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Renewable Energy Potential of the Jordan Valley

A GIS-Based Renewable Energy Decision-Support Framework for Policy Development

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TABLE OF CONTENTS

Executive Summary 3

1 Introduction 4

1.1 The Jordan Valley 4

1.2 Energy System of the Israeli Jordan Valley 5

1.3 National and Local Policy Context 7

2 Renewable Energy Planning and GIS: Conceptual Framework 7

3 Methodological Framework 9

3.1 Study Area and Spatial Resolution 9

3.2 Data Layers 9

3.3 From Spatial Data to Policy-Relevant Insights 10

3.4 Decision–Support Model and StoryMap 11

4 Applied GIS-Based Solar Energy Potential Assessment 11

4.1 Case Study Overview 11

4.2 Solar Energy Potential by Land-Use Category 12

5 Policy Implications 14

6 Transferability and Limitations 14

7 Conclusions and Policy Recommendations 15

8 References 18

Annex A: Technical Description of the GIS-Based Decision-Support Platform 19

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Executive Summary

The Jordan Valley is characterized by high solar irradiance, intensive agricultural activity, and strong water-energy connections, and growing electricity demand, while land availability is constrained by agriculture uses and environmental protection requirements [1] [2]. These conditions create an important opportunity and a complex planning challenge for renewable energy development in the region. Despite favorable conditions, the expansion of solar energy is limited by land-use constraints, infrastructure limits, and policy priorities.

This paper suggests that the key challenge is not the availability of solar resources, but the lack of an integrated, place-based policy framework that aligns national renewable energy targets with local land-use, infrastructure, and agricultural priorities.

In response to this planning challenge, this study develops a comprehensive Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA) to assess renewable energy deployment options in the Israeli Jordan Valley. The analysis adopts a technology-neutral approach, evaluating multiple solar pathways, including rooftop photovoltaics, floating solar panels on reservoirs, ground-mounted systems, and agrivoltaics, according to their suitability, feasibility, and compatibility with regional constraints. Building on this framework, an interactive GIS-based StoryMap is presented as a practical policy tool that helps decision-makers to explore where and how renewable energy can be deployed while minimizing land-use conflicts and aligning with regional sustainability priorities. The tool supports regional councils, planning authorities, and national stakeholders in prioritizing low-conflict deployment options and improving coordination between energy, land-use, and infrastructure planning.

The findings indicate that while the Jordan Valley has substantial solar potential, the achievable results are strongly shaped by land-use priorities, grid limitations, and environmental constraints. Distributed solar solutions, particularly rooftop systems and floating photovoltaics, emerge as the most policy-compatible pathways, offering opportunities to expand renewable energy without compromising agricultural productivity or environmentally sensitive areas.

A shift toward integrated, spatially informed policy approaches is essential to ensure that renewable energy development in the Jordan Valley supports energy security, agricultural sustainability, and long-term climate resilience. The approach demonstrated in this study can also be transferred to other regions facing similar land-use conflicts and water–energy–food interdependencies.

1 Introduction

1.1 The Jordan Valley

The Jordan Valley is part of Israel's eastern rift system and is characterized by topographic and climatic extremes. Within Israel, the valley extends along the western bank of the Jordan River from the southern edge of the Sea of Galilee to the Beit Shean Valley and the lower Jordan basin. Large areas of the region lie below sea level, and experience arid to semi-arid climatic conditions, extremely high summer temperatures, and some of the highest solar irradiance levels in the country (Figure 1).

Land use in the Israeli Jordan Valley is rural and agriculture oriented. Approximately one-third of the area is allocated to agriculture, including irrigated field crops, orchards, greenhouses, aquaculture facilities, and agro-industrial infrastructure. Built-up areas are limited and consist of small rural communities (kibbutzim and moshavim), alongside the urban center of Beit Shean. Future development is expected to occur primarily through intensification and technological upgrading rather than spatial expansion, reinforcing the importance of efficient land-use management.

The population of the Israeli Jordan Valley is estimated at 60,000 residents, with projections of growth to around 70,000 by 2030 and up to 100,000 by 2050. While agriculture remains a defining feature of the regional economy, employment patterns are gradually shifting toward food processing, services, tourism, and commuting to external employment centers. These trends are expected to drive increasing and spatially dispersed electricity demand [1].

