Climate Risk Assessment of Rooftop Solar Systems
Jaipur and Udaipur

Table of Contents

Acknowledgement

We thank Mr. Srihari Dukkipati, Fellow, Prayas Energy Group, and Ms. Mallika Sarabhai, Research Associate, SEEDS, for their contributions to the report on Climate Vulnerability Analysis of Solar Rooftop in Rajasthan. Their domain expertise and analytical inputs strengthened the rigour of the vulnerability assessment framework.

Finally, any error or omission is solely ours and should not be ascribed to any of the above-mentioned people or institutions.

Executive Summary

Rooftop solar planning in Rajasthan rests on a foundational assumption that the solar resource available today is broadly the same as what historical databases describe. This study finds that assumption to be wrong. Using 44 years of satellite-derived rainfall data, 35 years of irradiance and wind speed records, LANDSAT 8 land surface temperature imagery and actual generation records from 24 JVVNL-connected prosumers in Jaipur, the study identifies structural climate shifts that can degrade rooftop solar performance in ways that standard planning tools do not capture.

Decline in Surface Solar Irradiance (1991–2025)

The most consequential finding is a 6.5–6.8% decline in surface solar irradiance over the 35-year record (1991–2025) in both Jaipur and Udaipur. This is not a gradual drift. Change-point analysis identifies a step-down in the mid-to-late 2000s, after which irradiance stabilises at a permanently lower level—consistent with rising aerosol optical depth from industrial expansion, construction activity, and vehicular emissions across northwestern India. When current (2023–2025) irradiance is compared against the WMO 1991–2020 baseline, the deficit translates to a generation loss of approximately 56 kWh per kWp installed per year. For a 5 kWp household system, that is 280 kWh of annual output that no longer materialises. This loss is structural and compounding: it accumulates every year the trend persists, and it is embedded in the resource base before any equipment degradation, soiling, or operational issue is accounted for.

Net Effect of Rising Rainfall Frequency on Generation

Both cities show a statistically significant increase in the frequency of wet days since 2010 (25% more in Jaipur, 36% more in Udaipur) driven by a structurally strengthening monsoon linked to Indian Ocean warming. But the study's three-way decomposition of rainfall's effect on generation reveals a counterintuitive result i.e, at the monthly level, rainfall is approximately net-neutral. Cloud cover suppresses irradiance (negative), but rain simultaneously washes dust off panel surfaces (positive) and cools panels below their thermal de-rating threshold (positive). These effects roughly cancel. The real risk from rising rainfall is not lower monthly totals but higher day-to-day volatility that causes more individual days of near-zero output interspersed with recovery days. This matters for prosumers relying on daily self-consumption and for DISCOMs managing grid stability.

Declining Wind Speed and Reduced Convective Cooling

Wind speed has declined 13–14% across the study period. Wind provides convective cooling that lowers panel operating temperatures and partially offsets thermal de-rating during peak summer. The decline is modest in its direct generation impact which is roughly 1–2.5 percentage points of reduced de-rating mitigation during April–September. But it compounds a picture in which every natural buffer against heat-related performance loss is simultaneously weakening.

Seasonal Deviations from Benchmark: Prosumer Generation Data (2023–2025)

When JVVNL prosumer generation data (2023–2025) is benchmarked against Global Solar Atlas (GSA), winter is the worst-performing season. December through March runs 27–33% below benchmark. This is partly the irradiance decline expressing itself most acutely when the sun is lowest and fog and haze are most prevalent and partly because the benchmarks themselves embed historical irradiance levels that have since deteriorated. Monsoon months, by contrast, overperform benchmarks by 15–19%, driven by rain-cleaning and cooling effects that the conservative GSA model may underestimate. The pre-monsoon window (April–May) tracks closest to ideal, with shortfalls of only 1–4%. The implication is that the seasonal distribution of generation has shifted: winter is worse than expected, monsoon is better than expected and the post-monsoon recovery window (October–November) is being compressed by a later-withdrawing monsoon.

City-Level Divergence: Jaipur and Udaipur

The Urban Heat Island (UHI) phenomena for Jaipur recorded a mean land surface temperature of 47.7°C during April–May 2025, with dense built-up zones reaching 56°C. At these temperatures, rooftop panels operate at a sustained 6–12% efficiency deficit before any weather-related loss is factored in, and research indicates that panels in such thermal environments degrade at nearly double the manufacturer-warranted rate. Udaipur, by contrast, recorded a mean of 38°C—almost 10°C cooler—buffered by its lake system (Pichola, Fateh Sagar) which acts as a natural thermal regulator. Udaipur also has a superior solar resource baseline: 26% higher DNI, a cleaner atmospheric column, and a lower diffuse fraction. The two cities face structurally the same climate risks, but the severity and the economic consequences differ materially. RTS performance projections and financing assumptions applied uniformly across the state will overestimate Jaipur and underestimate Udaipur.

Implications for Planning and Financing

The generation benchmarks currently used to size systems, calculate payback periods, and underpin DISCOM cost-benefit assessments are calibrated to a climate that existed before 2010. The irradiance decline, the rising wet-day frequency, the weakening wind buffer, and the divergent thermal environments of Jaipur and Udaipur all point in the same direction: actual RTS performance is being shaped by a climate regime that standard planning tools have not yet absorbed. This study provides the empirical basis for climate-adjusted generation benchmarks, city-differentiated performance assumptions, and a recalibration of the financial and operational parameters on which Rajasthan's rooftop solar programme is being built.

1. Introduction

Rajasthan is among India's most solar-rich states. Its high irradiance levels, extensive rooftop potential across rapidly urbanising cities, and strong policy push under the PM Surya Ghar Muft Bijli Yojana and the state's Mukhya Mantri Nishulk Bijli Yojana (MMNBY) have made rooftop solar (RTS) central to the state's clean energy transition. JVVNL and AVVNL, the two distribution companies serving Jaipur and the southern Rajasthan region respectively, are mandated to facilitate large-scale RTS deployment across over a crore eligible household.

Yet the performance assumptions underpinning RTS deployment—system yield projections, payback period calculations, and DISCOM cost-benefit assessments—are overwhelmingly based on historical climate averages. The standard practice is to use long-term mean irradiance values from solar resource databases to estimate what a rooftop system will generate over its 25-year life. This approach implicitly assumes that the climate conditions of the past will persist into the future. If the climate has structurally shifted, those assumptions are already outdated.

This study tests that assumption. It analyses 44 years of satellite-based climate data covering rainfall patterns, 35 years of solar irradiance and wind speed records, and Land Surface Temperature data across both Jaipur and Udaipur. The objective is to determine whether the key climate variables that govern rooftop solar performance have undergone structural shifts, when those shifts occurred, and what they mean for systems operating today.

The analysis goes beyond trend identification. It compares long-term climate trends against actual generation data from 24 grid-connected rooftop solar prosumers in Jaipur (2023–2025), sourced from JVVNL records, benchmarked against ideal generation estimates from the Global Solar Atlas. This comparison reveals where and when climate-driven losses are materialising in practice—and whether they align with what the satellite record predicts.

The study is structured as follows. Section 1 reviews the existing literature on climate vulnerabilities affecting RTS in Rajasthan—thermal stress, dust soiling, humidity, wind patterns, and global dimming—establishing the scientific context. Section 2 presents the solar resource profiles of Jaipur and Udaipur using Global Solar Atlas data, identifying the seasonal and hourly patterns that determine when each city is most exposed to climate stressors. Section 3 details the methodology, including the datasets used, the statistical tests applied, and the approach to benchmarking actual generation against ideal output. Sections 4 present the core findings: the time-series analysis of rainfall patterns (Section 4), solar irradiance trends (Section 5), wind speed trends (Section 6), actual generation performance versus benchmarks (Section 7), and the Urban Heat Island analysis for both cities (Section 8). Section 9 draws conclusions.

This is one of the first studies to connect long-term climate trend analysis with actual DISCOM-recorded rooftop solar generation data for any Indian city. The findings are intended to inform DISCOM planning, financing assumptions, and policy design for RTS deployment in Rajasthan.

2. Objective

The performance assumptions underpinning rooftop solar deployment in Rajasthan—system yield projections, payback period calculations, and DISCOM cost-benefit assessments—rely on historical climate averages drawn from solar resource databases and IMD seasonal reports.

These averages treat the climate as stationary: they assume that the irradiance, rainfall, and wind conditions observed over the past three decades will persist over the 25-year operating life of systems being installed today. If the climate has structurally shifted, those assumptions are already outdated, and every financial and operational estimate built on them carries an unpriced risk. This study tests that assumption, drawing on 44 years of satellite-based rainfall data (1981–2025) and 35 years of solar irradiance and wind speed records (1991–2025) for Jaipur and Udaipur, to answer a question the existing literature does not address*:*

Has the pattern of weather-driven wet/rainy days, irradiance and wind speed has structurally shifted over time, and if so, what does it mean for rooftop solar systems operating today?

3. Literature Review

The performance and reliability of rooftop solar (RTS) installations in Rajasthan are dictated by the region's unique and often diverse climatic conditions across the state. While Rajasthan offers some of the highest solar irradiance levels in India, it also presents significant environmental challenges—ranging from extreme thermal stress to high aerosol and dust concentrations—that impact the efficiency, durability, and economic viability of solar energy systems. This literature review will serve the objective of understanding how climate vulnerability has impacted the rooftop solar (RTS) in Jaipur and Udaipur. However, because of a lack of substantial literature specific to Jaipur and Udaipur the paper has considered literature which ranges from different geography of Rajasthan.

3.1. Primary Climate Vulnerabilities

3.1.1. Thermal Stress and Temperature Effects

Elevated temperatures represent the most pervasive climate vulnerability identified in the literature. In Western Rajasthan, summer ambient temperatures frequently reach 40–50°C (Sisodia & Mathur, 2020). However, the critical metric for PV performance is the module operating temperature. Under composite climatic conditions typical of the region, cell temperatures have been observed peaking as high as 64.0°C (Yadav et al., 2025).

The physics of semiconductor materials dictate that as temperatures rise, the bandgap narrows, leading to a reduction in the open-circuit voltage and a subsequent drop in power output. Specifically, for every 1°C rise above the standard testing condition (STC) of 25°C, panel efficiency typically drops by 0.3% to 0.5% (Khan et al., 2023). This thermal de-rating is particularly acute in urban areas which undergoes urban heat island (UHI) phenomenon, (eg: Jaipur) where building-integrated photovoltaics (BIPV) have recorded peak temperatures of 68.18°C when lacking adequate ventilation or phase-change material (PCM) cooling (Bhagat et al., 2025). Research consistently indicates that cell temperature, influenced by solar absorption and poor heat dissipation is a more reliable predictor of performance loss than ambient air temperature alone (Anusuya et al., 2025).

3.1.2. Dust Accumulation and Soiling

Dust soiling is arguably the most critical operational challenge for RTS in Rajasthan's semi-arid environment. Atmospheric dust, often originating from the Thar Desert, forms a layer on the PV glass that attenuates incoming solar radiation through absorption and scattering (Sisodia & Mathur, 2020). The severity of this impact is highly sensitive to local geography and particle morphology. For instance, Bikaner experiences extreme transmittance losses of up to 96.1% due to the prevalence of very fine sand particles, whereas Barmer exhibits slightly lower losses of 78.4% (Sisodia & Mathur, 2020).

The physical properties of the dust such as particle size distribution and chemical composition determine how tightly particles adhere to the panel. Smaller particles create a more dense, uniform layer that blocks more sunlight than larger, coarser grains (Sisodia & Mathur, 2020). Furthermore, high concentrations of Particulate Matter (PM10 and PM2.5) in urban industrial corridors exacerbate soiling, creating a synergistic effect where humidity can cement dust to the panel surface, making natural cleaning by wind less effective (Sharma et al., 2024a).

