Semarak Engineering Journal

Journal homepage:
https://semarakilmu.my/index.php/sej/index
ISSN: 3036-0145

Solar Photovoltaic Adoption in East Java Non-Profit Organizations

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ARTICLE INFO

Article history:
Received 13 May 2026
Received in revised form 27 July 2026
Accepted 7 August 2026
Available online 9 September 2026

Keywords:
Solar photovoltaic; bibliometric review; East Java; meta-analysis; Monte Carlo simulation

ABSTRACT

Non-profit organizations in East Java need dependable electricity for service continuity, daily operations, and cost control, yet face capital, regulatory, behavioral, and tropical-climate barriers to rooftop solar photovoltaic adoption. This study combines a focused literature review, bibliometric mapping of 25 verified domain studies selected from 79 unique Scopus records, a random-effects synthesis of five Global Solar Atlas locations, and a 50,000-iteration Monte Carlo model for a common 12 kWp system. The 25 studies met predefined adoption, finance/policy, governance/behavior, and tropical-performance criteria and passed metadata verification. Modeled annual output ranges from 17.231 to 18.227 MWh; pooled yield is 4.03 kWh/kWp/day (95% CI: 3.92–4.14). Median NPV is IDR 40.7–54.9 million, with a conditional positive-NPV probability of 86.4–92.5%. Sensitivity analysis identifies the discount rate, tariff escalation, capital cost, avoided electricity value, and self-consumption as the dominant drivers of NPV. The five-city results are screening evidence, not a representation of all tropical climates or roofs. A 30% grant or blended-finance contribution raises positive-NPV probability above 99.8% and reduces median payback to 5.8–6.2 years.

1. Introduction

Solar photovoltaic (PV) systems can reduce operating expenditure, strengthen service continuity, and visibly align institutional practice with environmental missions [1-3]. These benefits are especially relevant to schools, religious foundations, social service providers, community clinics, and other non-profit organizations whose electricity demand is persistent but whose capital budgets are constrained [4-6]. Technology availability alone, however, does not produce adoption. Investment decisions are shaped by perceived risk, governance routines, policy stability, trust in installers, access to finance, and the fit between generation and daytime loads [7-10].

Indonesia combines strong solar resources with a policy environment that has repeatedly changed. Studies of rooftop PV perceptions and system dynamics show that financial attractiveness,

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https://doi.org/10.37934/sej.16.1.4964

procedural clarity, and institutional credibility influence willingness to invest [3,11]. The current rooftop-PV regime under Minister of Energy and Mineral Resources Regulation No. 2/2024 emphasizes self-use, quota-based development, and system reliability, while the former export-import settlement is no longer the default basis for new projects [12]; consequently, a non-profit organization should not evaluate PV as a simple export-revenue asset; it should prioritize self-consumption, operational resilience, and mission value.

The supplied evidence map identifies three interacting domains: financial and regulatory innovation, behavioral governance, and climate-responsive technical design. Direct evidence on East Java non-profit organizations is sparse, so several mechanisms are necessarily transferred from households, communities, municipalities, or broader Southeast Asian contexts. The five Global Solar Atlas (GSA) reports add a location-specific resource layer for Surabaya, Malang, Kediri City, Madiun, and Blitar. Still, these five locations represent a purposive regional sample rather than a comprehensive sample of East Java microclimates. The revised study, therefore, treats the five-city results as screening evidence and avoids extrapolating them to every tropical setting or every roof without site-specific validation.

The research gap is therefore methodological and decision-oriented. No integrated assessment was found that (i) verifies and maps a focused evidence corpus on PV adoption mechanisms, (ii) structures the evidence into an explicit schematic framework for mission-driven organizations, (iii) compares five sampled East Java locations with common performance indicators, and (iv) propagates technical and financial uncertainty into probability distributions. This integration is significant because deterministic payback calculations can hide downside risk, while purely narrative reviews cannot prioritize locations or financing interventions.

This study aims to transform the supplied descriptive evidence map and GSA reports into a transparent decision framework. The objectives are to: conduct a systematic literature review and bibliometric analysis; construct a schematic causal model linking finance, governance, behavior, and microclimate; compare and meta-analyze city-level PV performance; quantify investment uncertainty through Monte Carlo simulation; and derive implementation guidance for East Java non-profit organizations.

2. Methodology

2.1 Review Design and Evidence Verification

The supplied Scopus export contained 79 unique records and was treated as the starting pool rather than as a peer-reviewed synthesis. Titles, abstracts, journals, years, and digital object identifiers were checked where available, following a PRISMA-informed screening and eligibility protocol [13]. Records were retained for the focused domain corpus when they addressed at least one of four predefined domains—organizational or household PV adoption; financing and policy instruments; governance and behavioral mechanisms; or tropical PV performance—and provided an outcome or mechanism relevant to the decision framework. After screening, 25 studies met these domain criteria and had resolvable bibliographic metadata; 54 records were excluded from the domain corpus because they did not meet the predefined relevance criteria or were ancillary rather than domain evidence. Methodological references and official policy/data sources were maintained separately. The 25-study corpus includes the 23 domain references cited in the original manuscript, plus two additional Scopus-indexed studies added during revision to ensure the corpus accounts for explicit [14-15].

