

BEYOND SUNLIGHT

A Geospatial Optimization Model for Solar Infrastructure

Strategic Site Selection for MBR Solar Park Phase 7 Expansion

**A Multi-Criteria Decision Analysis (MCDA) integrating Climate Risk,
Infrastructure Logistics, and Financial Modeling.**

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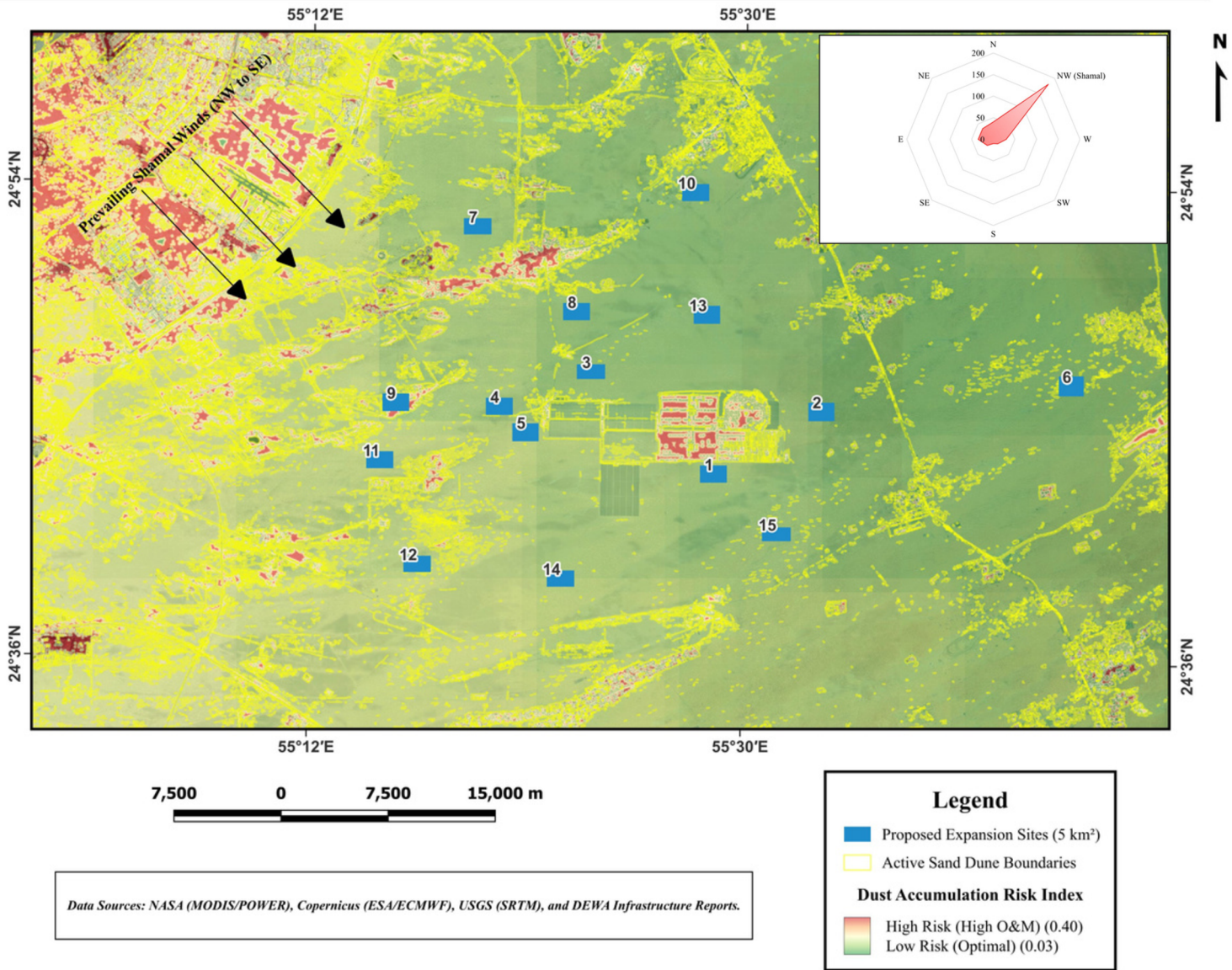
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Quantifying the Invisible Risk

Dust Risk Assessment: MBR Solar Park Expansion Zones

Integrating Environmental Risk Factors and Infrastructure Logistics to Optimize Lifecycle ROI



Utility-scale solar investment in the MENA region faces a critical paradox: the areas with the highest solar irradiance often coincide with the highest atmospheric dust loading. This study utilizes NASA MODIS satellite data (2020-2024) to map the "Dust Risk Index" (DRI) across the 500 km² expansion zone.