Water availability and management are central to the region's socio-ecological system. Agriculture accounts for most water use, with irrigation and aquaculture dominating demand. Water pumping, conveyance, treatment, and post-harvest processing require substantial electricity, creating a strong coupling between water and energy systems. This Water–Energy–Food–Ecosystems (WEFE) nexus emphasizes the need for spatially integrated planning and reinforces the relevance of GIS-based renewable energy assessment.

The spatial distribution of settlements and agricultural activities creates a dispersed pattern of electricity demand across the region. Irrigation pumps, aquaculture systems, and agro-industrial facilities are often located far from major urban centers and electricity substations. This dispersed demand structure increases the importance of distributed renewable energy systems that can supply electricity closer to consumption points, thereby reducing transmission losses and improving regional energy resilience.

Climate change projections indicate that the Jordan Valley will face disproportionate impacts, including rising average temperatures, longer and more frequent heatwaves, and higher evapotranspiration rates. These trends are expected to intensify electricity demand for cooling, irrigation, and water services. Importantly, peak electricity demand is likely to coincide with periods of maximum solar availability, reinforcing the strategic relevance of solar energy while increasing pressure on local grid infrastructure.

The geographic extent of the study area within the broader Jordan Valley region is illustrated in Figure 1.

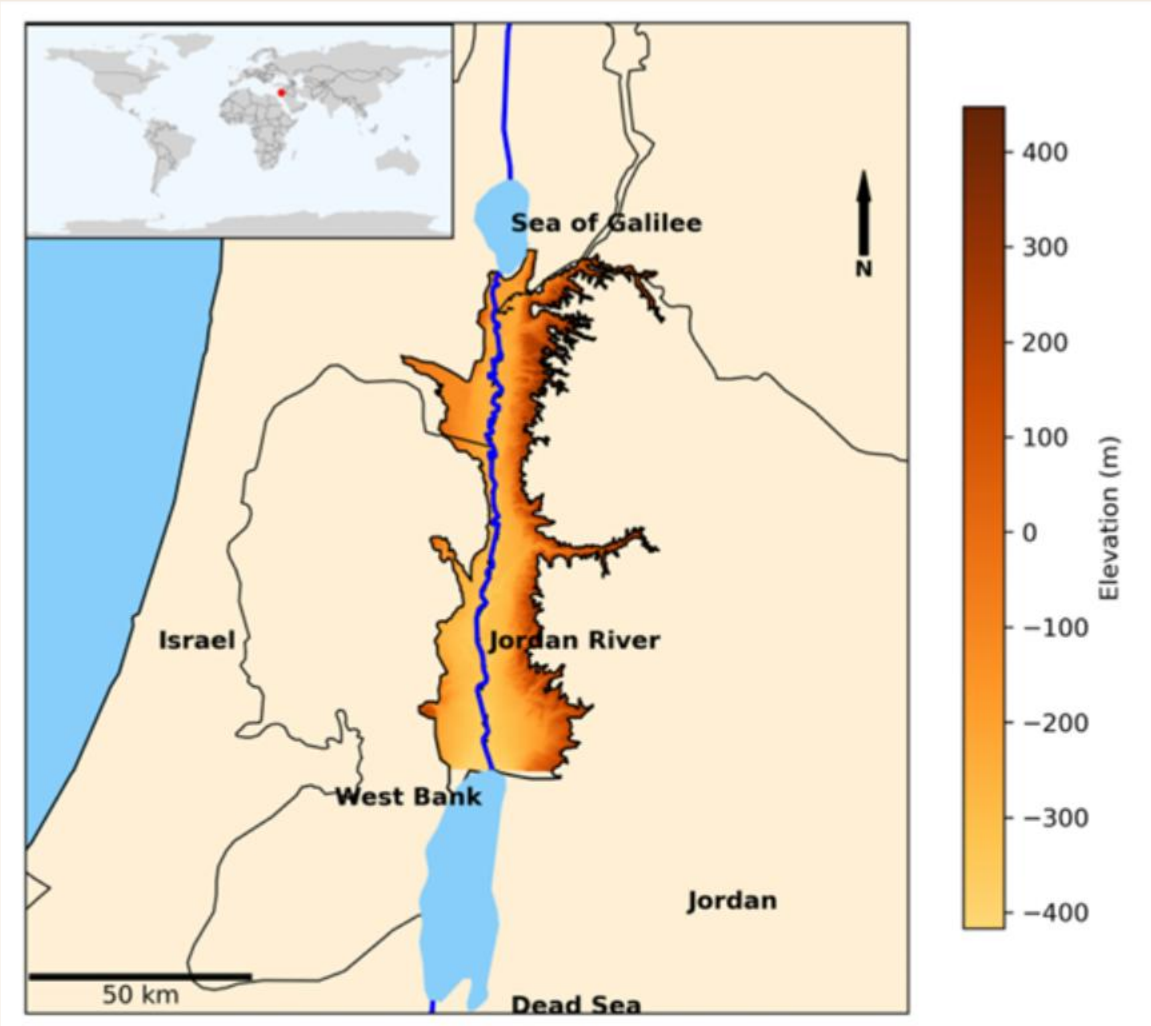


Figure 1: Geographic extent of the Jordan Valley study area across Israel, Palestine, and Jordan [3] [4]

1.2 Energy System of the Israeli Jordan Valley

The energy system of the Israeli Jordan Valley is integrated into Israel's centralized electricity and gas infrastructure, yet it exhibits distinct regional characteristics. Electricity supply is largely based on grid-connected generation, with a significant share delivered from natural gas-fired power plants, including the nearby Alon Tavor combined-cycle facility.

Current electricity demand in the region is estimated at approximately 100 MW, with annual consumption of around 260 GWh, projected to exceed 580 GWh by 2050 under conservative growth assumption [1]. Key energy characteristics of the Israeli Jordan Valley are summarized in Table 1.

Demand is driven primarily by agriculture and water-related activities, alongside increasing cooling and agro-industrial requirements.

Table 1: Key Energy Characteristics of the Israeli Jordan Valley [1] [4]

Parameter	Current Estimate	Future Trend
Population	~60,000	Up to ~100,000 (2050)
Annual electricity demand	~260 GWh	>580 GWh (2050)