Table 1
Review protocol and analytical eligibility criteria

Component	Operational definition	Decision rule
Population/context	Non-profit, public-interest, household, community, or analogous organizational adopters	Retain when mechanisms are transferable to mission-driven organizations.
Intervention/exposure	Rooftop PV, PV microgrid, financing, incentives, governance, behavioral interventions, or tropical design	Exclude studies unrelated to PV adoption or performance.
Outcomes	Adoption intention, deployment, cost, yield, reliability, efficiency, governance capacity, or policy effectiveness	Outcome must inform a framework component.
Evidence period	Primarily 2010–2025, with seminal behavioral and methodological studies earlier	Older studies are retained only when foundational.
Verification	Scopus metadata record, resolvable DOI or official publisher metadata; government regulation; World Bank/Solargis documentation	Unverifiable metadata excluded from quantitative claims; policy/data sources checked separately
Synthesis mode	Narrative/schematic for heterogeneous adoption outcomes; quantitative for comparable GSA yield estimates	No forced pooling of incompatible effect measures
Corpus accounting	79 unique Scopus records screened; 25 retained as domain studies	54 records excluded from the domain corpus under the eligibility rules; ancillary methods/policy/data sources kept separate

Figure 1 summarizes the evidence workflow. The final bibliometric domain corpus contained 25 verified studies drawn from the 79-record Scopus starting pool; the remaining 54 records were excluded from the domain corpus under the stated eligibility rules. The corpus is deliberately focused rather than database-exhaustive, and its 25 studies should therefore be interpreted as a decision-oriented evidence set, not as a comprehensive census of PV research. Verification required resolvable DOI or publisher metadata where applicable, with policy and resource sources checked against official documentation.

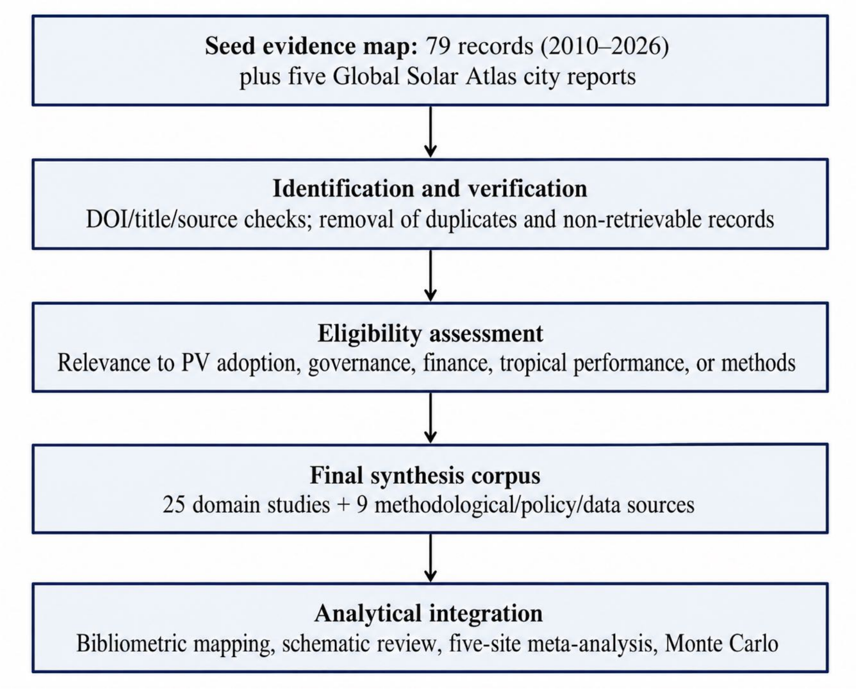

Fig. 1. Evidence identification, verification, and analytical integration workflow

2.2 Bibliometric and Schematic Literature Review

Bibliometric indicators were calculated from the verified domain corpus using publication year, source title, and normalized title/keyword terms. The procedure follows science-mapping principles described by Aria and Cuccurullo [16]. Singular/plural forms and close synonyms were consolidated, including regulation/policy, social learning/peer effects, and cooling/thermal management. Co-occurrence edges were formed when two normalized terms appeared in the same title or assigned keyword string. Because the corpus is deliberately focused rather than database-exhaustive, network centrality is interpreted as thematic prominence within the decision corpus, not as a universal ranking of the field.

The schematic review translated recurring evidence into a causal architecture. Inputs were grouped as financial-regulatory viability, behavioral-collaborative governance, technical-microclimate fitness, and organizational readiness. Mediating mechanisms include perceived behavioral control, subjective norms, trust, transaction cost reduction, data transparency, and learning by observation [1-2,7-10]. Outputs include adoption, sustained operation, cost resilience, and mission-aligned social value.

2.3 GSA Data and Comparative Performance Metrics

The five GSA reports were generated using a common 12 kWp fixed-tilt system with modules facing the equator at an optimum tilt of 12°. Extracted variables were direct normal irradiation (DNI), global horizontal irradiation (GHI), diffuse horizontal irradiation (DIF), global tilted irradiation at optimum angle (GTI), mean air temperature, elevation, and annual AC electricity output. GSA provides long-term modeled estimates of solar resources and PV potential rather than bankable site measurements [17-18]. The common 12 kWp configuration is intentional for cross-city comparability, but using one system size limits direct inference about economies of scale, roof-area constraints, battery integration, and load-specific sizing. The five locations also constitute a sampled set of East Java conditions; they are not a representative sample of all tropical climates. Consequently, the results are used for regional screening and comparative planning, while roof-level decisions require measured or site-specific data.

Specific yield = annual AC energy output / installed capacity

Performance ratio proxy = specific yield / optimum-plane irradiation

The performance-ratio value is a comparative proxy because the reports do not provide a complete measured loss budget. Monthly average daily system outputs were normalized by 12 kWp to compare seasonality across cities. All quantitative comparisons preserve the GSA configuration; they should not be interpreted as final engineering designs for individual roofs.

2.4 Geographic Random-Effects Meta-Analysis

A site-level random-effects synthesis was performed on each city's mean monthly normalized daily yield. The standard error was estimated from the twelve monthly values. The DerSimonian–Laird estimator was used to estimate the between-site variance [19], and heterogeneity was summarized using Cochran's Q and I^2 [20]. Calculations were cross-checked against the conventional inverse-variance formulation implemented in meta-analysis software [21]. This is a geographic evidence synthesis, not a clinical intervention meta-analysis; its purpose is to quantify the common East Java yield level and the residual location spread under a common system design.

2.5 Monte Carlo Techno-Economic Model

A 50,000-iteration Monte Carlo simulation propagated uncertainty over a 25-year project horizon following the general stochastic-sampling principle introduced by Metropolis and Ulam [22]. Each city was evaluated under direct purchase and a blended-finance scenario in which a grant, donation, or community contribution covered 30% of the initial capital cost. The model credits only self-consumed electricity, consistent with a conservative interpretation of the current Indonesian rooftop-PV regime [12]. No revenue was assigned to surplus electricity.