3.1.3. Humidity and Wind Patterns

Rajasthan is primarily arid to semi-arid. However, humidity plays a subtle but negative role by scattering sunlight and reducing Global Horizontal Irradiance (GHI), particularly during the pre-monsoon transition (Sharma et al., 2023). Wind patterns, conversely, offer a vital thermal management function. For rooftop installations, wind-driven convective cooling is significantly more effective than for ground-mounted systems, with convective heat loss being approximately 16.19% higher on roofs (Yadav et al., 2025). This enhanced airflow can lead to a 2.27% net improvement in annual energy yield, highlighting the importance of mounting height and orientation in urban RTS design.

3.1.4. Global Dimming and Increased Precipitation

In the context of Rajasthan, the major form of precipitation is rainfall. Increase in the number of precipitation days (or reduction in number of sunny days) lead to decrease in incoming solar radiation, thereby contributing to a phenomenon called Global Dimming. While solar panels themselves are generally waterproof and resilient to precipitation, the indirect consequences of rainfall significantly impact efficiency and capacity. Rainfall is almost always accompanied by cloud cover, which decreases the amount of solar radiation reaching the panels and is the primary reason for power drops during wet weather[1]. The effect of global dimming is more noticeable on urban agglomerations with an average reduction of 0.16 W/m2 per annum (Alpert et al. 2005). In the context of Rajasthan, tremendous growth in urbanisation has been observed across regions, leading to an increase in aerosols, thus contributing to factors affecting dimming. Chang et al. (2019) reported that for every 1% decrease in solar radiation due to dimming, there is approximately a 0.8% decrease in PV energy yield, thereby impacting energy production.

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[1] Climate change impact on solar system in Malaysia: Techno-economic analysis

Persistent moisture from rainfall can cause wiring oxidation and damage, further shortening the lifespan of system components.

3.2. Performance and Economic Impacts

3.2.1. Efficiency and Yield Losses

The cumulative effect of these vulnerabilities results in substantial quantified losses. Daily efficiency reductions from heat alone average 12%, with maximum losses reaching 20.4% during heatwave conditions (Yadav et al., 2025). In similar arid environments, continuous dust exposure without cleaning for six months has led to power declines of up to 50% (Sisodia & Mathur, 2020). For cities like Jaipur, the annual energy loss attributable to environmental factors is estimated at 20% if a standard cleaning schedule is not maintained (Sharma et al., 2024b).

3.2.2. Future Climate Projections

Long-term climate modelling indicates that Rajasthan's solar resource is under threat. National projections suggest a 2.3% to 3.3% decline in PV potential by 2050 due to rising temperatures and increased aerosol loading (Ghosh et al., 2024). Operating temperatures for PV cells in the region are projected to rise by 0.26°C per decade, which will increase the number of "high-loss days" by 18 to 26 days per year (Gadain & Libanda, 2025; Ghosh et al., 2024).

3.2.3. Economic Implications

These vulnerabilities shift the economic profile of RTS projects. High thermal de-rating often requires system oversizing. For example, increasing a 7.4 kW array to 8.2 kW—to meet the same load, increasing initial capital expenditure (Khan et al., 2023). Furthermore, the Levelized Cost of Electricity (LCOE) is sensitive to maintenance costs. While payback periods in Rajasthan remain attractive (5–8 years), the economic viability is increasingly dependent on 'performance-based cleaning' where the cost of water and labor is balanced against the revenue recovered from higher energy yields (Singh, 2025).

3.3. Summary Tables

Table 1: Summary of Climate Vulnerabilities and Observed Impacts

Vulnerability	Observed Impact	Mechanism	Supporting Evidence (Reference)
Extreme Temperature	12% average daily efficiency loss; peak loss >20%.	Bandgap narrowing.	Yadav et al. (2025); Khan et al. (2023)
Thermal Stress	Cell temperatures up to 68°C in Jaipur.	Urban heat island effect; lack of BIPV ventilation.	Bhagat et al. (2025)
Dust/Soiling	78% to 96% transmittance loss; 35% power loss.	Shading/attenuation of the solar spectrum.	Sisodia & Mathur (2020)
Wind Cooling	+2.27% energy yield improvement.	Convective heat dissipation on roofs.	Yadav et al. (2025)

Table 2: Climate Risk for RTS in Rajasthan

Risk Factor	Risk Level	Rationale	Management Priority
High Temperature	Critical	Constant summer de-rating + future warming trends.	High (Cooling/Ventilation)
Dust/Soiling	High	Rapid accumulation requires frequent cleaning (15-day cycle).	High (Cleaning Schedule)
Extreme Winds	Medium	Risk of physical damage vs. benefit of cooling.	Medium (Mounting Integrity)
Humidity	Low	Only affects GHI during brief monsoon/pre-monsoon.	Low (System Monitoring)

4. Solar Profile Analysis

The literature review identifies the climate stressors; this section identifies *where and when* each city is most exposed to them. A city may record a high annual irradiation value while losing a disproportionate share of its generation potential during specific hours or seasons when climate stressors are most active. Mapping these windows of vulnerability is what connects the risk factors catalogued above to the long-term trend analysis that follows—establishing, for each city, the seasonal and hourly patterns against which structural climate shifts will be assessed.

To do so, this section analyses the average hourly profiles of total Photovoltaic Power Output (PVOUT) and Direct Normal Irradiation (DNI) derived from the Global Solar Atlas (World Bank / Solargis, 2026).[2] The key variables examined are the ratio of PVOUT to DNI as a proxy for diffuse versus direct beam dependence, the daily generation window by season and the identification of the hours and months where each city's generation is most sensitive to the climate stressors.

Table 3: Solar resource parameters — Jaipur and Udaipur

Parameter	Jaipur		Udaipur	
	Per year	Per day	Per year	Per day
GHI (kWh/m^2) Global Horizontal Irradiation	1884	5.16	2029	5.56
DNI (kWh/m^2) Direct Normal Irradiation	1516	4.15	1910	5.23
DIF (kWh/m^2) Diffuse Horizontal Irradiation	874	2.39	775	2.12
GTI optimum (kWh/m^2) Tilted irradiation at 28°	2081	5.70	2242	6.14
PVOUT specific (Wh) AC output per kWp installed	1629	4.46	1674	4.59

Source: Global Solar Atlas, World Bank / Solargis (2026)

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[2] The amount of electrical energy generated by a solar photovoltaic system over a specific period of time.

4.1. Jaipur

Jaipur, the capital of Rajasthan, lies at 26.91°N, 75.79°E at a terrain elevation of 434 metres above mean sea level. With a population exceeding 4.5 million, it is one of the fastest-growing urban agglomerations in northwest India. Its climate is classified as hot semi-arid (BSh under the Köppen system), characterised by extreme summer temperatures, a concentrated southwest monsoon between July and September and dry, fog-prone winters influenced by western disturbances.

In terms of solar resource, Jaipur receives a Global Horizontal Irradiation (GHI)[3] of 1,884.4 kWh/m^2 per year, equivalent to a daily average of 5.16 kWh/m^2. At the optimum panel tilt of 28° south-facing (Global Tilted Irradiation (GTI)[4]), a standard 1 kWp rooftop system can be expected to deliver 1,629 kWh annually which is approximately 4.46 kWh per day under long-term average conditions. These figures position Jaipur firmly among India's high solar-potential cities. However, Jaipur's Diffuse Horizontal Irradiation (DIF)[5] stands at 874 kWh/m^2 per year is the highest of the two cities studied here. This elevated diffuse fraction reflects Jaipur's significant aerosol component which is a consequence of urban density, vehicular emissions and proximity to industrial corridors that scatters incoming direct beam radiation into diffuse.

The 2025 monsoon season, documented in the IMD 2025 Monsoon Report[6] illustrates the scale of the cloud-cover risk in the region. Jaipur received 918.5 mm of rainfall during June–September 2025 against a long period average (LPA) of 524.3 mm which is a 75% excess, placing it in the Large Excess category. This was part of a state-wide monsoon that produced 715.9 mm against an LPA of 435.6 mm, the second highest monsoon total in 125 years of records. Jaipur recorded 22 days of heavy to extremely heavy rainfall during the season. Beyond direct rainfall, the monsoon onset brought prolonged cloud cover that suppresses the direct beam. The DNI hourly profile shows July and August dropping to just 1,953 and 2,214 Wh/m^2 monthly, the lowest values of the year (Fig 2). In winter, a separate and less studied risk emerges. Western disturbances (WD) bring moisture into the otherwise dry Rajasthan atmosphere, triggering overnight dew deposition on panel surfaces followed by morning radiation fog. In the December–February window, their effect on solar generation is most damaging: fog suppresses irradiance during morning generation hours and evaporating dew leaves a dust soiling layer that degrades performance for days even after the fog event itself has passed. Figure 1 presents the average hourly PVOUT and DNI values for Jaipur across all twelve months and Figure 3 presents the average hourly profile of total photovoltaic power output in Jaipur.

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[3] The total solar radiation received per unit area on a horizontal surface.

[4] Total solar radiation received on a surface that is tilted at an optimum angle from the horizontal.

[5] Solar radiation received from the sky (excluding direct sunlight) on a horizontal surface.

[6] Rajasthan Monsoon Report - 2025

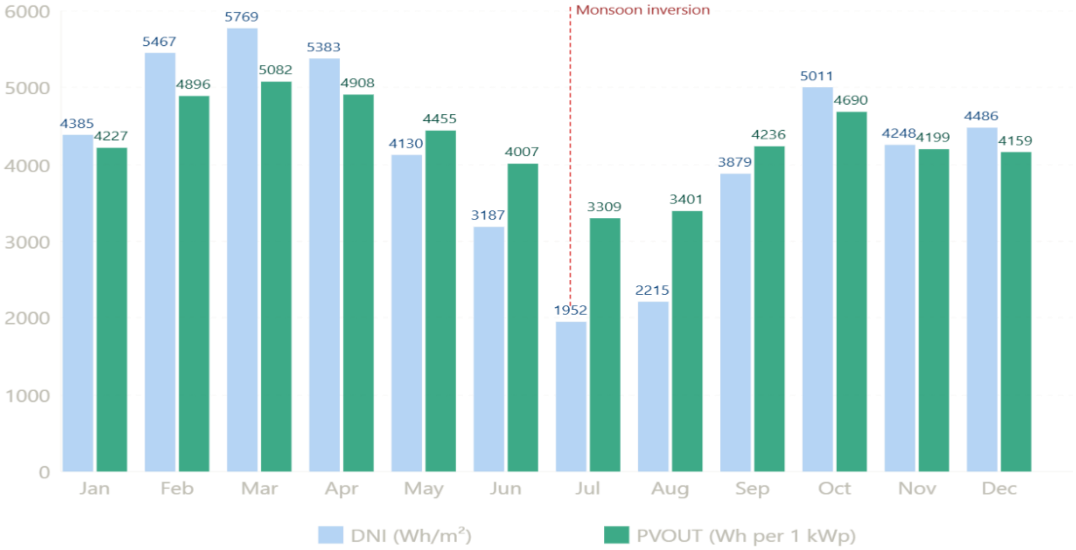
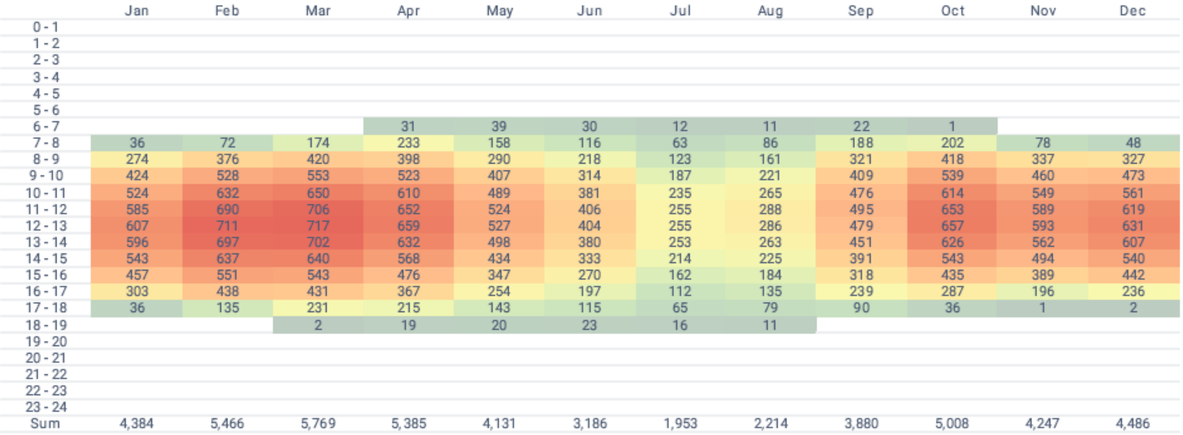