Dominant energy source	Grid electricity (natural gas)	Increasing electrification based on renewable energy.
Key demand drivers	Agriculture, water services	Cooling, agro-industry
Renewable resource	Solar energy	High and stable

Electricity demand is highly localized and seasonally variable. Agricultural operations, water pumping stations, and aquaculture systems create energy “hotspots” that are often located far from grid infrastructure. This spatial mismatch between supply infrastructure and demand centers highlights the importance of distributed renewable energy systems.

Renewable energy deployment in the Jordan Valley has grown rapidly in recent years, with solar photovoltaics making up most of the renewable mix. Installed renewable capacity exceeds 300 MW, in distributed PV systems connected to medium- and low-voltage networks, including rooftop installations, ground-mounted systems, floating photovoltaics on reservoirs, and agrivoltaics setups.

Despite abundant solar resources, further expansion is constrained by grid capacity limitations, land-use regulations, environmental protection requirements, and visual impact considerations. As a result, the key challenge is not identifying solar potential but determining where and how renewable energy can be deployed in a manner that is technically feasible, socially acceptable, and aligned with long-term land-use priorities.

1.3 National and Local Policy Context

At the national level, Israel's energy strategy aims to increase the share of renewable electricity to 30% by 2030, mainly through solar energy [5]. While these targets provide strong policy direction, they do not fully address the spatial and institutional challenges associated with implementing renewable energy projects in complex rural and agricultural regions.

At the local level, renewable energy deployment in the Jordan Valley follows specific planning guidance created by the Jordan Valley regional councils. This framework generally focuses on rooftop and built-environment solar installations, as well as installations on existing infrastructure surfaces and water reservoirs, while considering open agricultural land and visually sensitive areas.

This multi-level governance structure creates a gap between national ambitions and local implementation. Renewable energy deployment decisions are often made on a project-by-project basis, without a comprehensive spatial framework to guide prioritization and minimize conflicts.

As a result, the central challenge in the Jordan Valley is not the availability of solar resources, but the lack of an integrated, place-based policy approach that aligns energy planning with land use, agricultural systems, environmental protection, and infrastructure constraints. Addressing this gap requires tools that can translate national renewable energy targets into locally feasible and spatially optimized deployment strategies.