Table 2
Monte Carlo input assumptions for a 12 kWp non-profit installation

Variable	Distribution	Minimum / mode/maximum	Rationale
Installed capacity	Fixed	12 kWp	Fixed for cross-city comparability; alternative system sizes not evaluated
Capital cost	Triangular	IDR 11.5 / 14.0 / 17.0 million per kWp	Scenario range: procurement-specific quotation required
Annual O&M	Triangular	1.0 / 1.5 / 2.0% of full CAPEX	Routine inspection, cleaning, monitoring, and minor repair
Self-consumption	Triangular	70 / 85 / 95%	Daytime-load alignment is the principal value driver
Avoided electricity value	Triangular	IDR 1,250 / 1,450 / 1,700 per kWh	Scenario input, not an official tariff quotation
Tariff escalation	Triangular	0 / 2 / 4% per year	Captures long-term avoided-cost uncertainty
Discount rate	Triangular	6 / 8 / 11%	Non-profit opportunity-cost and financing uncertainty
PV degradation	Triangular	0.3 / 0.5 / 0.8% per year	Consistent with long-term PV degradation literature [23]
Interannual weather	Normal, truncated	Mean 1.00; SD 0.03	Represents year-to-year resource variation
Inverter replacement	Discrete + triangular	Year 12–15; 6 / 8 / 12% of full CAPEX	Lifecycle replacement risk

For iteration i and year t, the net present value (NPV) was calculated as the discounted sum of self-consumption benefits, less capital, operating, and replacement costs. The levelized cost of electricity (LCOE) is calculated by dividing discounted lifecycle costs by discounted generation. Simple payback was linearly interpolated in the first year when the cumulative undiscounted cash flow became non-negative. Results are reported as 5th, 50th, and 95th percentiles and as the conditional Monte Carlo probability of NPV > 0; this probability summarizes the share of simulated cases that are favorable under the specified input distributions and should not be interpreted as an empirical frequency. Figure 9 reports a rank-correlation sensitivity analysis to identify which uncertain inputs contribute most strongly to NPV variation.

3. Results and Discussion
3.1 Comparison with the Supplied Evidence Map

The original document is best understood as a supplied evidence map: it organizes claims and references but does not disclose a reproducible search string, verification procedure, or quantitative model. The present study explicitly separates source-derived statements, the 25-study verified domain corpus, GSA data, and scenario assumptions.

Table 3
Comparison of the supplied evidence map and the rewritten study

Dimension	Supplied evidence map	Rewritten integrated study
Primary purpose	Broad thematic synthesis	Decision-oriented assessment for East Java non-profits
Evidence control	Supplied an evidence map with heterogeneous metadata	DOI/source verification and explicit eligibility rules
Literature method	Narrative grouping by finance, behavior, climate, and governance	Systematic, bibliometric, and schematic review
Regional data	General discussion of East Java microclimate	Five-city common-configuration GSA comparison
Quantitative synthesis	Meta-analysis mentioned but not implemented	Inverse-variance geographic random-effects synthesis
Uncertainty	Limitations described qualitatively	50,000-iteration probabilistic lifecycle model
Actionability	General policy and design recommendations	City ranking, risk probabilities, and phased implementation matrix
Main limitation	Direct non-profit evidence is sparse	Still relies on transferability and modeled—not measured—site data

3.2 Bibliometric Structure and Thematic Convergence

The focused 25-study corpus shows a transition from early diffusion and peer-effect studies toward Indonesia-specific policy, institutional, and tropical performance research. Figure 2 displays the publication pattern. The concentration after 2020 reflects increasing attention to adoption governance, customer intention, low-carbon transition, and tropical system performance. It also reveals a fragmentation problem: behavioral studies usually model intention, while engineering studies quantify temperature, cooling, or output, and financial-policy studies evaluate incentives. Few studies integrate all three levels. Because the corpus is intentionally narrow, these patterns describe the selected decision evidence rather than the entire PV literature.

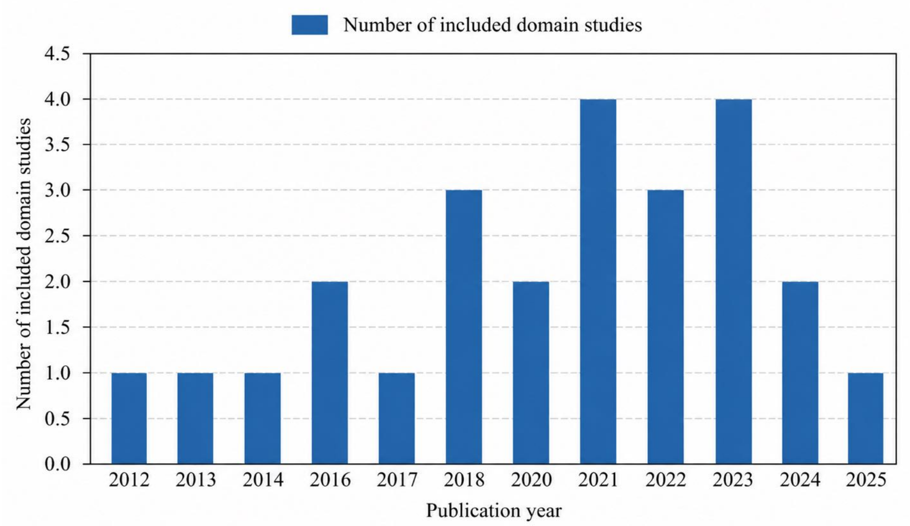

Fig. 2. Annual distribution of the verified domain literature

The co-occurrence map in Figure 3 places adoption, policy, Indonesia, behavior, and technical performance near the thematic core. Finance connects through business models, incentives, and crowdfunding; behavior connects through community, peer effects, and social learning; technical performance connects through tropical conditions, cooling, and reliability. The topology supports an integrated framework rather than a single-factor explanation.

