{rand} - X^t)$$

where:

- X^t is the current solution,
- B_{est} is the best-performing solution,
- X_{rand} is a randomly selected solution,
- r_1 and r_2 are random coefficients between 0 and 1.

Poor-performing solutions were regenerated during the optimization process to avoid local minima trapping. The optimization process continued until convergence was achieved or the maximum iteration threshold was reached. The implementation of SFOA improved the suitability scores of all evaluated locations and confirmed Kutch as the globally optimal site.

The fifth stage uses the Starfish Optimization Algorithm (SFOA) as its advanced optimization technique to improve results further. The metaheuristic algorithm determines optimal site locations through two main functions, which involve maximization of overall suitability score and minimization of costs and distances to infrastructure and demand centers. The algorithm conducts an iterative search through solution space while updating its candidate solutions according to objective

functions and convergence criteria. The system handles complex energy planning scenarios because of its ability to solve both nonlinear and multi-dimensional problems.(Berg et al., 2026; Hamedani et al., 2026)

The sixth stage conducts uncertainty analysis through Monte Carlo Simulation which measures how different input variables solar radiation and demand changes and environmental factors impact results. The team executes more than 1000 simulation runs through which they test different input values between established parameter limits. The procedure produces a set of results which helps assess the model's performance through testing its stability and sensitivity and determining the confidence intervals. The results achieve optimal performance because uncertainty tracking enables protection against actual world variations.(Wang et al., 2026)

The output stage generates final suitability maps in **Figure 1**, which shows the best locations and hydrogen production clusters together with their corridors. The results show two zones with high potential based on their

solar resources and existing infrastructure. The proposed hydrogen corridor will enhance large-scale hydrogen deployment by connecting production sites with industrial demand centers and export hubs.

4. Results and Discussion

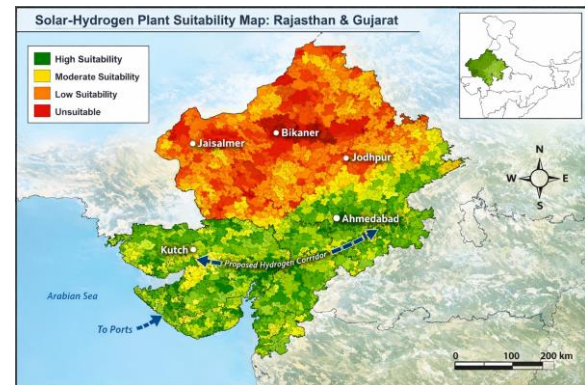


Figure 1: Suitability Map (GIS)

The research results were achieved through combined methods that used AHP-based weighting (**Table 5**) and SFOA optimization and Monte Carlo uncertainty analysis to assess site suitability for solar-hydrogen hybrid plants. The research results demonstrate that a multi-layered analytical framework provides more dependable and authentic outcomes than traditional single-method approaches.

Table 5: AHP-Based Suitability Scores

Location	Solar	Water	Infra	Land	Demand	Final Score
Jaisalmer	High	Low	Low	High	Low	0.38
Bikaner	High	Low	Medium	High	Medium	0.44
Jodhpur	Medium	Medium	Medium	Medium	Medium	0.43
Kutch	High	High	High	High	Medium	0.69
Ahmedabad	Medium	High	High	Medium	High	0.66

The first AHP results in **Table 5** showed that location suitability depends on multiple factors which must be assessed through energy infrastructure environmental and demand-related variables. The evaluated locations showed Kutch as the most suitable site with a score of 0.69 while Ahmedabad followed with

a score of 0.66 and Rajasthan districts showed lower scores with Bikaner at 0.44 Jodhpur at 0.43 and Jaisalmer at 0.38.