Figure 1: Monthly PVOUT vs DNI – Jaipur (1 kWp system, 28° tilt)
Source: Global Solar Atlas, World Bank / Solargis (2026)



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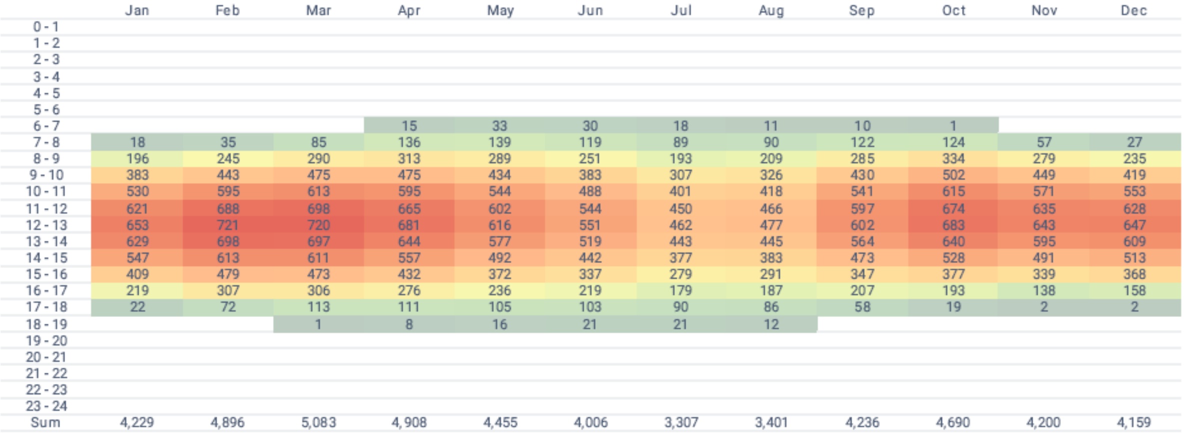
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6												
6 - 7				31	39	30	12	11	22	1		
7 - 8	36	72	174	233	158	116	63	86	188	202	78	48
8 - 9	274	376	420	398	290	218	123	161	321	418	337	327
9 - 10	424	528	553	523	407	314	187	221	409	539	460	473
10 - 11	524	632	650	610	489	381	235	265	476	614	549	561
11 - 12	585	690	706	652	524	406	255	288	495	653	589	619
12 - 13	607	711	717	659	527	404	255	286	479	657	593	631
13 - 14	596	697	702	632	498	380	253	263	451	626	562	607
14 - 15	543	637	640	568	434	333	214	225	391	543	494	540
15 - 16	457	551	543	476	347	270	162	184	318	435	389	442
16 - 17	303	438	431	367	254	197	112	135	239	287	196	236
17 - 18	36	135	231	215	143	115	65	79	90	36	1	2
18 - 19			2	19	20	23	16	11				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	4,384	5,466	5,769	5,385	4,131	3,186	1,953	2,214	3,880	5,008	4,247	4,486

Figure 2: Average hourly profile of Jaipur – Direct normal irradiation (Wh/m2)
Source: Global Solar Atlas, World Bank / Solargis (2026)



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2 - 3												
3 - 4												
4 - 5												
5 - 6												
6 - 7				15	33	30	18	11	10	1		
7 - 8	18	35	85	136	139	119	89	90	122	124	57	27
8 - 9	196	245	290	313	289	251	193	209	285	334	279	235
9 - 10	383	443	475	475	434	383	307	326	430	502	449	419
10 - 11	530	595	613	595	544	488	401	418	541	615	571	553
11 - 12	621	688	698	665	602	544	450	466	597	674	635	628
12 - 13	653	721	720	681	616	551	462	477	602	683	643	647
13 - 14	629	698	697	644	577	519	443	445	564	640	595	609
14 - 15	547	613	611	557	492	442	377	383	473	528	491	513
15 - 16	409	479	473	432	372	337	279	291	347	377	339	368
16 - 17	219	307	306	276	236	219	179	187	207	193	138	158
17 - 18	22	72	113	111	105	103	90	86	58	19	2	2
18 - 19			1	8	16	21	21	12				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	4,229	4,896	5,083	4,908	4,455	4,006	3,307	3,401	4,236	4,690	4,200	4,159

Figure 3: Average hourly profile of Jaipur – Total photovoltaic power output (Wh)

Source: Global Solar Atlas, World Bank / Solargis (2026)

Key findings - Jaipur Solar Profile:

- Monsoon months (July–August) see the sharpest drop in direct sunlight, but panels still generate because they can use diffuse (scattered) light. This means monsoon cloud cover causes a sustained seasonal depression in generation rather than sharp daily crashes
- March (5,082 Wh) and October (4,690 Wh) are the best generation months, outperforming the longer summer days of May (4,455 Wh) and June (4,007 Wh). Extreme heat in April–June actually penalises panel efficiency, eroding the benefit of longer daylight
- Shoulder seasons (Feb–Apr, Oct–Nov) carry the highest dust loss risk, as PVOUT is almost entirely direct-beam driven. Any dust or aerosol event during these months carries the maximum generation loss penalty per affected day
- Winter mornings (8 to 11 am) alone contribute approximately 26% of the entire day's output. This is precisely when western disturbance fog peaks in Jaipur, meaning a single fog event can remove a quarter of a day's generation and multi-day WD episodes can compound this into significant losses

4.2. Udaipur

Udaipur lies at 24.59°N, 73.70°E at an elevation of 586 metres above mean sea level in the southern Aravalli range. A mid-sized city of approximately 6 lakh-plus population, it is characterized by complex terrain, lower urban density and a pronounced lake system that introduces localised humidity characters which is not present in the flatter, drier Jaipur landscape.

Udaipur's solar resource is superior to Jaipur's across every metric. GHI stands at 2,028.5 kWh/m^2 per year (5.56 kWh/m^2/day), DNI at 1,910.4 kWh/m^2 per year (5.23 kWh/m^2/day), and GTI at optimum tilt reaches 2,242.2 kWh/m^2 per year (6.14 kWh/m^2/day). A 1 kWp system yields 1,674.0 kWh annually (4.59 kWh/day) which is a 2.8% advantage over Jaipur. The DNI advantage is more pronounced: 26% higher than Jaipur, reflecting a cleaner atmospheric column. Udaipur's diffuse fraction of 38.2% confirms that proportionally more of its solar resource arrives as direct beam, undiluted by scattering.

The IMD Monsoon 2025 data, however, reveals an important divergence in how the two cities experienced the exceptional 2025 monsoon season. While Jaipur recorded a 75% excess above its LPA, Udaipur recorded a comparatively moderate 44% excess (890 mm against a normal of 617.7 mm). Notably, September 2025 ran 85% above its LPA for the subdivision, extending cloud suppression into what is normally a solar recovery month. Figure 4 presents the average hourly PVOUT and DNI values for Udaipur across all twelve months, based on a 1 kWp south-facing rooftop system at the optimum tilt of 28° and Figure 6 presents the average hourly profile of total photovoltaic power output in Udaipur.

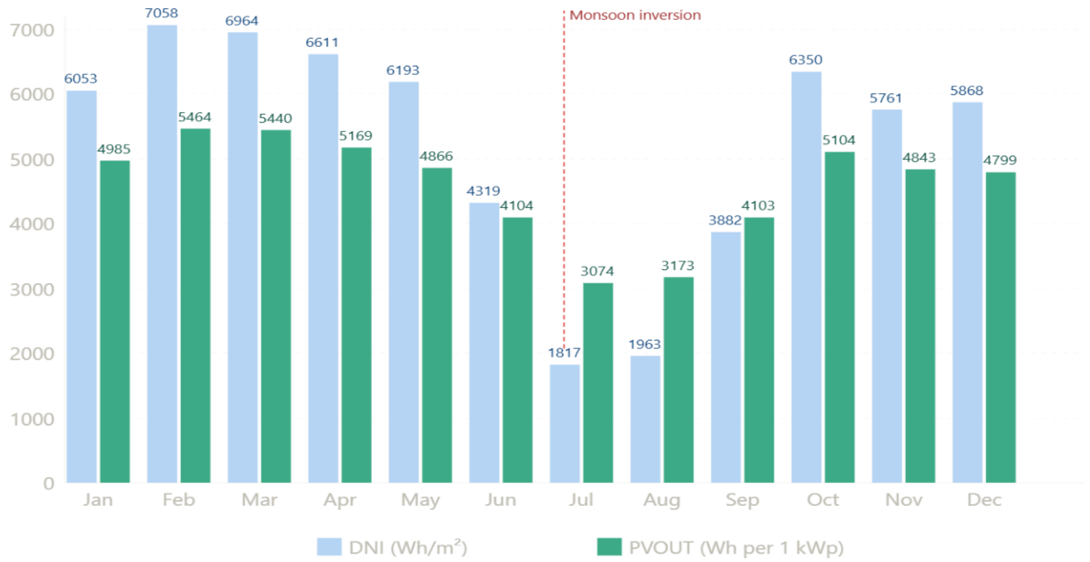
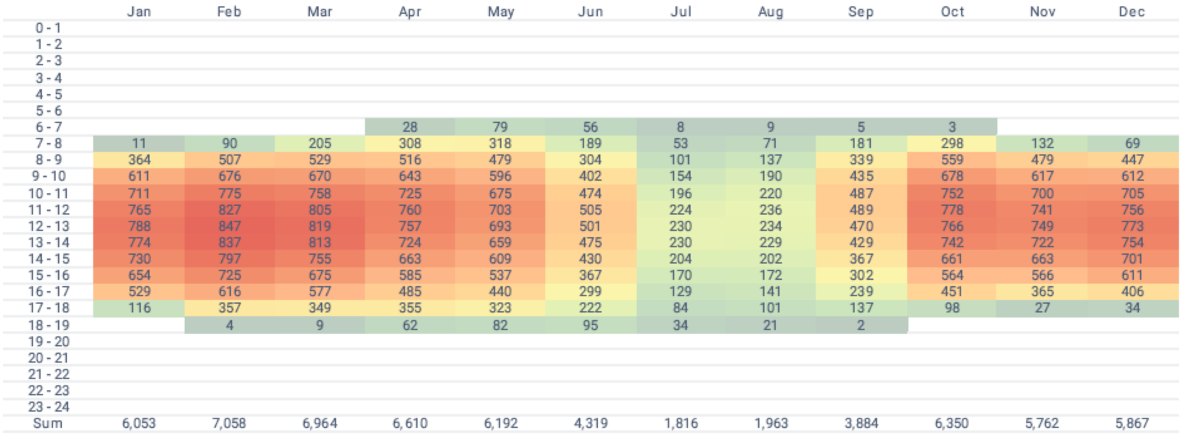


Figure 4: Monthly PVOUT vs DNI – Udaipur (1 kWp system, 28° tilt)

Source: Global Solar Atlas, World Bank / Solargis (2026)