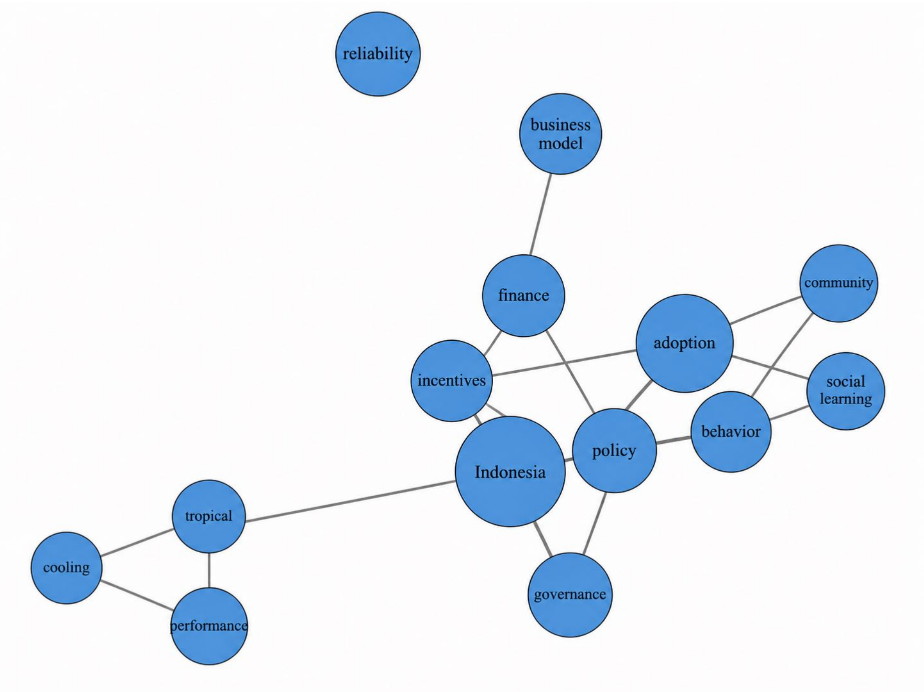

Fig. 3. Normalized keyword and title-term co-occurrence network

Table 4
Schematic evidence synthesis by adoption domain

Domain	Consistent evidence	Transfer to non-profit organizations	Residual uncertainty
Finance and regulation	High upfront cost and unstable incentives suppress adoption; PPA, leasing, loans, and crowdfunding can reduce capital barriers [3-6,11,24]	Use blended finance, service contracts, and donor-backed guarantees; size for self-consumption	The comparative performance of each model among Indonesian non-profits is not directly observed.
Behavior and governance	Attitude, subjective norms, perceived control, trust, and peer learning influence intention and implementation [1-2,7-10,25]	Engage boards, facility staff, beneficiaries, and trusted intermediaries; publish performance results.	Intention models may not predict actual procurement under institutional rules.
Technical and climate	Irradiance, temperature, humidity, dust, and cooling affect output and degradation [23,26-33]	Conduct roof survey, shading analysis, thermal design, monitoring, and maintenance planning.	GSA averages do not capture roof-specific shading, soiling, or equipment quality
Institutional readiness	Governance fragmentation, regulatory ambiguity, and weak coordination create transaction costs [34-35]	Assign decision rights, lifecycle budget, and accountability before tendering.	Power asymmetry and procurement constraints vary by organization.
Integrated implementation	Transparent data and staged pilots reduce uncertainty and build legitimacy.	Pilot–verify–scale approach with defined acceptance thresholds	Longitudinal evidence on mission outcomes remains limited

Figure 4 synthesizes these mechanisms. Financial viability is necessary but insufficient: a nominally attractive project can fail when the board distrusts vendors, no staff member owns performance monitoring, or system sizing ignores daytime load. Conversely, strong environmental commitment cannot compensate for a structurally negative cash flow. Adoption is most robust when the four domains are treated as mutually constraining design conditions.

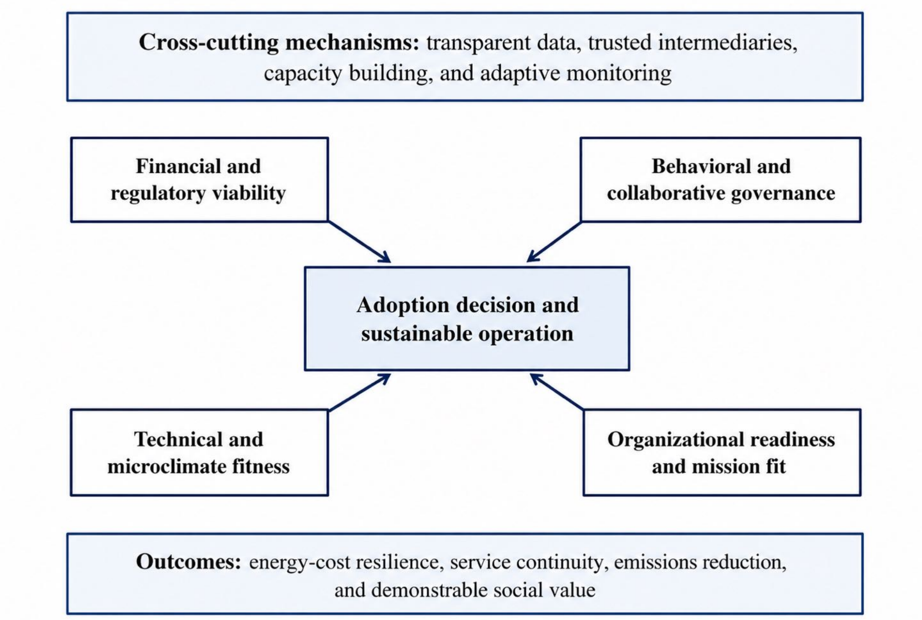

Fig. 4. Integrated strategic management and behavioral governance framework

3.3 Five-City Solar Resource and Output Comparison

Table 5 presents the harmonized GSA data. Kediri City has the highest GHI, GTI, and annual output, followed by Madiun and Surabaya. Blitar and Malang have lower irradiation and modeled output. Surabaya is the hottest location, whereas Malang is the coolest and at the highest elevation. The proxy performance ratio varies narrowly from 0.754 to 0.762, indicating that most output differences arise from solar resource rather than modeled system-loss assumptions.