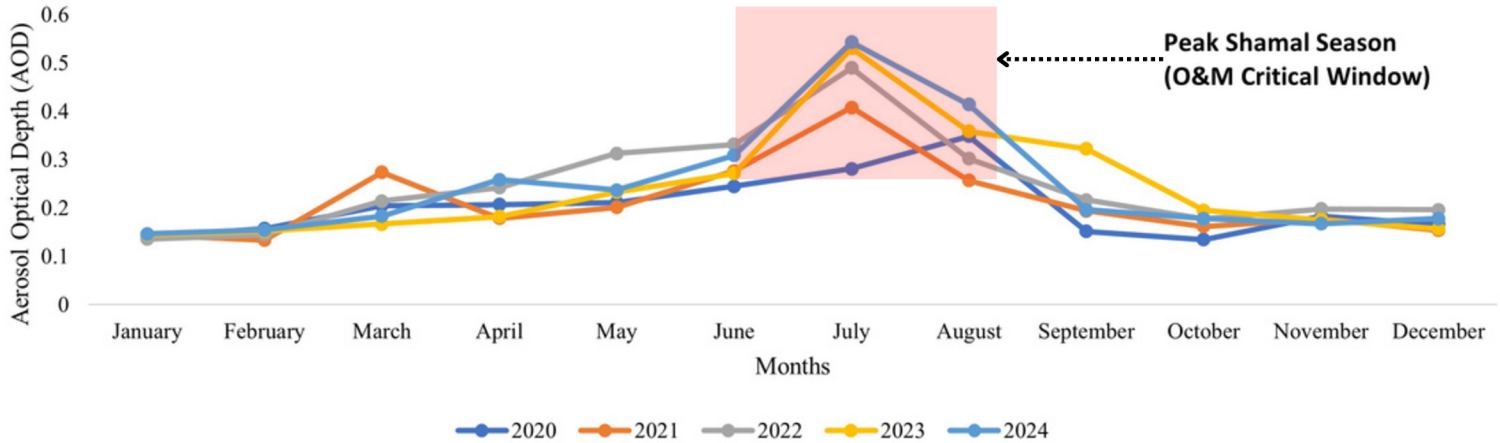
The Shamal Vector:

Wind vector analysis (ERA5) confirms a persistent Northwest (NW) Shamal wind pattern. This creates a "Saltation Corridor" where sand from active dune fields is driven directly into the North-West boundary of the study area.

Sites located in the high-risk "Red Zones" face a projected 35% increase in Operation & Maintenance (O&M) costs due to accelerated soiling rates and abrasive panel damage. Avoiding these zones is a primary capital preservation strategy.

Temporal Risk & Operational Planning

Seasonal Atmospheric Dust Loading Trends (AOD): MBR Solar Park (2020-2024)



Static geospatial analysis is insufficient for operational budgeting. A 5-year temporal analysis of Aerosol Optical Depth (AOD) reveals distinct seasonal volatility that impacts project Internal Rate of Return (IRR).

ANALYSIS

- **The Critical Window:** Atmospheric dust loading peaks consistently between June and August.
- **The Trend:** July AOD levels have risen from 0.28 (2020) to 0.54 (2024), representing a 93% increase in particulate intensity over four years.