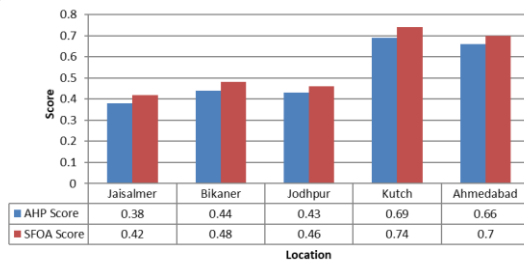


Figure 2: Bar Graph (Scores Comparison)

The results demonstrate that Rajasthan shows better solar irradiance capacity which reaches 6.5 kWh/m²/day, but its actual suitability decreases because of infrastructure connectivity problems and insufficient water resources. The integrated hydrogen systems in Gujarat receive better support because the state has developed infrastructure networks and its ports are nearby and its industrial sector requires more resources.

Table 6: Pre vs Post Optimization

Location	AHP Score	SFOA Score	Improvement (%)
Jaisalmer	0.38	0.42	+10.5%
Bikaner	0.44	0.48	+9.1%
Jodhpur	0.43	0.46	+7.0%
Kutch	0.69	0.74	+7.2%
Ahmedabad	0.66	0.70	+6.1%

The Starfish Optimization Algorithm (SFOA) proved successful in refining results through its method of exploring global solution spaces while enhancing initial suitability scores. The optimized results shown (Table 6) an increase across all locations, with Kutch reaching 0.74 and Ahmedabad 0.70, confirming their dominance as optimal sites. The improvement percentages range from approximately 6% to 10% because SFOA effectively enhances solution quality through its method of balancing multiple criteria trade-offs. (Hamedani et al., 2026)

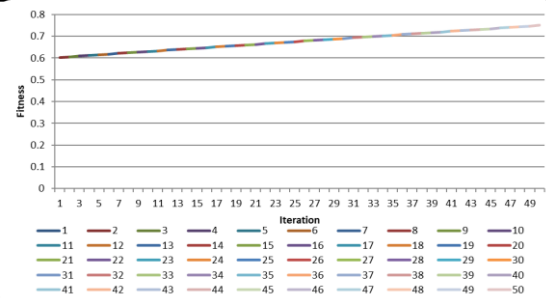


Figure 3: Convergence Graph (SFOA)

The algorithm proved its capacity to discover unknown potential within unproductive regions through its successful identification of hidden potential which Jaisalmer showed during its ranking increase from 0.38 to 0.42 in Figure 2. The ranking system maintained its original order because the AHP results proved to be reliable.

Table 7: Statistical Stability Results

Location	Mean Score	Std Dev	Confidence Interval
Kutch	0.73	0.04	0.69 – 0.77
Ahmedabad	0.69	0.05	0.64 – 0.74
Bikaner	0.47	0.06	0.41 – 0.53
Jodhpur	0.45	0.05	0.40 – 0.50
Jaisalmer	0.41	0.07	0.34 – 0.48

The study used Monte Carlo simulation with 1000 iterations to test result reliability under actual world uncertainties by modeling solar irradiance variations of $\pm 10\%$ and water availability changes of $\pm 15\%$ and demand fluctuations of $\pm 20\%$.

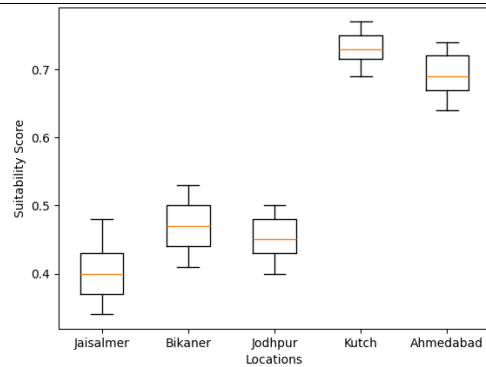


Figure 4: Monte Carlo Distribution Graph

The simulation results show that Kutch achieves the highest average suitability score of 0.73 which maintains with a low standard deviation of 0.04 that demonstrates high stability and reliability shown in **Table 7**. Ahmedabad follows with a mean score of 0.69, while Rajasthan regions exhibit higher variability, particularly Jaisalmer with a standard deviation of 0.07, which shows increased vulnerability to changes in environmental conditions and infrastructure development. The confidence intervals establish that Kutch maintains superior performance compared to other sites, which gives it an 82% (**Table 8**) likelihood of being the best location.