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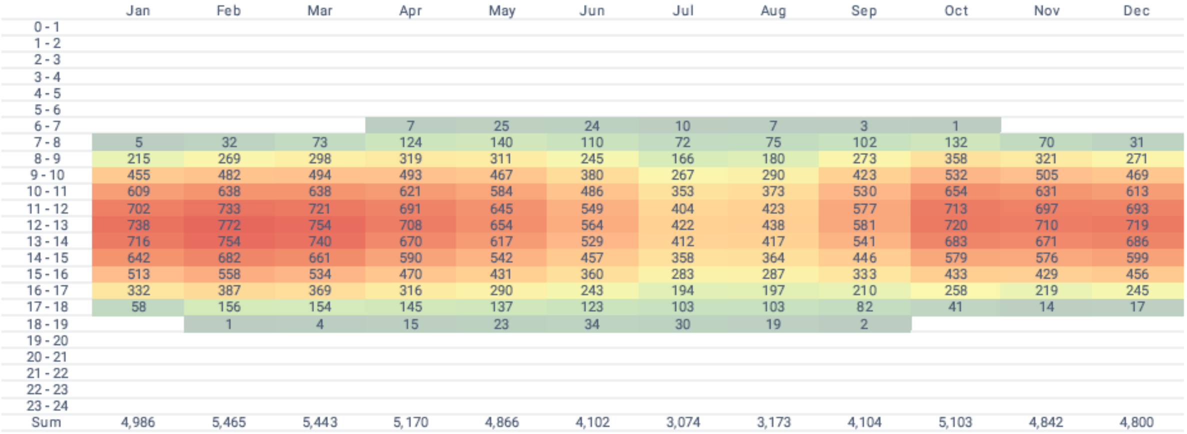
6 - 7				28	79	56	8	9	5	3		
7 - 8	11	90	205	308	318	189	53	71	181	298	132	69
8 - 9	364	507	529	516	479	304	101	137	339	559	479	447
9 - 10	611	676	670	643	596	402	154	190	435	678	617	612
10 - 11	711	775	758	725	675	474	196	220	487	752	700	705
11 - 12	765	827	805	760	703	505	224	236	489	778	741	756
12 - 13	788	847	819	757	693	501	230	234	470	766	749	773
13 - 14	774	837	813	724	659	475	230	229	429	742	722	754
14 - 15	730	797	755	663	609	430	204	202	367	661	663	701
15 - 16	654	725	675	585	537	367	170	172	302	564	566	611
16 - 17	529	616	577	485	440	299	129	141	239	451	365	406
17 - 18	116	357	349	355	323	222	84	101	137	98	27	34
18 - 19		4	9	62	82	95	34	21	2			
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	6,053	7,058	6,964	6,610	6,192	4,319	1,816	1,963	3,884	6,350	5,762	5,867

Figure 5: Average hourly profile of Udaipur – Direct normal irradiation (Wh/m2)

Source: Global Solar Atlas, World Bank / Solargis (2026)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6												
6 - 7				7	25	24	10	7	3	1		
7 - 8	5	32	73	124	140	110	72	75	102	132	70	31
8 - 9	215	269	298	319	311	245	166	180	273	358	321	271
9 - 10	455	482	494	493	467	380	267	290	423	532	505	469
10 - 11	609	638	638	621	584	486	353	373	530	654	631	613
11 - 12	702	733	721	691	645	549	404	423	577	713	697	693
12 - 13	738	772	754	708	654	564	422	438	581	720	710	719
13 - 14	716	754	740	670	617	529	412	417	541	683	671	686
14 - 15	642	682	661	590	542	457	358	364	446	579	576	599
15 - 16	513	558	534	470	431	360	283	287	333	433	429	456
16 - 17	332	387	369	316	290	243	194	197	210	258	219	245
17 - 18	58	156	154	145	137	123	103	103	82	41	14	17
18 - 19		1	4	15	23	34	30	19	2			
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	4,986	5,465	5,443	5,170	4,866	4,102	3,074	3,173	4,104	5,103	4,842	4,800

Figure 6: Average hourly profile of Udaipur – Total photovoltaic power output (Wh)

Source: Global Solar Atlas, World Bank / Solargis (2026)

Key findings - Udaipur Solar Profile:

- DNI is substantially higher than Jaipur across all non-monsoon months. This higher direct-beam baseline means greater absolute generation loss on any bad-weather day
- The monsoon inversion is more severe than Jaipur. July DNI reduces to 1,817 Wh/m^2 (a 74% drop from October peak). Yet PVOUT falls only 40%. This means that Udaipur's more southerly position comparatively reduces the direct beam more during the monsoon season
- December and January PVOUT sits well below October–November values and the morning generation window (08:00–12:00) is the same narrow slot as Jaipur. But there could also be a chance that with Udaipur's lakes sustaining overnight humidity, potentially making fog events more persistent and prolonged than Jaipur

4.3. Comparative Summary

Udaipur has a higher solar resource baseline, lower aerosol atmosphere and a distinct hydrological environment that creates specific fog risk. Jaipur has a higher urban heat island (UHI) intensity, greater aerosol scattering and flatter terrain. The climate risks they face are structurally the same, but their relative severity and seasonal timing differ.

In 2025, a year where Rajasthan experienced its second-highest monsoon rainfall in the last 125 years of history, Jaipur absorbed a 75% excess concentration in an explosive early-onset event, while Udaipur experienced a more distributed 44% excess with late-season intensification. Identifying and distinguishing these different temporal signatures through the change-point analysis is a core analytical contribution of this study.

5. Methodology

5.1. Rainfall Analysis

The rainfall data comes from CHIRPS v2.0 (Climate Hazards Group InfraRed Precipitation with Station data)[7], a globally validated satellite-plus-ground-station dataset available at approximately 5km spatial resolution. CHIRPS provides daily precipitation values going back to 1981, making it well suited for long-term trend analysis. The analysis focuses more on number of wet days[8] rather than total rainfall volume. This choice is deliberate as for solar generation, what matters more is whether the sky was cloudy rather than how much rain fell. A day with 3mm of rain blocks sunlight just as effectively as a day with 100mm of heavy rain. Wet day count is therefore a more direct proxy of generation loss days than total rainfall volume.

5.2. Solar Irradiance and Wind Speed

Solar irradiance is measured using Surface Solar Radiation Downwards (SSRD)[9] from the ERA5-Land dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). This is a reanalysis dataset, meaning it combines satellite observations with weather models to produce a consistent, long-term record of solar energy reaching the earth's surface. Wind speed

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[7] CHIRPS v2.0

[8] Defined as any day recording 2.5mm or more of rainfall, following the IMD definition.

[9] Total solar radiation reaching the earth's surface.

data at 10m spatial resolution comes from the same ERA5-Land source. Both are analysed from 1991 to 2025.

5.3. Statistical Methods

Two well-established statistical tests are applied to each time series data:

i. The Pettitt test[10] identifies whether there is a single year where the data structurally shifted. It does not assume any particular pattern of change. It simply finds the year where the difference between the two halves of the time series (before and after that year) is greatest, and tests whether that difference is statistically meaningful.

ii. The Mann-Kendall test[11] confirms whether there is a consistent upward or downward trend running through the entire time series. Sen's slope[12] then quantifies the rate of that change (e.g., how many additional wet days per year).

5.4. Connecting Climate to Actual Generation

Climate data is compared against actual generation data from grid-connected rooftop solar (RTS) sourced from JVVNL (Jaipur Vidyut Vitran Nigam Limited) covering 24 prosumers in Jaipur from 2023 to 2025. To benchmark what each system should generate under normal conditions, the study uses the Global Solar Atlas[13] PVoutput[14] model, which provides the ideal monthly generation benchmark based on each prosumer's location, system size, tilt, and orientation. The gap between the ideal simulation and actual DISCOM-recorded generation is treated as the climate-driven loss or gain.

5.5. Urban Heat Island (UHI) Analysis

The UHI effect is calculated using LANDSAT 8 satellite's[15] [Landsat Collection 2 Level-2] Land Surface Temperature (LST) data for 2025. The analysis was done for the months of April and May which are recorded to be the hottest months of both cities according to IMD reports. This captures current surface temperatures that rooftop panels are exposed to during peak summer.

5.6. Limitations of the Methods

While this study provides an analysis of RTS performance against climate constraints, certain limitations inherent in the data and methodology should be acknowledged:

- The analysis is purely based on open-source secondary data. Consequently, the results may lack the granular precision typically associated with high-resolution satellite datasets
- The ideal generation values used in the analysis are derived from international open-source repositories. These figures should be interpreted as high-level benchmarks rather than established performance standards tailored specifically to the local geography

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[10] Pettitt's test is used to identify a single change point in the long-term data, representing a shift in the central tendency of the time series.

[11] The Mann Kendall test is used globally to analyze trends in metrological variables across a time series

[12] Sen's Slope is a non-parametric method used to quantify trends in time series data. It is often used to understand the rate of change.

[13] Global solar atlas - 1Kwp system ideal generation

[14] A publicly accessible model developed by the US National Renewable Energy Laboratory (NREL)

[15] LANDSAT 8 satellite data

- The comparative analysis between climate variables and actual RTS generation is restricted to Jaipur city. A similar assessment for Udaipur city was not feasible due to the unavailability of generation data from the Ajmer Discom
- There is a possibility that prosumer systems used for analysis here underwent capacity expansion (oversizing) during the three-year study period. However, as the Discom records did not explicitly document such upgrades, this study assumes that the system capacities for the 24 selected prosumers remained constant. While rigorous data cleaning was performed to mitigate the impact of extreme deviations, the results are predicated on the stability of the initial installed capacities

Table 4: Details of Data and Sources Used in the Study

Variable	Source	Period	Coverage	Unit
Solar Irradiance (SSRD)	ERA5 (ECMWF Reanalysis)	1991–2025	Jaipur & Udaipur	$W/m^2/day$
Wind Speed (10m)	ERA5 (ECMWF Reanalysis)	1991–2025	Jaipur & Udaipur	m/s
Rainfall	CHIRPS v2.0	1981–2025	Jaipur & Udaipur	mm/month
Wet Days	CHIRPS v2.0	1981–2025	Jaipur & Udaipur	days/month
Solar Generation	JVVNL Prosumer Records	2023–2025	Jaipur, 24 rooftop prosumers	kWh/month
Urban Heat Island (UHI)	Land Surface Temperature, LANDSAT 8, USGS	2025	Jaipur & Udaipur	℃

6. Results and Key Findings

6.1. Time-Series Analysis of Rainfall Patterns

The Southwest Monsoon (June to September) is the defining climate feature of Rajasthan. It delivers roughly 85–90% of the annual total rainfall in just four months. Its intensification, documented here across 45 years of CHIRPS data, has a complex and non-linear relationship with solar energy. More rainfall means more cloud cover and more disruption to irradiance, which affects generation. But it also means more panel-cleaning events that reduce soiling losses.

6.1.1. Jaipur – Key Findings

- 2010 is the year when Jaipur's rainfall pattern structurally changed (Fig. 7)
- Before 2010, Jaipur averaged about 40 wet days per year. After 2010, this rose to about 51 days which is a 25% increase that is statistically highly significant (Fig. 11)
- Annual rainfall volumes are roughly 33% higher in the post-2010 period (Fig. 7)
- The monsoon months (June–September) account for almost all of the increase, with monsoon wet days rising 26% after 2010 (Fig. 7)

- The most recent years (2022–2025) show some of the largest departures from normal in the entire 44-year record (Figure 9). The 2025 monsoon, with 918.5 mm against a 524.3 mm average, is the most extreme expression of a shift that has been building for over a decade

6.1.2. Udaipur– Key Findings

Udaipur shows a broadly similar pattern but with two notable differences:

- Rainfall volumes began rising earlier. The statistical change-point for total precipitation falls in 2004, six years before Jaipur's. This means individual rainfall events started intensifying before the overall frequency of wet days began climbing (Fig. 7)
- The increase is also larger and faster. Annual wet days rose 36% after the change-point (vs 25% for Jaipur) and the rate of increase is 0.47 additional wet days per year (vs 0.38 for Jaipur) (Fig. 7)
- In recent years, unusually high wet day counts extend into October, suggesting the monsoon withdrawal is occurring later. This is significant because October is normally one of the two best months for solar generation (alongside March). A shrinking post-monsoon recovery window directly affects the most productive part of the solar year (Fig. 11)

6.1.3. What This Means for Solar Generation

The rising trend in rainfall is consistent with the strengthening monsoon documented by the IPCC Sixth Assessment Report[16], driven by a warming Indian Ocean providing more moisture for monsoon circulation. The change-point timing (2010–2015) aligns with a period of rapid Indian Ocean surface warming.

For rooftop solar, the implication is nuanced. More rainy days means more individual days of near-zero generation, increasing volatility and unpredictability in generating output. But as the next sections will show, rainfall also cleans dust off panels and cools them, partially offsetting the cloud-cover loss at a monthly level. The real risk is not that monthly totals collapse, but that day-to-day reliability worsens.