This paper responds to this need by presenting a GIS-based decision-support framework and interactive StoryMap designed to support policymakers and planners in identifying renewable energy deployment pathways that are both technically viable and compatible with regional priorities.

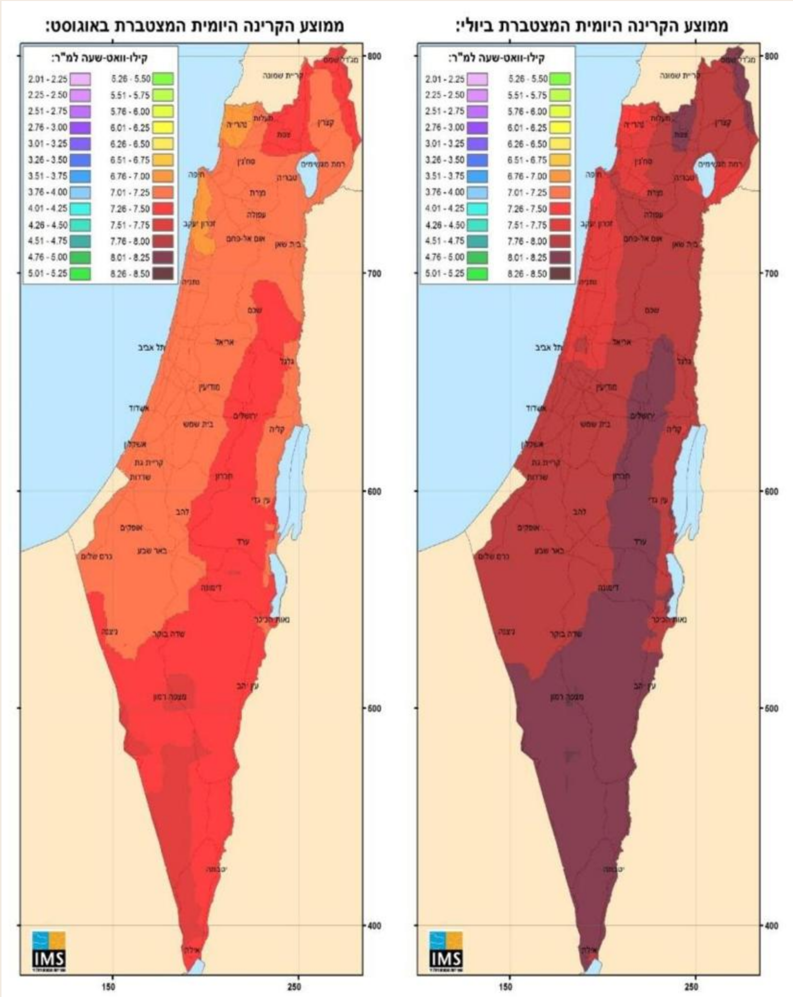
2 Renewable Energy Planning and GIS: Conceptual Framework

Renewable energy planning in regions such as the Jordan Valley is inherently a spatial policy challenge. Solar resource availability, land-use compatibility, infrastructure access, and environmental sensitivity vary significantly across space, making uniform or single-criterion planning approaches insufficient. As a result, decision-makers require tools that can integrate these spatial dimensions and support informed, context-specific planning.

GISs provide a platform for such approaches by enabling the integration of heterogeneous datasets, visualization of spatial trade-offs, and identification of areas where renewable energy development can be aligned with land-use and environmental constraints. In Israel, solar irradiance varies across regions, with particularly high values observed in the eastern parts of the country, including the Jordan Valley, as illustrated in Figure 2, which presents multi-year average solar radiation patterns for the summer months (July and August). These data highlight the strong solar resource base while also emphasizing the need to consider spatial constraints in deployment decisions. To move from resource assessment to actionable planning, Multi-Criteria Decision Analysis (MCDA) is used to evaluate renewable energy deployment options across multiple, often competing criteria. These include solar irradiance, topography (slope and aspect), land-use type, proximity to grid infrastructure, and environmental protection requirements. By assigning weights to these criteria, MCDA enables decision-makers to reflect policy priorities, such as agricultural protection or infrastructure efficiency within the planning process.