Table 5
Global Solar Atlas comparison for the common 12 kWp configuration

City	DNI	GHI	GTI	Temp.	Elev.	Annual	Yield	PR
Surabaya	1479.0	1952.0	1988.9	27.4	2	17.988	1499.0	0.754
Malang	1384.7	1867.6	1897.5	23.9	451	17.315	1442.9	0.760
Kediri City	1477.7	1964.4	1999.7	25.2	69	18.227	1518.9	0.760
Madiun	1413.5	1957.2	1990.1	25.9	68	18.078	1506.5	0.757
Blitar	1336.0	1853.9	1883.7	24.6	176	17.231	1435.9	0.762

All irradiation values are in kWh/m²/year, temperature is in °C, elevation is in m, annual output is in MWh/year, and yield is in kWh/kWp/year. The maximum-to-minimum annual output spread is 0.996 MWh, equivalent to 5.8% of the Blitar value. This difference is material for lifecycle economics but not large enough to justify ignoring organizational load, roof condition, or procurement quality.

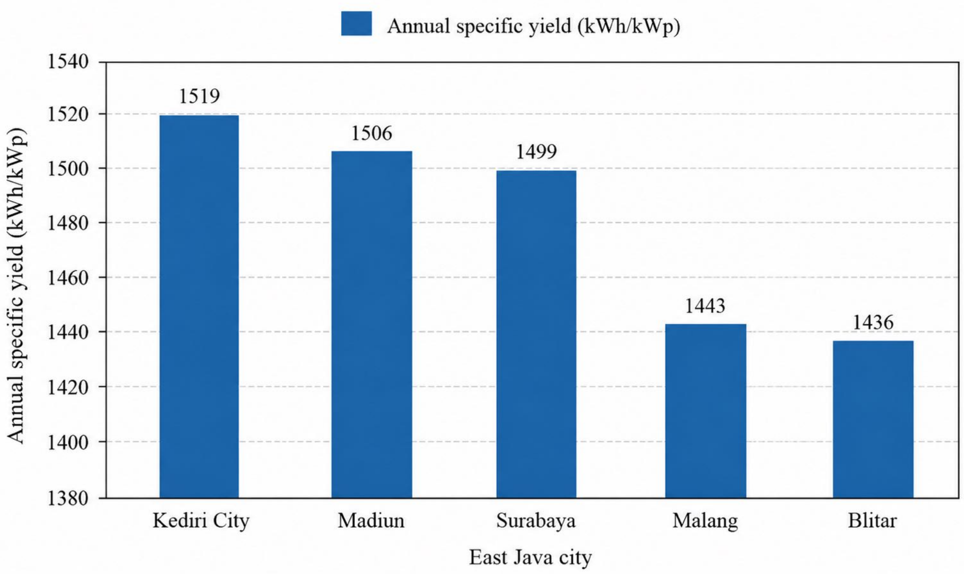

Fig. 5. Annual specific yield ranking across the five East Java locations

Monthly normalized profiles in Figure 6 show a consistent dry-season advantage. September is the peak month in every location, while December or January is generally the lowest. Surabaya has the largest peak-to-trough ratio (approximately 1.56), suggesting greater seasonal variability. A non-profit facility should therefore avoid sizing critical services based solely on the annual mean; monthly demand and resilience requirements should be assessed against the low-output season.

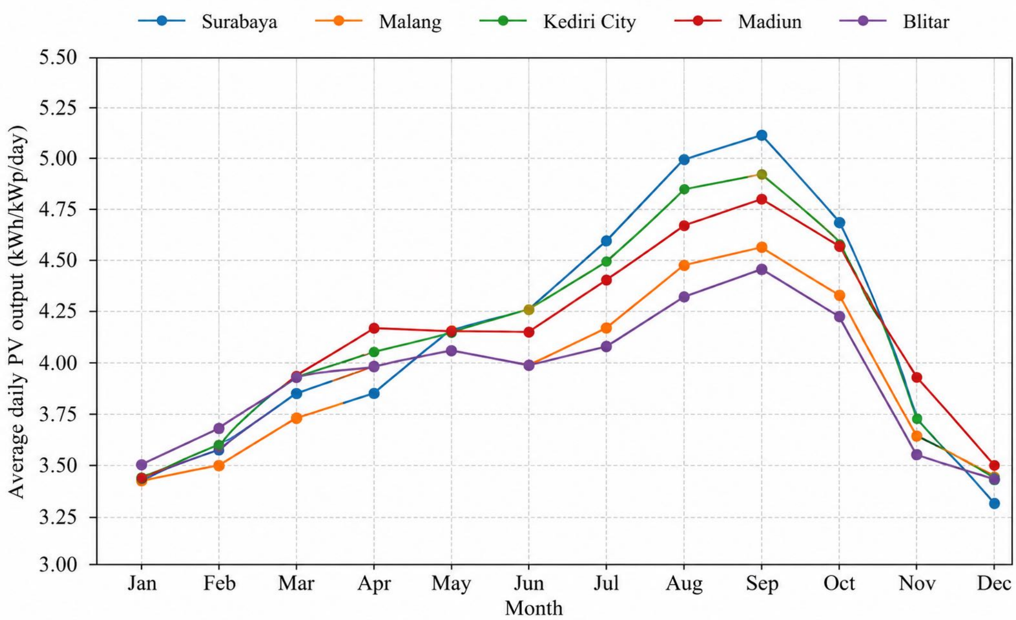

Fig. 6. Monthly normalized average daily PV output from the five GSA reports

3.4 Geographic Meta-Analysis

The site-level means range from 3.94 to 4.15 kWh/kWp/day. The random-effects pooled estimate is 4.03 kWh/kWp/day (95% CI: 3.92–4.14), equivalent to approximately 1471 kWh/kWp/year. Cochran's Q is 2.74 with 4 degrees of freedom, τ^2 is 0.0000, and I^2 is 0.0%. The negligible estimated heterogeneity reflects overlapping monthly uncertainty and a common tropical regional resource regime.