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[16] IPCC AR6 assessment report - Summary for policymakers

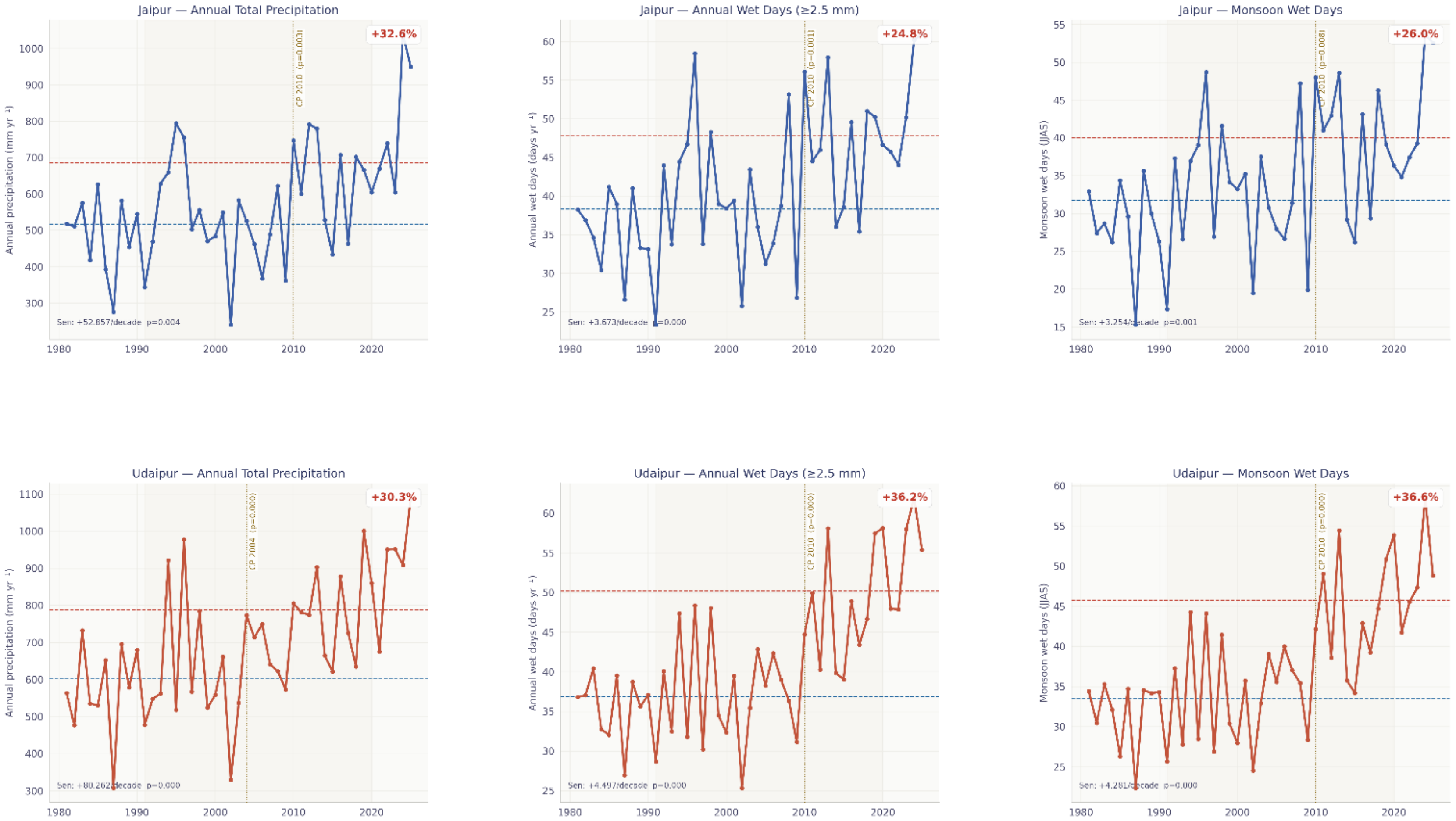

Figure 7: Rainfall Change-Point Analysis for Jaipur and Udaipur, 1981–2025. Upward structural breaks are visible, especially post-2010.

Source: Author’s Analysis

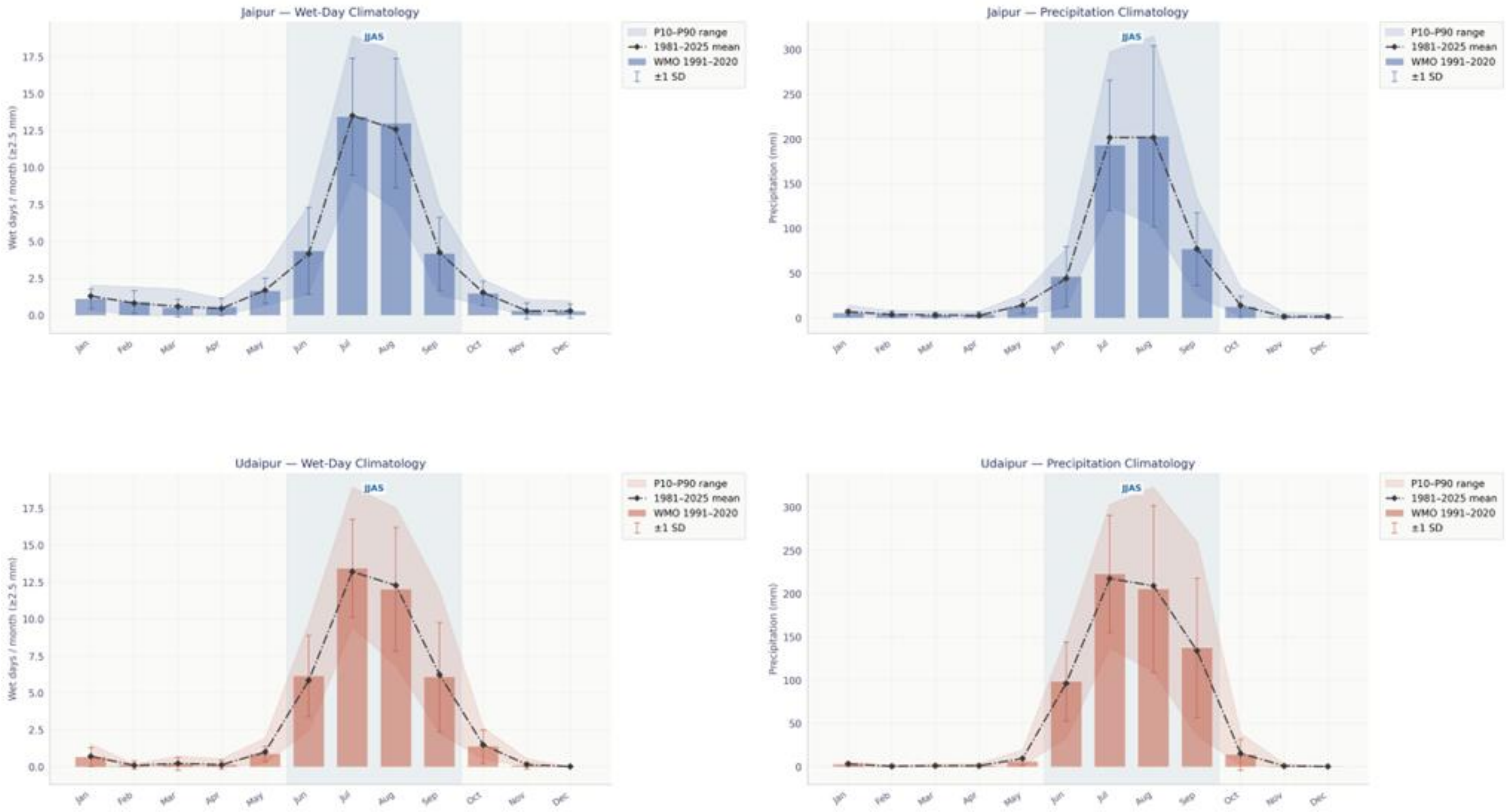

Figure 8: Mean monthly rainfall climatology (mm) with spread, 1981–2025. ~85–90% of annual rainfall falls in the June–September monsoon window

Source: Author's analysis

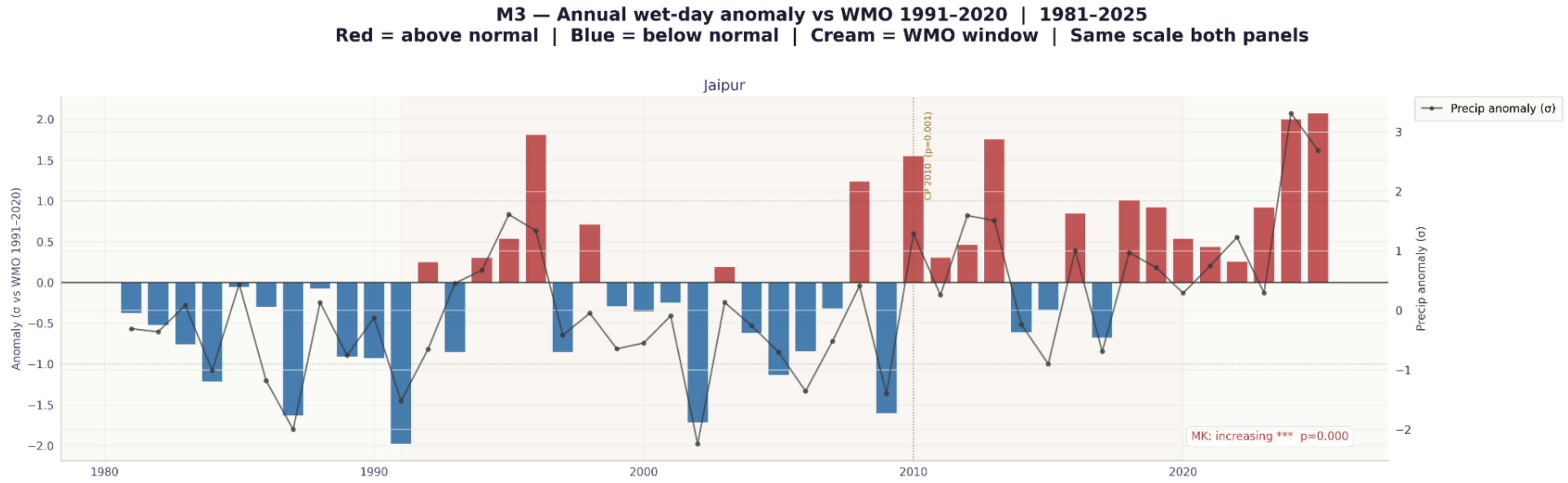

Figure 9: Trend analysis (1981-2025) for Jaipur city - Annual Wet-day Anomaly against WMO Normal

Source: Author's Analysis

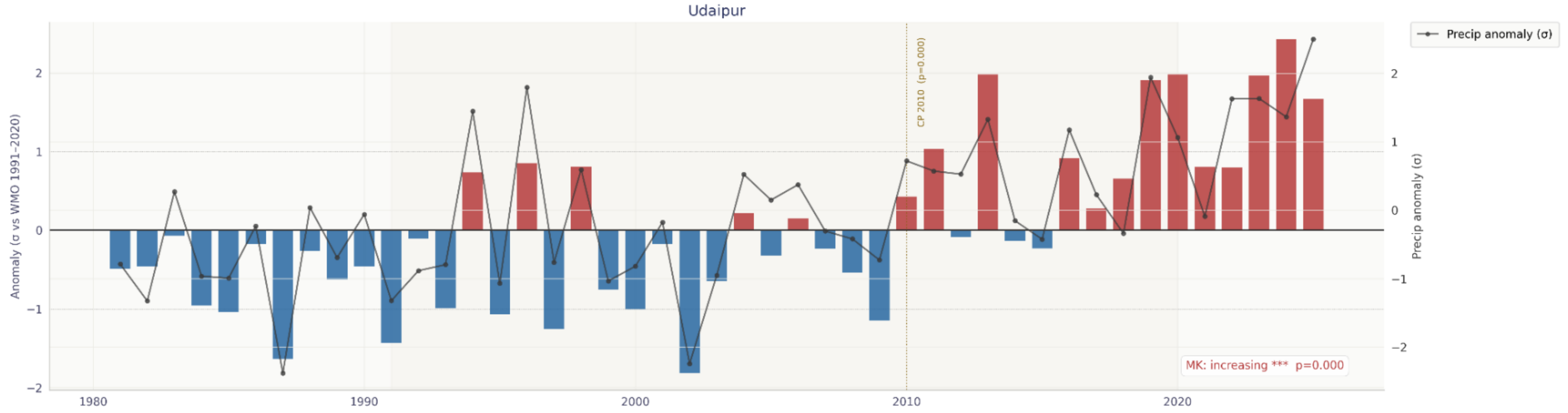

Figure 10: Trend analysis (1981-2025) for Udaipur city - Annual Wet-day Anomaly against WMO Normal