When combined, GIS and MCDA form the basis of Spatial Decision Support Models (DSMs), which translate complex spatial data into decision-relevant insights. In the context of the Jordan Valley, these models allow planners and policymakers to evaluate how different solar deployment strategies interact with land-use priorities, grid limitations, and environmental considerations. Importantly, such tools also support scenario analysis, enabling decision-makers to test alternative assumptions and assess trade-offs between competing objectives.

Rather than providing a single optimal solution, this approach enables a structured and transparent decision-making process. It supports the identification of deployment pathways that minimize land-use conflicts while maximizing alignment with regional development goals.



Picture 2: Spatial distribution of average daily accumulated solar radiation in Israel in August (left) and July (right) [6]

3 Methodological Framework

3.1 Study Area and Spatial Resolution

The study area covers the Israeli part of the Jordan Valley. Spatial resolution was selected to balance data availability with planning relevance, enabling parcel- and land-use-level assessment while maintaining practical usability for planning applications.

3.2 Data Layers

The decision-support tool integrates multiple spatial datasets relevant for renewable energy planning (Table 2), including solar radiation, land use, topography, water bodies, infrastructure, and environmental constraints.

These datasets represent the key factors influencing where renewable energy can be deployed, reflecting both technical feasibility and policy considerations such as land-use protection and environmental sensitivity.

Table 2: GIS Data Layers Used in the Analysis [7]

Data Layer	Description	Purpose
Solar radiation	Seasonal and annual irradiance	Resource assessment
Land use	Agriculture, built-up, open space	Suitability screening
Topography	Slope, aspect	Technical feasibility
Water bodies	Reservoirs, ponds	Floating PV potential
Infrastructure	Roads, substations, grid	Grid access
Environmental constraints	Protected areas, buffers	Exclusion zones

3.3 From Spatial Data to Policy-Relevant Insights

To translate spatial data into decision-relevant outputs, the analysis applies a multi-criteria evaluation approach in which different factors, such as solar resource availability, land-use compatibility, infrastructure proximity, and environmental constraints are assessed together within a single framework.

Rather than producing a single "optimal" solution, the approach enables the identification of areas with varying levels of suitability for renewable energy deployment. This allows decision makers to compare alternative development options and assess trade-offs between competing priorities, including agricultural land protection, environmental considerations, and infrastructure accessibility.

The resulting outputs are presented as spatial suitability maps that highlight areas where renewable energy development can be expanded with minimal conflict. These maps provide a transparent and evidence-based basis for planning decisions, supporting the prioritization of deployment pathways that align with regional land-use and sustainability objectives.

3.4 Decision–Support Model and StoryMap

The conceptual structure of the GIS-based decision-support model used in this study is illustrated in Figure 3. The model integrates multiple spatial datasets within a unified framework to support the evaluation of renewable energy deployment scenarios.

Building on this model, the results are made accessible through an interactive GIS-based StoryMap, which translates complex spatial analysis into an intuitive interface for policymakers and planners. Through this tool, users can:

- explore spatial patterns of renewable energy potential
- identify suitable locations for different solar technologies
- assess trade-offs between energy development, agriculture, and environmental protection
- support evidence-based planning and policy decisions

By linking spatial analysis with an interactive platform, the tool enables a more transparent and coordinated approach to renewable energy planning in the Jordan Valley.