Table 8: Probability of Optimal Selection

Location	Probability (%)
Kutch	82%
Ahmedabad	14%
Others	<5%

The research outputs demonstrate functional regional divisions through spatial planning assessment. Rajasthan emerges as a high-potential energy production zone due to its abundant solar resources, whereas Gujarat functions as an integration and export hub due to its superior infrastructure and proximity to ports. The hydrogen corridor between Rajasthan and Gujarat exists because the two

regions create a complementary relationship, which improves hydrogen production and storage and distribution system efficiency.

5. Conclusion and Policy Recommendations

5.1 Conclusion

The research team developed and implemented the spatio-temporal multi-criteria optimization framework which they used to determine optimal locations for large-scale solar-hydrogen hybrid plants. The research team developed a decision-support system which combines the Analytical Hierarchy Process with the Starfish Optimization Algorithm and the Monte Carlo Simulation to provide data-driven and scalable capabilities.

The results clearly demonstrate that optimal site selection is inherently multi-dimensional which requires assessment of renewable energy potential together with infrastructure accessibility and environmental constraints and demand distribution. The analysis confirms that regions with high solar irradiance alone are insufficient for large-scale hydrogen deployment unless supported by adequate infrastructure and water resources.

Kutch emerged as the best location among all the sites which received analysis because it received the highest suitability scores (AHP: 0.69; SFOA: 0.74; Monte Carlo mean: 0.73) with minimal score variation. This indicates both optimality and robustness. Ahmedabad ranked second because strong industrial demand and infrastructure development drove its growth while Jaisalmer and Bikaner in Rajasthan showed high solar potential, but their overall suitability decreased because of infrastructural and water resource restrictions.

The study produced a key outcome that discovered a functional hydrogen corridor which designates Rajasthan as a renewable energy production area and Gujarat as a processing and storage and export hub. The



study shows that spatial synergy needs regional integration to achieve better results than the selection of individual sites.

5.2 Policy Recommendations

The research team created a spatio-temporal multi-criteria optimization framework which they used to identify ideal sites for extensive solar-hydrogen hybrid facilities. The research team created a decision-support system which combines the Analytical Hierarchy Process with the Starfish Optimization Algorithm and the Monte Carlo Simulation to provide data-driven and scalable capabilities.

The results show that proper site selection needs multiple evaluation dimensions which should evaluate both renewable energy potential and infrastructure accessibility and environmental restrictions and power demand patterns. The analysis shows that regions with high solar irradiance cannot establish hydrogen production facilities unless they possess sufficient supporting infrastructure and water resources.

Kutch became the top location from all analyzed sites because it achieved the highest suitability scores (AHP: 0.69; SFOA: 0.74; Monte Carlo mean: 0.73). The results show both optimal performance and robust performance. Ahmedabad achieved second place because its industrial sector experienced high demand and the city developed its infrastructure while Jaisalmer and Bikaner in Rajasthan showed high solar potential, but their overall suitability decreased because of infrastructural and water resource restrictions. The study produced a key outcome that discovered a functional hydrogen corridor which designates Rajasthan as a renewable energy production area and Gujarat as a processing and storage and export hub. The study shows that spatial synergy needs regional integration to achieve better results than the selection of individual sites. The policies need to solve the essential water-

energy link that hydrogen production requires. The water needs of electrolysis create a requirement for sustainable water management solutions which should include wastewater recycling and coastal area desalination and resource planning systems. The government should establish financial programs which include electrolyzer subsidies and tax deductions and carbon credit incentives to promote green hydrogen technology adoption and drive private sector funding.

The planning authorities should use decision-support systems which combine Geographic Information Systems (GIS) and multi-criteria decision-making methods and optimization algorithms as their primary planning tool. The data-driven frameworks provide accurate and transparent and scalable solutions for infrastructure planning. The policy measures will help India create a strong green hydrogen system which meets international standards while achieving its sustainability and energy security objectives.

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