Table 6
Random-effects synthesis of normalized daily output

Location	Mean	SE	95% CI
Surabaya	4.111	0.177	3.764–4.458
Malang	3.951	0.117	3.722–4.181
Kediri City	4.153	0.139	3.879–4.426
Madiun	4.125	0.128	3.873–4.377
Blitar	3.944	0.099	3.751–4.138
Pooled random effects	4.030	0.056	3.921–4.140

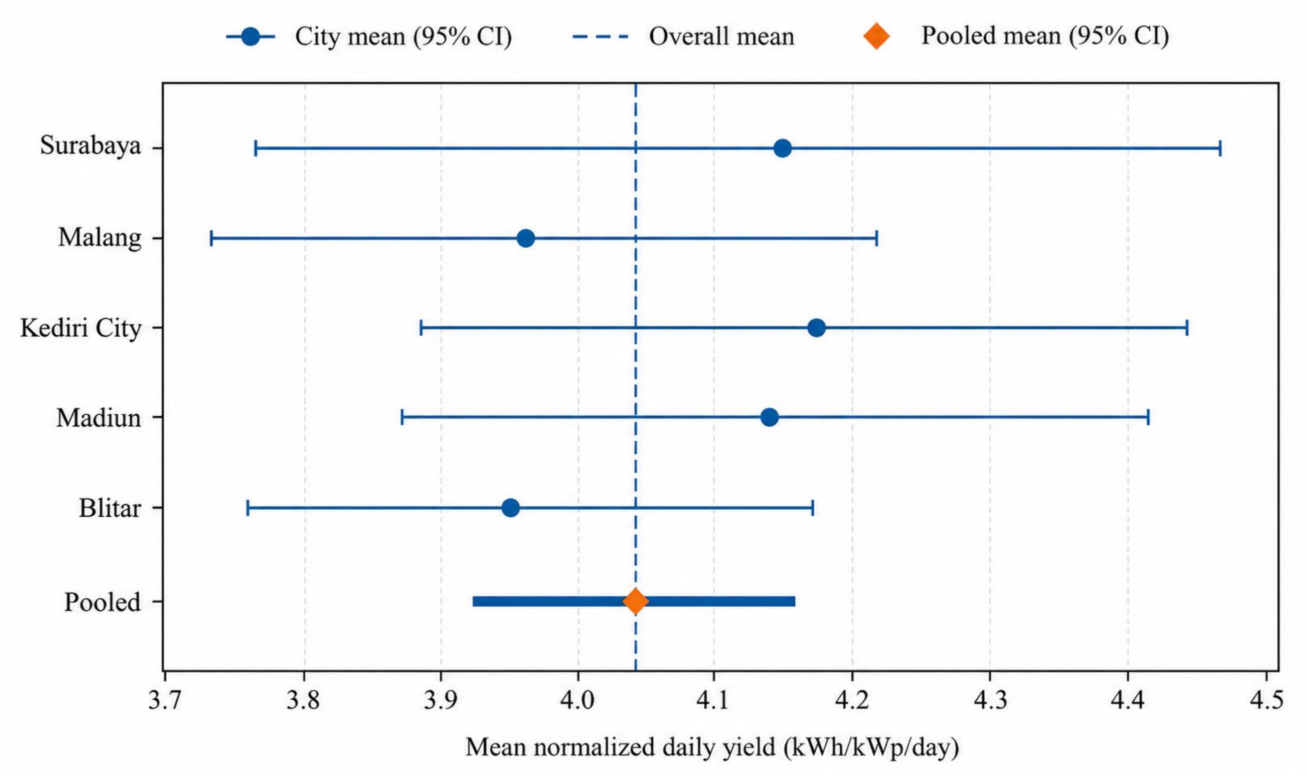

Fig. 7. Forest plot of city-level monthly mean normalized PV output

The pooled result should not be read as evidence that location is irrelevant. The GSA model standardizes equipment, tilt, and system assumptions, whereas actual projects introduce differences in roof orientation, shading, wiring, inverter efficiency, soiling, and maintenance. The five-city sample also cannot represent the full climatic and built-environment diversity of East Java, much less tropical climates globally. The synthesis therefore provides a regional screening estimate of approximately 4.0 kWh/kWp/day before site-specific adjustment, not a bankable yield estimate.

3.5 Monte Carlo Investment Risk

The direct-purchase simulation produces a positive median NPV in every city, but downside risk remains. Kediri City has the strongest distribution, followed by Madiun and Surabaya. Blitar and

Malang have lower median values due to lower modeled yields. The CDFs in Figure 8 show that the risk ordering is stable across most of the distribution, rather than driven solely by extreme outcomes.