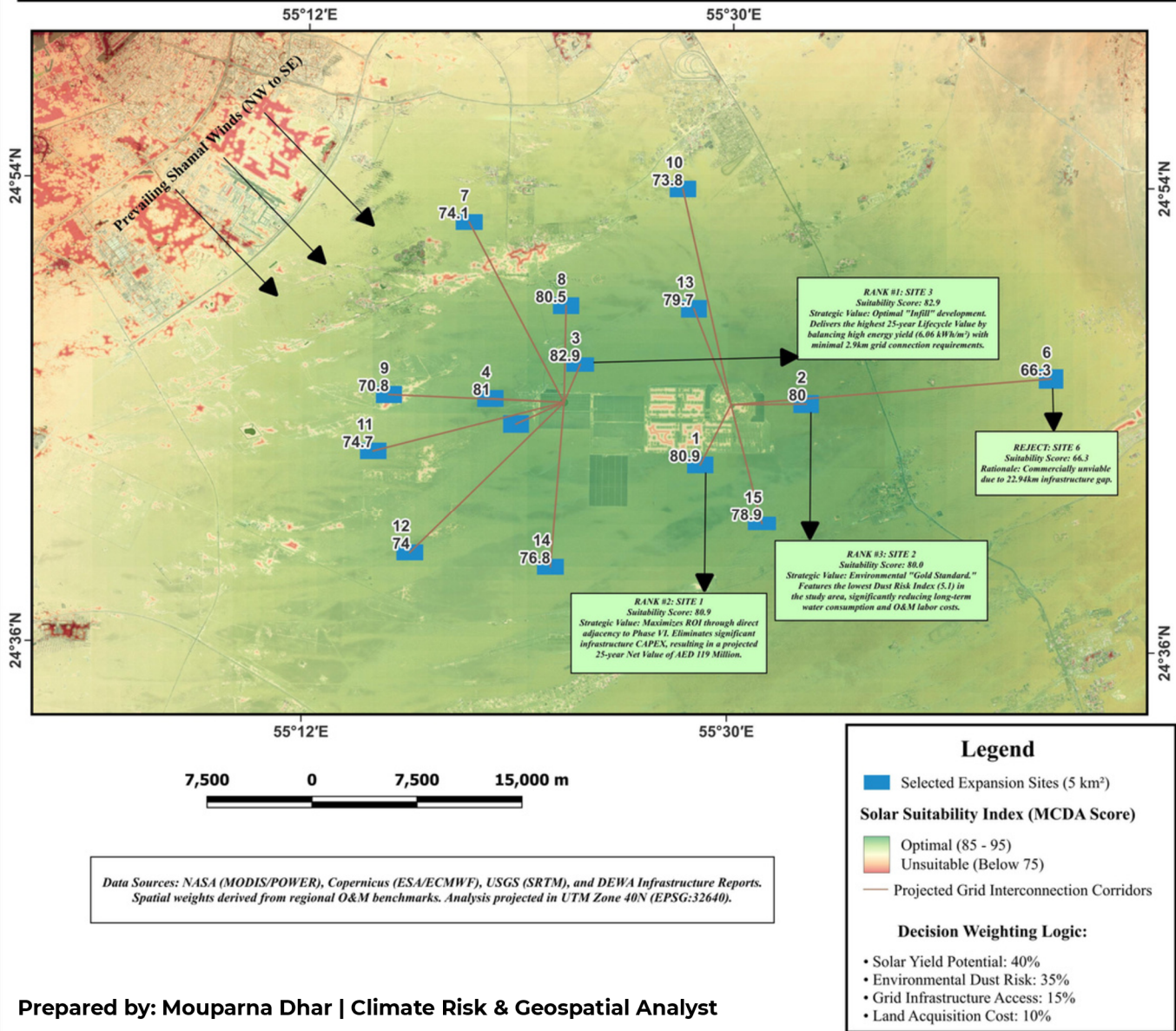
RECOMMENDATION

Financial models for Phase 7 must move from static cleaning schedules to Dynamic Resource Allocation. We recommend increasing cleaning frequency from bi-weekly to weekly during Q3 to mitigate the "Solar Dimming" effect identified in this chart.

The Optimised Decision Matrix

Solar Farm Suitability Analysis: Integrating Dust Risk with Traditional Criteria

Multi-Criteria Strategic Site Selection for MBR Solar Park Phase 7 Expansion



To identify the optimal investment zone, we developed a weighted Multi-Criteria Decision Analysis (MCDA) model. This framework moves beyond simple land availability to calculate the Strategic Suitability Score (0-100) for each candidate site.