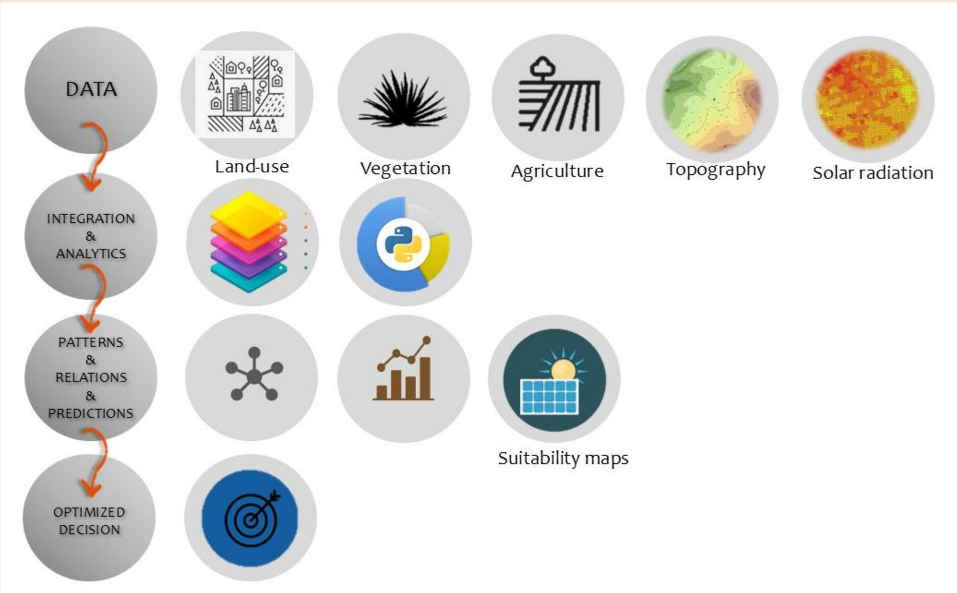


Figure 2: GIS-Based Renewable Energy Decision-Support Model [7]

4 Applied GIS-Based Solar Energy Potential Assessment

4.1 Case Study Overview

The assessment applies the GIS-based decision-support framework to the Israeli part of the Jordan Valley, integrating solar resource data with land-use, environmental, and infrastructure constraints. The objective is not only to estimate solar potential, but to identify deployment pathways that are compatible with regional planning priorities.

4.2 Solar Energy Potential by Land-Use Category

The analysis highlights that the suitability of solar energy deployment varies significantly across land-use categories (Table 3).

Table 3: Relative Suitability of Solar Energy Deployment Options

Solar Application	**Relative Suitability**	**Key Considerations**
Rooftop PV	High	Minimal land conflict
Floating PV (reservoirs)	High	Evaporation reduction
Ground-mounted PV	Medium	Land-use trade-offs
Agrivoltaics	Medium	Crop compatibility
Open natural areas	Low	Environmental impact

The results show that not all solar technologies are equally compatible with regional conditions. Rooftop photovoltaic systems and floating solar installations on reservoirs emerge as the most suitable options, as they minimize conflicts with agricultural land use and environmental protection priorities. In contrast, large-scale ground-mounted installations present trade-offs related to land use and visual impact, while deployment in natural open areas is generally constrained by environmental considerations.

Rather than focusing solely on theoretical solar potential, the analysis demonstrates that deployable potential is primarily determined by land-use compatibility and infrastructure access.

Spatial modelling results indicate that the most favourable locations for renewable energy deployment are concentrated in areas where high solar irradiance coincides with existing built environments, water infrastructure, and proximity to grid connections. This reinforces the importance of prioritizing distributed and infrastructure-integrated solar solutions.

Solar radiation conditions were assessed using representative seasonal scenarios and validated against data from the Israeli Meteorological Service. These inputs were combined with land-use, infrastructure, and environmental criteria to produce spatial suitability maps that support planning decisions.

4.3 Model Outputs

The model and its outputs can be accessed through an interactive StoryMap available at the following website:

https://storymaps.arcgis.com/stories/ec1d874feb294a95aaa570ba041a3fc9

The platform serves as a practical decision-support tool, enabling policymakers, planners, and regional stakeholders to translate spatial analysis into actionable planning decisions.

Through the StoryMap, users can:

- identify suitable locations for different solar technologies (e.g., rooftop PV, floating PV, agrivoltaics)
- compare deployment options across land-use categories
- assess trade-offs between energy development, agriculture, and environmental protection
- evaluate proximity to infrastructure and grid connection points
- explore alternative planning scenarios based on different policy priorities

The platform integrates spatial datasets, suitability maps, and analytical tools within a single interface, supporting transparent and evidence-based decision-making. A detailed description of the platform's technical components and data structure is provided in Annex A.

Importantly, the tool does not prescribe a single optimal solution. Instead, it enables decision-makers to explore multiple scenarios and select deployment strategies that align with regional priorities, including agricultural sustainability, environmental protection, and infrastructure capacity.

In this way, the StoryMap serves as a bridge between technical analysis and policy implementation, supporting a more coordinated and place-based approach to renewable energy development in the Jordan Valley.

5 Policy Implications

The spatial assessment highlights that renewable energy planning in the Jordan Valley is not constrained by resource availability, but by the need to balance energy generation with agricultural productivity, environmental protection, and infrastructure capacity.