Source: Author's Analysis

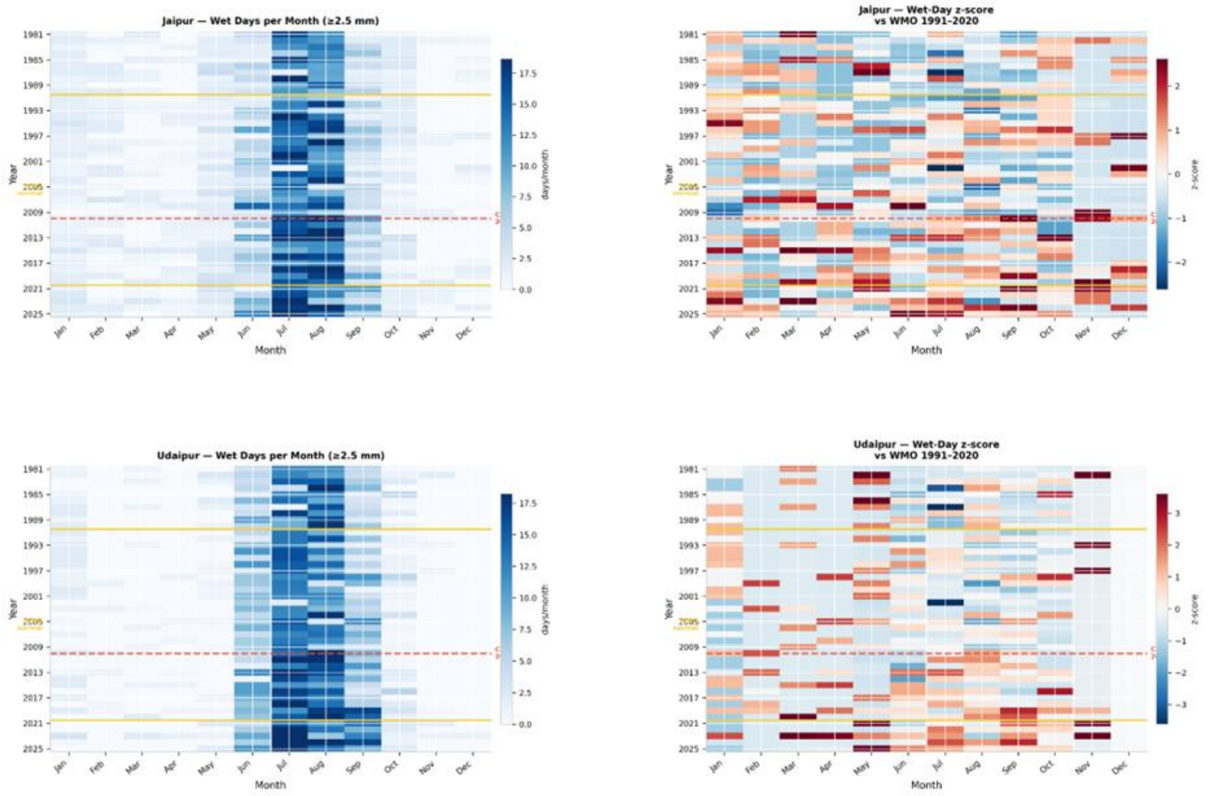

Figure 11: Heatmap of wet days per month (1981-2025) - Jaipur (top) and Udaipur (bottom)

Darker cells = more wet days; Source: Author's Analysis

6.2. Time-Series Analysis of Solar Irradiance

If one section of this report demands the most urgent policy attention, it is this one. The decline in Surface Solar Radiation Downwards (SSRD) is the single most consequential climate change signal for solar energy in Rajasthan. Solar irradiance in Jaipur and Udaipur has declined by 6.5–6.8% over 35 years and it is not a gradual but structural shift.

Key Findings:

- Both cities show a clear step-down in irradiance in the mid-to-late 2000s, after which sunlight levels stabilise at a permanently lower level. A step-change is more alarming than a gradual drift because it suggests the atmosphere has shifted to a fundamentally different state (Fig. 12)
- Jaipur's annual solar radiation has declined by approximately 2.3% overall, with a monsoon-season decline of 4.6% (Fig. 12)
- Udaipur shows a 3.1% annual decline and a 7.1% monsoon-season decline (Fig. 12)

6.2.1. Reason For the Decline

The most likely cause would be the rapid growth in aerosol optical depth (AOD) over north-western India from the 2000s onward, driven by industrial expansion, construction dust, vehicular emissions and increased atmospheric moisture from a structurally changing monsoon. These particles scatter and absorb incoming sunlight before it reaches rooftop panels.

6.2.2. What This Means for Solar Generation

When the 2023–2025 irradiance levels are compared to the WMO (World Meteorological Organisation) 1991–2020 normal, the result is an annual generation loss of approximately 56 kWh per kWp installed (Fig. 12). For a typical 5 kWp rooftop system, that translates to roughly 280 kWh lost per year. Energy that the system would have produced if sunlight levels had remained at historical norms. Unlike a one-off weather event, this is a structural and compounding loss that accumulates every year as the trend continues.

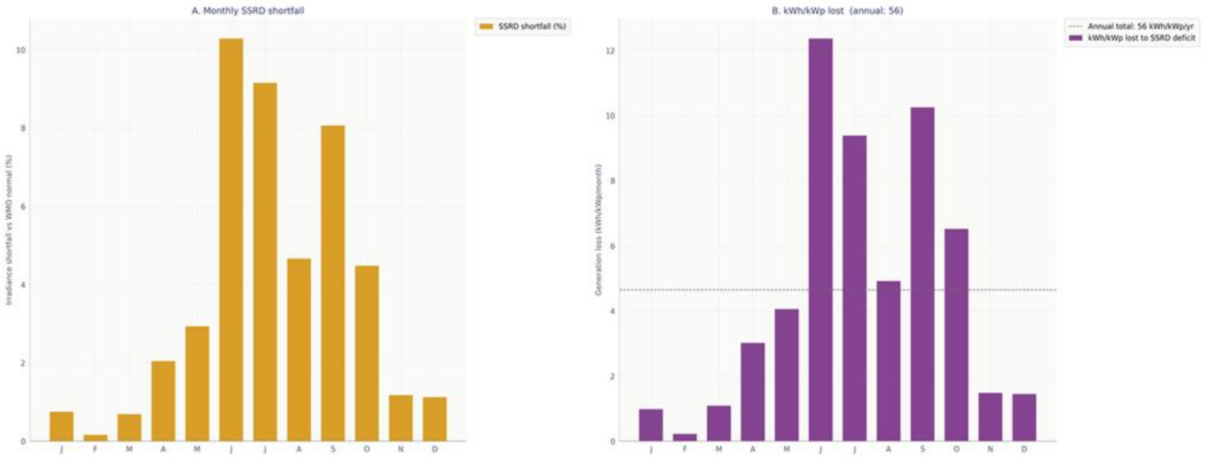

Figure 12: Solar Irradiance Loss Attribution 2023–2025 vs WMO 1991–2020; Left = monthly SSRD shortfall (%). Right = kWh/kWp lost per month due to SSRD deficit; Source: Author's analysis

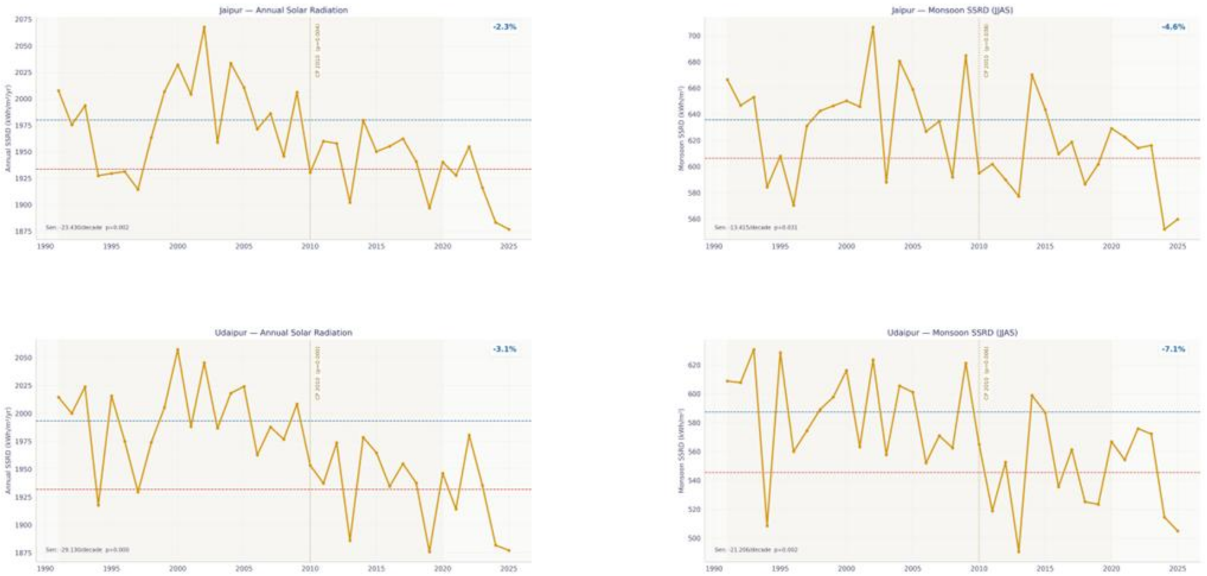

Figure 13: Change-point analysis of monthly SSRD (W/m^2/day) for Jaipur and Udaipur, 1991–2025; Source: Author's analysis

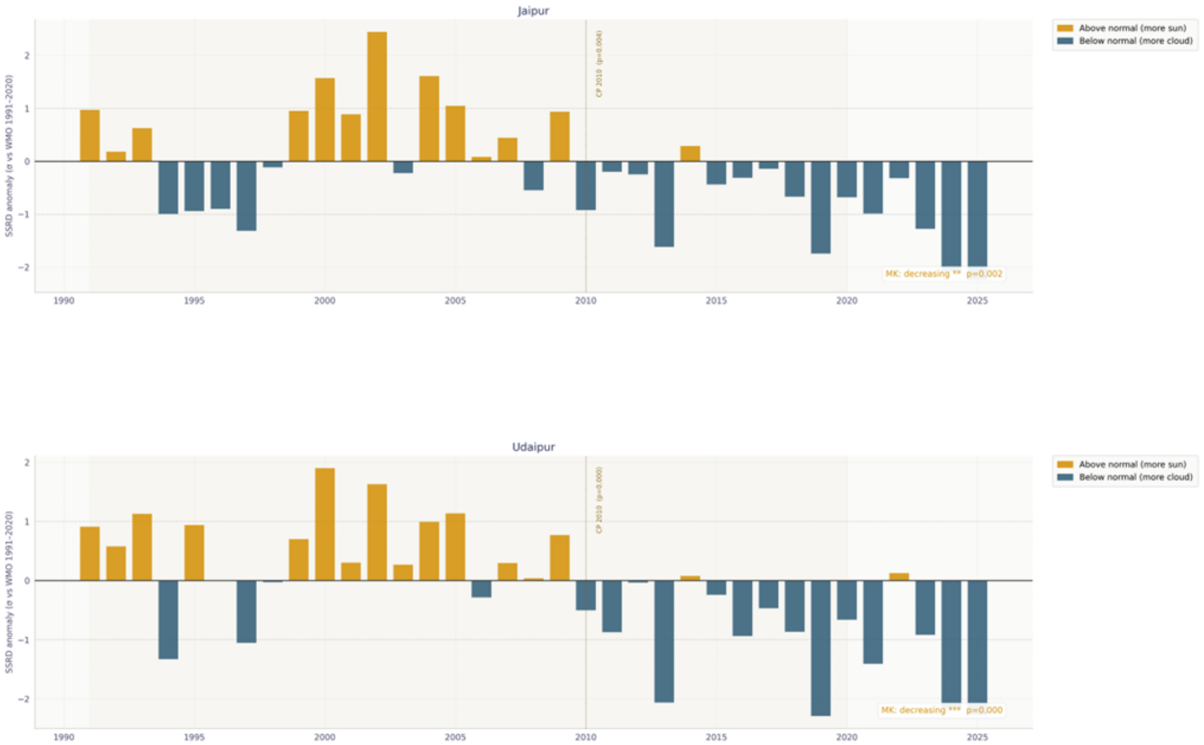

Figure 14: Annual SSRD anomaly ($W/m^2/day$) relative to 1991–2025 mean. Red = above-average irradiance, blue = below-average; Source: Author's analysis

6.3. Wind Speed Trends

Wind plays an indirect but real role in solar panel performance. Moving air carries heat away from panel surfaces, reducing operating temperatures and improving efficiency. The analysis reveals that wind speeds are declining at both locations.