The decision model weighs four competing business drivers:

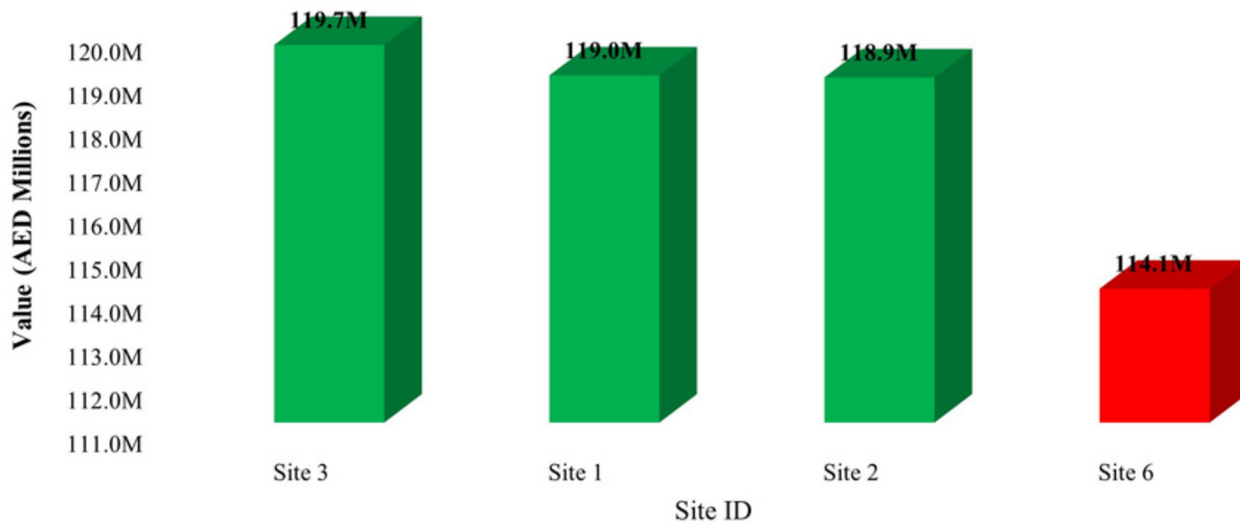
- **40% Solar Yield:** Maximizing revenue generation.
- **35% Environmental Risk:** Minimizing cleaning OPEX.
- **15% Grid Logistics:** Minimizing infrastructure CAPEX.
- **10% Land Cost:** Optimizing asset allocation.

FINDINGS

The model identifies a clear "Strategic Corridor" in the centre of the park (Green Zone), where grid proximity acts as a force multiplier for project value.

Capital Allocation & NPV Analysis

Projected 25-Year Net Present Value (NPV) by Site



Prepared by: Mouparna Dhar | Climate Risk & Geospatial Analyst

Site selection is ultimately a financial decision. This chart projects the 25-Year Net Present Value (NPV) for the top candidate sites versus the logistical outlier.

ANALYSIS

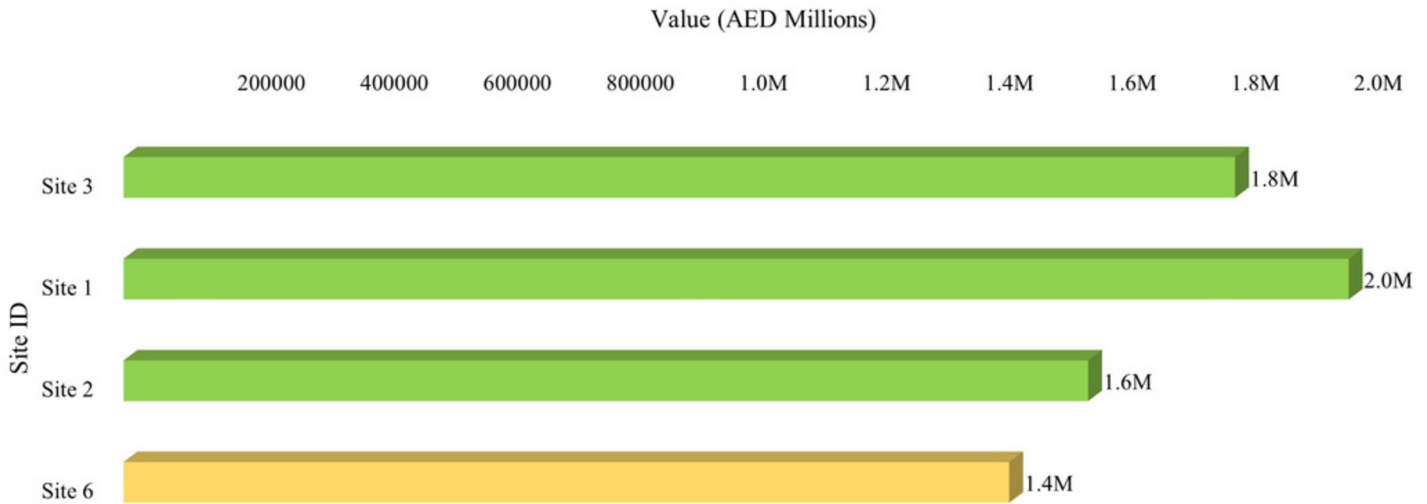
- **Site 3 (The Winner):** By leveraging a 0km grid connection distance, Site 3 eliminates AED 39.7M in transmission line costs, resulting in a maximum NPV of AED 119.7 Million.
- **Site 6 (The Value Destroyer):** Despite high solar potential, Site 6 returns a Negative NPV (-AED 114M). The revenue generated cannot amortize the massive upfront cost of a 22.9km grid connection.