While the region benefits from exceptionally high solar irradiance, only a portion of the theoretical potential can be realistically deployed due to land-use restrictions, environmental considerations, and grid limitations. This emphasizes the importance of moving from resource-based planning toward spatially informed, policy-driven deployment strategies.

The findings indicate that distributed solar systems represent the most compatible pathway for renewable energy expansion in the region. Especially rooftop photovoltaic systems and floating solar installations on reservoirs provide opportunities to increase energy generation while minimizing land-use conflicts.

A key insight concerns the strong interlinkages between energy and water systems. Irrigation reservoirs and aquaculture ponds represent both major electricity consumers and strategic locations for solar deployment. Integrating solar technologies with water infrastructure can therefore deliver multiple benefits, including reduced evaporation losses, improved energy efficiency, and enhanced system resilience.

The spatial distribution of demand further highlights the importance of decentralized energy systems. Locating renewable energy generation close to agricultural and water-related demand centers can reduce transmission losses, alleviate pressure on grid infrastructure, and improve regional energy security.

These findings point to the need for a coordinated policy approach that integrates energy planning with land-use management, agricultural systems, and water infrastructure.

6 Transferability and Limitations

The GIS based decision support framework developed in this study is transferable to other regions facing similar planning challenges, particularly areas where renewable energy expansion must be balanced with agricultural land use, environmental protection, and infrastructure constraints.

Regions characterized by strong water–energy–agriculture interconnections, such as arid and semi-arid agricultural basins, may particularly benefit from spatial planning tools that integrate renewable energy potential with water infrastructure and agricultural systems.

At the same time, several limitations should be considered. The model outputs depend on the availability, quality, and spatial resolution of input datasets. In addition, the weighting of criteria within the MCDA framework may influence the resulting suitability assessments and should therefore be interpreted as scenario-based rather than deterministic outcomes.

Furthermore, detailed modelling of grid hosting capacity and transmission constraints was beyond the scope of this study. Incorporating high-resolution grid data, economic feasibility assessments, and dynamic demand projections would further strengthen the applicability of the model for operational planning.

Despite these limitations, the framework provides a robust basis for supporting strategic planning and policy development.

7 Conclusions and Policy Recommendations

The Jordan Valley is characterized by exceptional solar energy potential, and can thus play an important role in Israel's renewable energy transition. However, realizing this potential requires a shift from resource-based assessments toward integrated, spatially informed planning approaches that align energy development with land-use priorities, infrastructure capacity, and environmental considerations.

This study demonstrates that GIS-based decision-support tools can support this transition by enabling policymakers and planners to identify renewable energy deployment pathways that are both technically feasible and compatible with regional constraints. Distributed and infrastructure-integrated solar solutions emerge as the most viable pathways for expanding renewable energy while minimizing conflicts.

The key policy recommendations emerging from the analysis are summarized in Table 4.

Table 4: Key Policy Recommendations

Policy Area	Recommendation	Key Actions	Expected Impact
Deployment Strategy	Prioritize low-conflict solar solutions	Promote rooftop PV, floating PV, and infrastructure-based installations	Minimize land-use conflicts and enable faster deployment
Spatial Planning	Develop regional solar zoning framework	Define priority, conditional, and restricted zones for solar deployment	Improve planning clarity and reduce conflicts
Grid Integration	Align renewable deployment with grid capacity	Conduct hosting capacity assessments and plan targeted upgrades	Increase system reliability and avoid bottlenecks
Agriculture Integration	Support agrivoltaics	Develop regulatory and financial incentives for dual land use	Maintain productivity while expanding solar capacity
Water–Energy Nexus	Integrate solar with water infrastructure	Promote PV on reservoirs, aquaculture, and pumping systems	Increase efficiency and reduce evaporation losses
Governance	Strengthen cross-sector coordination	Establish coordination mechanisms between energy, agriculture, and planning bodies	Improve policy coherence and implementation
Decision-Support Tools	Institutionalize GIS-based tools	Integrate tools such as the Story Map into planning processes	Enhance evidence-based decision-making

These recommendations highlight the importance of integrating spatial planning tools with policy frameworks to enable coordinated and conflict-sensitive renewable energy deployment. By linking spatial analysis with practical decision-support tools, renewable energy development in the Jordan Valley can be aligned with broader goals of agricultural sustainability, environmental protection, and climate resilience. The approach presented in this study provides a replicable model for other regions facing similar land-use and resource management challenges.