Key Findings:

- Wind speeds in Jaipur have declined approximately 14% since 1991, with a structural break detected in 2010 (the same year as the rainfall and irradiance shifts) (Fig. 15).
- Wind speeds in Udaipur experienced a 13% decline, with structural break in 2019 (at a much later stage compared to Jaipur) (Fig. 15).

6.3.1. What This Means for Solar Generation

The physical consequence of declining wind speed for solar generation is indirect but real. Lower wind speeds reduce convective heat removal from panel surfaces, raising cell operating temperatures and increasing thermal derating. Wind peaks in May–June, which fortunately coincides with the period when panels most need cooling. However, the declining trend means this natural cooling buffer is gradually eroding. The practical takeaway is that wind cooling is a real but modest mitigant of thermal derating, contributing approximately 1–2.5% points of derating reduction in the months where it matters most (April–September).

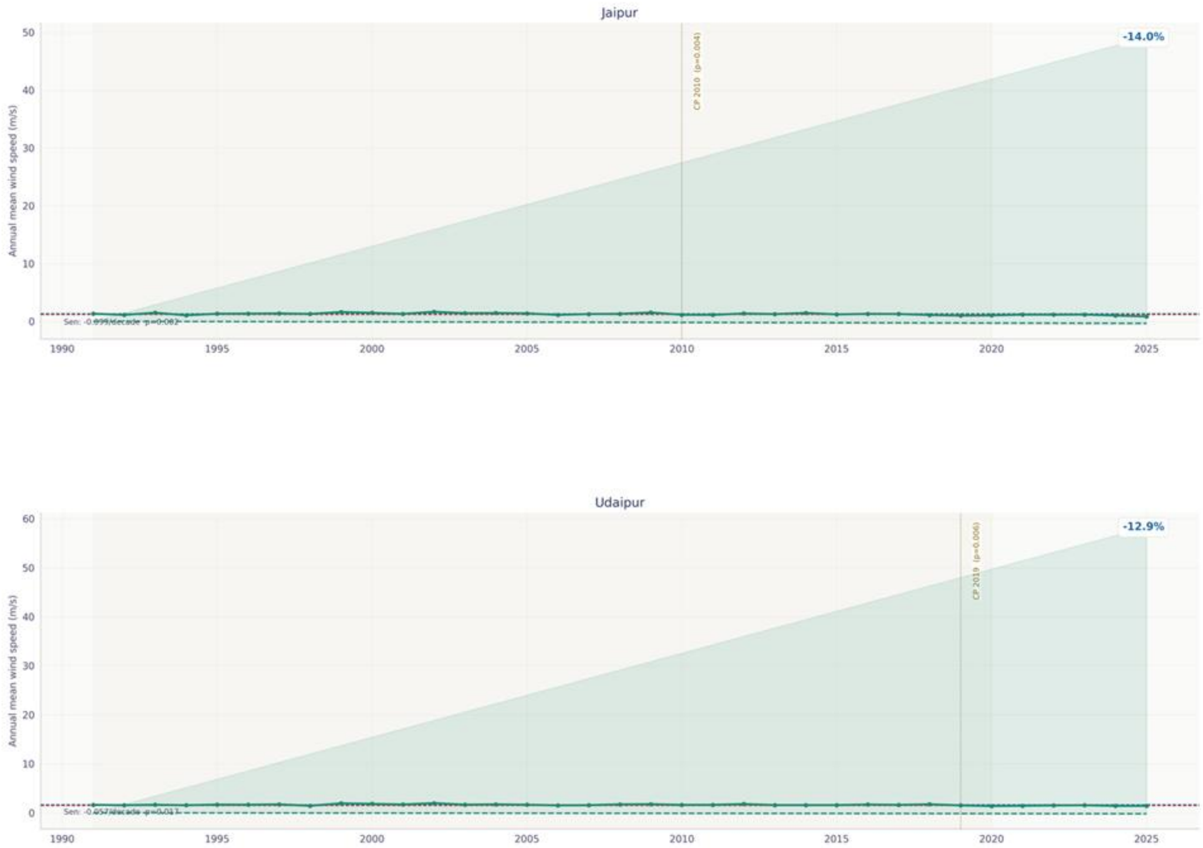

Figure 15: Annual mean wind speed change-point and trend 1991–2025, Jaipur and Udaipur; Source: Author's analysis

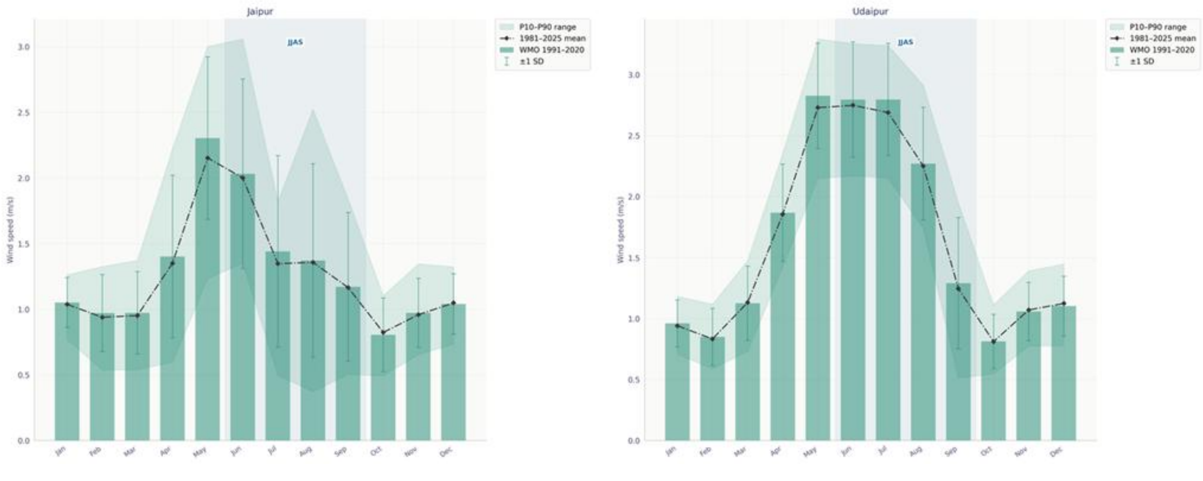

Figure 16: Monthly Wind Speed Climatology (m/s) vs WMO 1991–2020; Jaipur (left) and Udaipur (right); Source: Author's analysis

6.3.2. What the Actual Generation Data Shows

The climate trends identified in the previous sections are not just abstract findings. When actual rooftop solar generation data from 24 prosumers in Jaipur city (2023–2025) is compared against ideal benchmarks from the Global Solar Atlas (GSA), clear patterns of underperformance and overperformance emerge.

6.3.3. Ideal vs Observed Generation

The chart below shows what each month's average generation should be (blue line, based on the Global Solar Atlas model) versus what was actually recorded by the JVVNL generation data (red line).

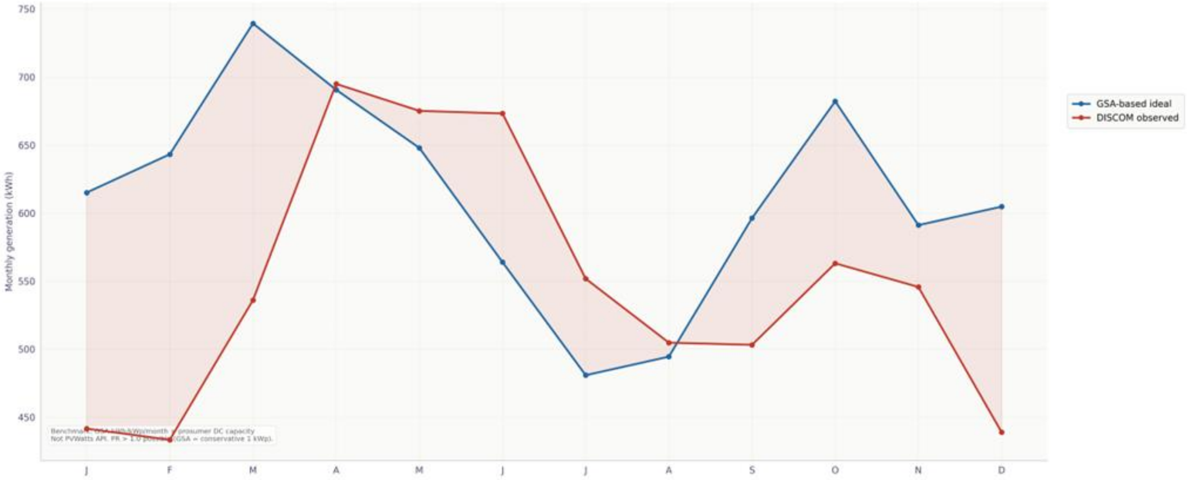

Figure 17: Ideal vs. observed monthly generation 2023–2025. The gap is largest in winter and widening over time; Source: Author's analysis

The gap between the two lines tells a clear story. Actual generation exceeds the ideal benchmark during June–August (the monsoon months) but falls significantly short during the winter months (December–March) and the post-monsoon period (October–November) (Fig. 18).