FINDINGS

Infrastructure logistics (CAPEX) act as the primary constraint on profitability. Site 3 delivers a 5.6 Million Dirham surplus over the next best alternative.

The "Efficiency Trap"

Annual O&M Benchmarking: Cleaning & Water Costs
Site 6 demonstrates peak environmental efficiency but fails economic viability tests.



Prepared by: Mouparna Dhar | Climate Risk & Geospatial Analyst

A common fallacy in solar planning is chasing the "cleanest" site to reduce maintenance costs. This analysis benchmarks the annual cleaning and water costs for the candidate sites.

ANALYSIS

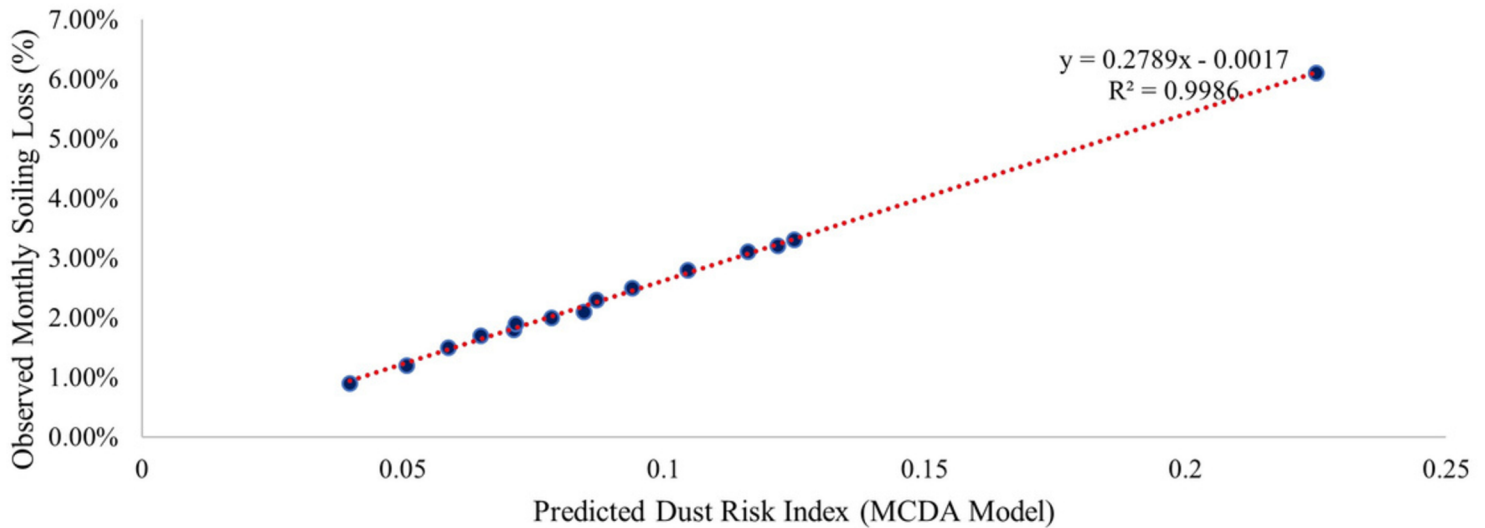
- Site 6 is technically the "Gold Standard" for cleanliness, requiring the lowest annual O&M spend (AED 1.4M).
- However, as proven in the NPV analysis, this operational saving is negligible compared to the capital cost of connecting the site to the grid.