8 References

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Annex A: Technical Description of the GIS-Based Decision-Support Platform

A1. Overview:

This annex provides a technical description of the GIS-based decision-support platform developed to assess renewable energy deployment options in the Jordan Valley. The platform is implemented as an interactive StoryMap within the ArcGIS Online environment of the Arava Institute and integrates multiple spatial datasets, analytical layers, and visualization tools.

While the main text presents policy-relevant findings, this annex documents the underlying data structure, analytical framework, and modelling components that support the spatial assessment.

A2. Spatial Data and Geodatabase

The platform is based on a geodatabase that integrates multiple spatial datasets relevant for renewable energy planning (see Table A2).

Table A2. Spatial Data Layers Integrated in the Geodatabase for Renewable Energy Planning

Category	Dataset / Layer	Description / Relevance for Planning
Solar Resource	Solar radiation data	Seasonal and annual irradiance levels to identify high-potential solar zones
Land Use	Land-use data	Classification of agriculture, built-up areas, and open spaces for siting
Topography	Topographic data	Slope and aspect analysis to assess technical feasibility of installations
Water Systems	Water bodies	Includes reservoirs and aquaculture systems with potential for floating PV
Infrastructure	Infrastructure data	Roads, substations, and grid connections for accessibility and integration
Environmental Constraints	Protected areas and buffer zones	Identification of restricted or sensitive areas to avoid development conflicts

Each dataset includes both spatial and attribute information and is harmonized within a common coordinate system to enable integrated spatial analysis.

A3. Multi-Criteria Decision Analysis (MCDA) Framework

The analysis applies a Multi-Criteria Decision Analysis (MCDA) approach to evaluate the suitability of different locations for renewable energy deployment.

The framework integrates multiple criteria, including:

- solar resource availability
- land-use compatibility
- proximity to infrastructure
- environmental constraints

Each criterion is standardized and assigned as a relative weight reflecting its importance within the planning framework. These weights can be adjusted to reflect alternative policy priorities or planning scenarios.

A4. Spatial Processing and Suitability Modelling

Spatial analysis is performed within a GIS environment, combining input datasets through a weighted overlay approach. The model generates a composite suitability index that represents the relative suitability of each spatial unit for renewable energy deployment.

Solar radiation conditions are assessed under representative seasonal scenarios and validated against data from the Israeli Meteorological Service.

The model operates at the level of spatial polygons (e.g., agricultural plots, reservoirs, built-up areas), enabling analysis at a scale relevant for regional planning.

A5. Model Outputs

The platform produces several types of outputs, including:

- Spatial suitability maps indicating areas with varying levels of appropriateness for solar energy deployment
- Technology-specific suitability assessments (e.g., rooftop PV, floating PV, agrivoltaics)
- Estimated solar energy potential, expressed in Wh/m^2 and aggregated to MWh

- Land-use-based aggregation of solar potential

These outputs support the identification of locations where renewable energy deployment is technically feasible and compatible with land-use and environmental constraints.

A6. Infrastructure and Proximity Analysis

The platform includes tools for assessing proximity to key infrastructure elements, including:

- electricity substations and grid connections
- road networks and accessibility

Buffer-based spatial analysis is used to identify areas with higher feasibility for grid connection and implementation.

A7. Scenario Exploration

The model is designed as a parametric framework, allowing users to explore alternative planning scenarios by adjusting:

- weighting of suitability criteria
- land-use assumptions
- spatial constraints

This enables the evaluation of trade-offs between competing objectives, such as maximizing energy generation, protecting agricultural land, or minimizing environmental impacts.

A8. Platform Implementation

The decision-support model is implemented as an interactive Story Map, which integrates:

- spatial datasets
- suitability maps
- analytical outputs
- visualization tools

The platform is hosted within the ArcGIS Online environment of the Arava Institute and provides an accessible interface for exploring renewable energy deployment options.

The GIS-based decision-support platform provides a structured and flexible framework for assessing renewable energy deployment in the Jordan Valley. By integrating multiple spatial datasets and analytical components, the model supports scenario-based exploration and evidence-based planning.

This annex complements the main paper by documenting the technical foundation of the analysis, while the main text focuses on policy implications and decision-making applications.