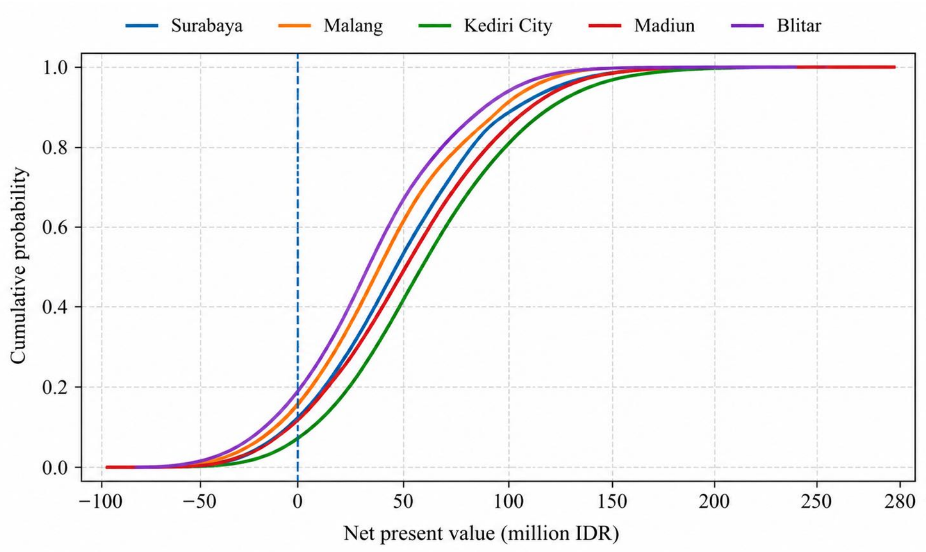

Fig. 8. Monte Carlo cumulative distributions of direct-purchase NPV

Table 7
Probabilistic financial results for the 12 kWp system

City	Scenario	NPV P5	NPV P50	NPV P95	P(NPV>0)	Payback	LCOE
Surabaya	Direct	-9.4	51.4	124.9	91.4%	8.3	1149
Surabaya	30% blended	44.7	102.1	173.6	100.0%	5.9	866
Malang	Direct	-17.2	41.9	112.7	87.2%	8.7	1193
Malang	30% blended	36.8	92.7	162.0	99.9%	6.2	899
Kediri City	Direct	-6.4	55.2	129.6	92.8%	8.2	1134
Kediri City	30% blended	47.1	105.3	177.9	100.0%	5.8	855
Madiun	Direct	-8.0	52.6	126.4	92.0%	8.3	1144
Madiun	30% blended	45.8	103.5	176.0	99.9%	5.9	862
Blitar	Direct	-18.0	40.7	112.2	86.4%	8.7	1199
Blitar	30% blended	35.6	91.4	161.2	99.9%	6.2	903

NPV values in Table 7 are in million IDR, payback is the median in years, and LCOE is the median in IDR/kWh. Under direct purchase, median NPV ranges from IDR 40.7 million in Blitar to IDR 54.9 million in Kediri City. The probability of positive NPV ranges from 86.4% to 92.5%, showing that a favorable median does not eliminate investment risk. The 30% blended-finance scenario raises the median NPV to IDR 91.4–105.9 million, reduces the median payback to 5.8–6.2 years, and raises the probability of a positive NPV above 99.8%.

The sensitivity analysis in Figure 9 indicates that the discount rate, tariff escalation, capital cost, avoided electricity value, and self-consumption dominate the variance of NPV; specific yield is important but less influential than several financial and operational assumptions. The 86.4–92.5% positive-NPV range should therefore be read as conditional on these assumed distributions rather than as a fixed property of the five cities. This result is strategically important: organizations should not choose a city or module technology while neglecting load alignment, financing terms, and procurement cost. Increasing self-consumption through load scheduling can be as valuable as modest gains in panel efficiency.

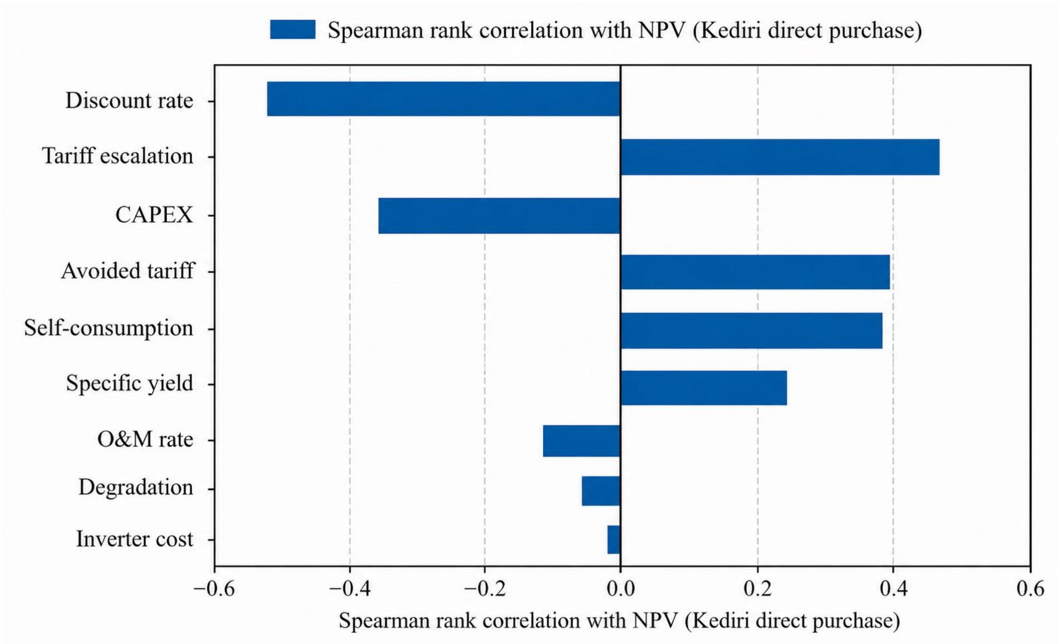

Fig. 9. Rank-correlation sensitivity of Kediri City direct-purchase NPV

3.6 Implementation Framework for Non-Profit Organizations

The integrated evidence supports a staged adoption model rather than a single procurement decision. Stage 1 establishes mission and governance fit: the board defines objectives, risk tolerance, decision rights, and beneficiary communication. Stage 2 verifies technical feasibility through load profiling, roof and structural inspection, shading analysis, electrical protection review, and a site-specific energy model. Stage 3 selects a financing structure that protects service budgets, including direct purchase, donor capital, revolving funds, PPA/service contracts, leasing, or pooled procurement [5-6]. Stage 4 implements transparent tendering and commissioning. Stage 5 monitors energy, uptime, self-consumption, savings, and maintenance, then uses verified performance to justify scaling.