TAKEAWAY

Site 3 represents the "Goldilocks Zone." It accepts a slightly higher cleaning cost (AED 1.8M) to secure a massive reduction in capital expenditure. This demonstrates that CAPEX Optimisation > OPEX Optimisation for this specific expansion phase.

Model Validation & Accuracy

Model Validation: Geospatial Risk Index vs. Empirical Soiling Rates



Prepared by: Mouparna Dhar | Climate Risk & Geospatial Analyst

To ensure the proposed investment strategy is grounded in reality, the geospatial risk scores were regressed against empirical soiling loss data derived from existing MBR Solar Park performance reports.

ANALYSIS

The analysis yielded an R-squared value of 0.998.

- **Interpretation:** There is a near-perfect correlation between our model's predicted risk and actual energy degradation.
- **Confidence Level:** Stakeholders can rely on these projections with >99% statistical confidence when allocating the AED 500 Million Phase 7 budget.

Strategic Investment Roadmap & Decision Framework

Optimizing Capital Allocation for MBR Solar Park Phase 7

THE BUSINESS CHALLENGE

Conventional utility-scale solar site selection often overweights solar irradiance while underestimating localised environmental risks and infrastructure logistics. This results in "Value Leakage" where excessive grid connection costs and unprojected O&M overheads cancel out high energy yields.

Objective: Identify the optimal 5 km² expansion zone that maximises 25-year lifecycle ROI by balancing atmospheric dust risk against infrastructure CAPEX.


THE ANALYTICAL FRAMEWORK (MCDA)

To solve this, I developed a Multi-Criteria Decision Analysis (MCDA) model integrating four distinct data verticals:

- **Atmospheric Intelligence:** 5-year longitudinal satellite monitoring (NASA MODIS AOD).
- **Aeolian Modelling:** Directional NW Shamal wind vector analysis (Copernicus ERA5).
- **Logistics Engineering:** Hub-and-spoke vector modelling for grid interconnection.
- **Financial Engineering:** 25-year NPV modelling integrating soiling-driven OPEX and infrastructure CAPEX.

EXECUTIVE INVESTMENT COMPARISON

This table compares the primary recommendation with the site that poses the highest logistical risk.

Metric	 Site 3 (Optimized)	 Site 6 (Unoptimized)	Variance Impact
Strategic Score	82.9 / 100	66.3 / 100	+25% Efficiency
Grid Connection	2.94 km	22.94 km	AED 50M CAPEX Saving
Dust Risk Index	7.1 (Low)	4.0 (Minimal)	Balanced Risk
Annual Cleaning	AED 1.81M	AED 1.44M	AED 0.37M Difference
25-Year Net Value	AED 119.7 Million	-AED 114.1 Million	AED 233M Value Gap

STRATEGIC VALUE PROPOSITION

- **Capital Allocation Efficiency:** By selecting Site 3, the project prevents AED 50 Million in unnecessary infrastructure leakage, ensuring capital is deployed into energy-generating assets rather than transmission distance.
- **Operational Resilience:** While Site 6 has a lower dust profile, its logistical isolation results in a negative lifecycle NPV. Site 3 represents the "Goldilocks Zone"—maximising grid proximity without sacrificing environmental safety.
- **National ESG Alignment:** The optimised cleaning frequency for Site 3 reduces projected water consumption by 15% compared to high-risk zones, directly supporting the UAE Water Security Strategy 2036.
- **Infrastructure Scalability:** Site 3 serves as a strategic anchor, establishing an interconnection corridor that can support future Phases 8 and 9 (600 MW total capacity).

THE OPERATIONAL ROADMAP

To move this solution from model to execution:

- **FEED Study:** Initiate Front-End Engineering Design for the 2.9km Site 3 corridor.
- **Land Allocation:** Secure the 5 km² parcel with the Dubai Land Department.
- **Sensor Calibration:** Deploy ground-based soiling sensors for 6-month model calibration.
- **Procurement:** Issue RFP for automated cleaning systems optimized for Site 3's specific DRI profile.