City prioritization should be used as one decision layer. Kediri City and Madiun offer the strongest modeled resource economics; Surabaya is close but requires more attention to high operating temperature and urban soiling. Malang's cooler climate may benefit module efficiency and longevity, but lower irradiation reduces annual output. Blitar has the lowest modeled output and therefore benefits most from grant support, aggressive procurement, high self-consumption, and careful lifecycle cost control. These are screening conclusions, not substitutes for site surveys.

Table 8
Recommended implementation and control matrix

Phase	Core actions	Decision gate	Key evidence/indicator
1. Governance readiness	Form a cross-functional team; define mission, risk, and authority; identify a trusted technical adviser.	Written project charter approved	Named owner, approved objectives, stakeholder map
2. Technical due diligence	Interval load profile; roof/structure/shading survey; protection and interconnection review	Site-specific yield and safety case accepted	Low-season energy, self-consumption, structural, and electrical compliance
3. Financial structuring	Compare direct, grant, PPA, lease, and pooled procurement; test the Monte Carlo downside.	Probability thresholds approved	P(NPV>0), P(payback≤15), budget-at-risk, contract allocation
4. Procurement and commissioning	Performance-based specifications; warranty verification; baseline measurements	Acceptance tests passed	Installed capacity, insulation/protection tests, monitored initial yield
5. Operation and learning	Dashboard, cleaning triggers, anomaly detection, annual review, and public reporting	Scale/modify/stop decision	PR trend, availability, self-consumption, realized savings, service outcomes.

Thermal management should be proportional to risk. Tropical performance studies show that module temperature, dust, and humidity affect output [23,26-33]. Passive ventilation beneath modules, adequate rear clearance, reflective or thermally appropriate roof surfaces, and maintenance access are generally lower-complexity interventions than pumped cooling. Phase-change materials or heat sinks may be justified for constrained roofs or demonstration projects, but lifecycle maintenance and fire/safety requirements must be evaluated before adoption [27-29].

3.7 Limitations and Research Agenda

Four limitations bound interpretation. First, the 25-study evidence corpus is intentionally small and focused, and direct empirical studies of Indonesian non-profit organizations remain scarce; behavioral and financing mechanisms are therefore transferred from households, communities, and public-interest analogs, which limits generalizability. Second, the GSA inputs are long-term modeled averages rather than measured roof-level data, so that the results may miss local shading, soiling, outages, and equipment-specific losses [17-18]. Third, the geographic synthesis covers only five sampled locations in East Java and one common 12 kWp configuration; it does not establish representativeness across East Java, other tropical climates, or alternative system sizes. Fourth, the Monte Carlo distributions are transparent scenario assumptions rather than vendor quotations, official tariff offers, or financing contracts, so the 86.4–92.5% positive-NPV probabilities are conditional model outputs, not guarantees. These constraints should be considered when translating the framework into procurement decisions.

Future work should collect interval electricity demand data, governance readiness measures, and procurement outcomes from schools, religious institutions, clinics, and foundations. A prospective multi-site pilot could randomize or phase interventions such as board workshops, peer demonstrations, energy dashboards, and blended-finance offers. Technical monitoring should record plane-of-array irradiance, module temperature, soiling, AC energy, downtime, and maintenance. The resulting dataset would permit a true multilevel meta-analysis linking organizational behavior to measured engineering and financial outcomes.

4. Conclusions

This study converts the supplied evidence map and five city reports into a reproducible, multi-method assessment. The literature indicates that PV adoption by mission-driven organizations is not a purely technical investment. Financial access, regulatory clarity, perceived control, social learning, trust, organizational accountability, and climate-responsive design jointly shape whether a system is adopted and sustained. The framework is intended primarily for non-profit boards and facility managers, with secondary use by policymakers, donors, development partners, and technical advisers who influence the conditions for financing, procurement, and implementation.

The five-city comparison indicates favorable and relatively homogeneous solar potential. Kediri City ranks first with 18.227 MWh/year for the common 12 kWp system, while Blitar ranks lowest at 17.231 MWh/year. The pooled regional estimate is 4.03 kWh/kWp/day (95% CI: 3.92–4.14). The 5.8% city output spread is meaningful but smaller than the economic influence of discount rate, capital cost, tariff trajectory, and self-consumption.

Probabilistic analysis demonstrates the practical value of blended finance. Direct purchase is economically promising in the median case but retains a 7.5–13.6% conditional probability of negative NPV across the cities under the stated assumptions. A 30% grant, donation, or blended contribution reduces the median payback period to approximately 6 years and raises the probability of positive NPV above 99.8%. These findings do not eliminate uncertainty because the model is based on a small, focused literature corpus, five sampled cities, modeled solar data, and a single common 12 kWp configuration. Stakeholders should therefore operationalize the framework in a pilot–verify–scale sequence: policymakers can simplify permitting and support clear self-consumption rules; donors can target capital support or guarantees where downside risk is highest; and non-profit organizations can collect interval load data, conduct roof/shading and structural surveys, obtain procurement quotations, set explicit NPV/payback acceptance thresholds, and verify performance before scaling. In this use, the framework is a decision-support tool rather than a substitute for site-specific engineering and financial due diligence.

Acknowledgement
An internal grant from the State University of Malang funded this research.

Conflict of Interest Statement
The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions Statement
Ely Siswanto contributed to the conceptualization and design of the study, as well as the data analysis and interpretation. Achmad Hamdan was responsible for the methodology and conducted the bibliometric mapping. Lulu Nurul Istanti facilitated the literature review and contributed to the drafting of the manuscript. Shahir Akram Bin Hassan provided expertise in solar resource data and conducted the Monte Carlo simulation. All authors have reviewed and approved the final manuscript for publication and agree to be accountable for the accuracy and integrity of the work.

Data Availability Statement
All city-level data analyzed in this study are contained in the five Global Solar Atlas reports provided. The probabilistic model assumptions and derived summary statistics are reported in the manuscript. Additional calculation files may be made available by the corresponding author upon reasonable request.

Ethics Statement

This study used published literature, public policy documents, and modeled solar-resource reports. It did not involve human participants, personal data, animals, or experimental interventions; therefore, institutional ethical approval and informed consent were not required.

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