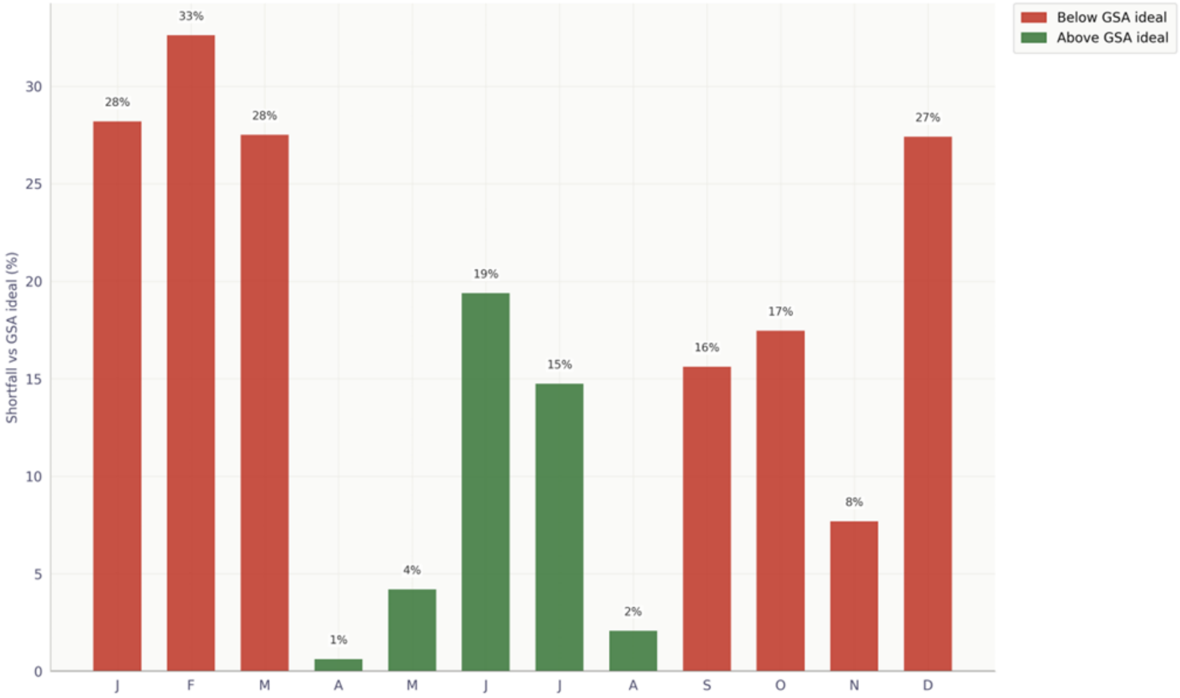

Figure 18: Monthly shortfall percentage vs Ideal monthly generation, 2023-2025; Red = underperformance; Green = overperformance; Source: Author's analysis

The Seasonal Picture:

- ***Winter is the worst season for solar generation*** with actual generation running 27–33% below the ideal benchmark in December, January, February, and March. This is partly because the solar atlas benchmarks embed historical irradiance levels that have since declined, and partly because fog, haze, and low sun angles compound the loss.
- ***Monsoon over performs.*** June and July show 15–19% above the ideal benchmark. This is likely because monsoon rain cools panels and washes off accumulated dust and the conservative solar atlas model may overestimate how much the monsoon suppresses generation.
- ***Pre-monsoon (April–May) is closest to the ideal,*** with only 1–4% shortfall. These months have the strongest direct sunlight and least weather disruption.
- ***Post-monsoon (October–November) shows 8–17% shortfall***, from lingering cloud cover and the extending monsoon tail.

6.3.4. The Complex Relation of Rainfall and Generation

One of the study's most important findings is that rainfall does not have a simple negative relationship with generation. When looked at month by month, higher rainfall months are not automatically lower generation months (Fig. 19).

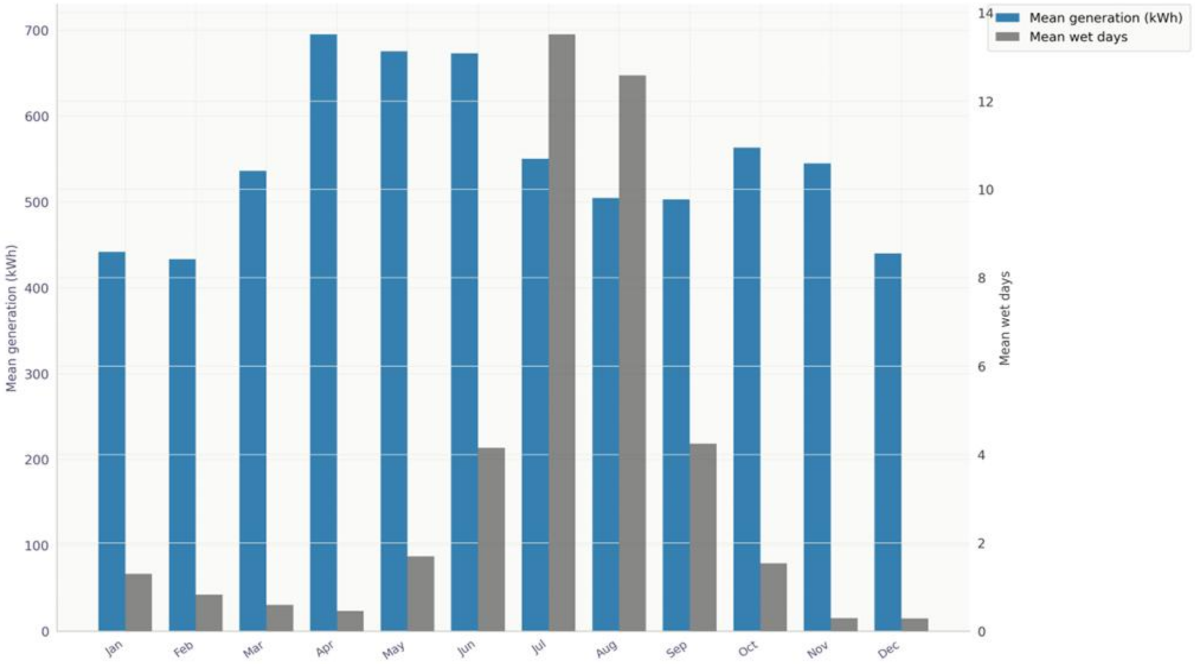

Figure 19: Seasonal climatology of wet days vs. mean generation (2023–2025 average) by calendar month; Source: Author's analysis

The reason becomes clear when rainfall's three simultaneous effects on solar generation are separated (Fig. 20):

- Cloud cover and rain block sunlight (negative effect on generation)
- Rain washes dust off panel surfaces (positive effect - cleaner panels generate more)
- Cooler temperatures during rain improve panel efficiency (slight positive effect)

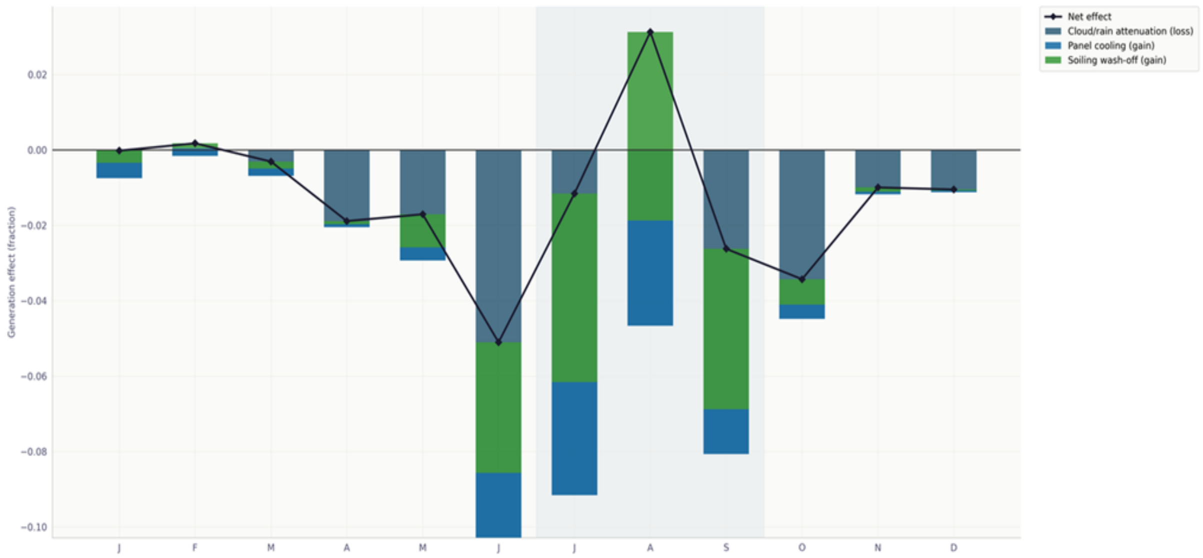

Figure 20: Monthly three-way rainfall decomposition of generation effects. The dust-cleaning benefit (green) partially offsets cloud attenuation (grey); Source: Author's analysis

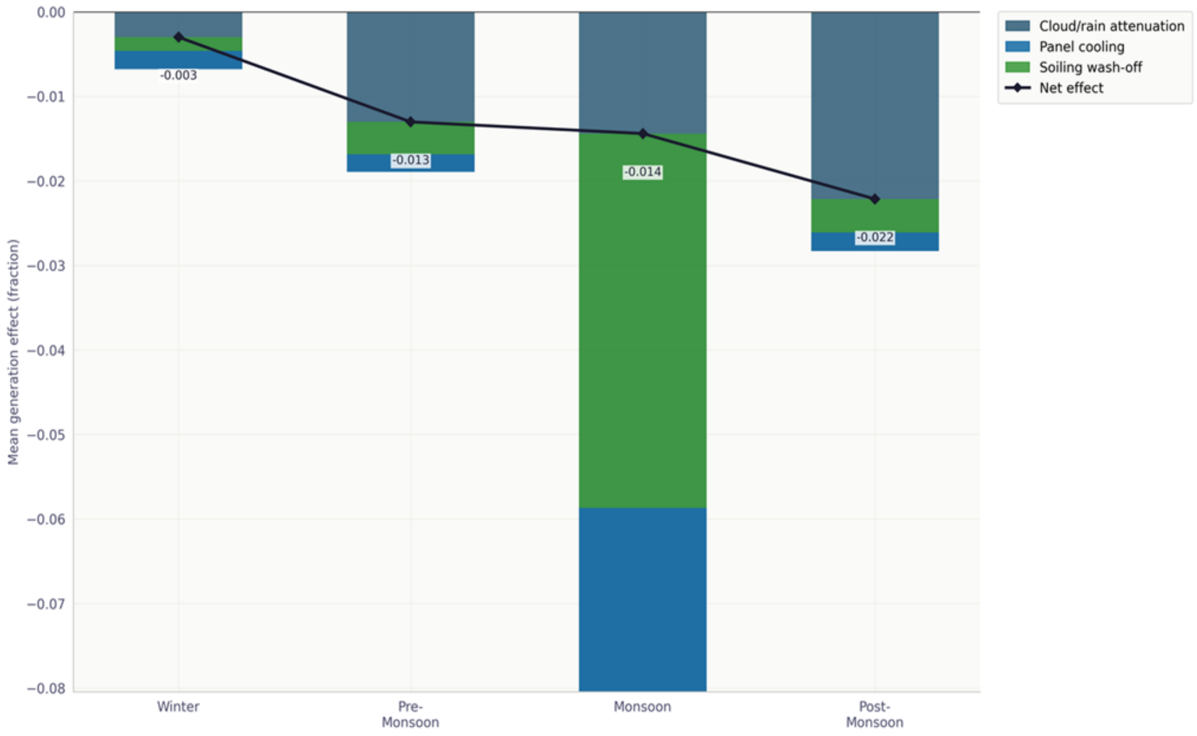

Figure 21: Three-way rainfall decomposition aggregated to four seasons; Source: Author's Analysis

At the monthly level, these effects roughly cancel out. The dust-cleaning and cooling benefits of rain partially compensate for the cloud-cover loss. The net effect of rainfall on generation is slightly negative in all seasons but small, ranging from −0.3% in winter to −2.2% in the post-monsoon period (Fig. 21).

More rainy days therefore do not mean proportionally less generation at the monthly level. But they do mean more individual days of near-zero output, increasing volatility and unpredictability. For prosumers who depend on daily self-consumption or grid export, this day-to-day uncertainty is what matters most.

7. Urban Heat Island Analysis

Solar panels lose efficiency as they get hotter. For every degree above 25°C, a typical panel loses 0.3–0.5% of its output. In cities where rooftops routinely exceed 45–50°C in summer, this thermal penalty is substantial and permanent throughout the hot months.

7.1. Jaipur: A Rising Heat Island

Jaipur recorded a mean land surface temperature of 47.7°C during April–May 2025, with temperatures ranging from 34°C at vegetated fringes to 56°C in dense built-up zones. Residential and commercial rooftops consistently exceed 45°C. The city's high built-up density and absence of large water bodies means heat accumulates across the urban surface with little natural mitigation (Fig. 22).

At a surface temperature of 47–50°C, panels are already operating at a sustained 6–12% efficiency deficit before accounting for any weather-related losses. Research by NCPRE and NISE[17] found that panels in hotter regions degrade at 1.01% per year, nearly double the 0.6% that manufacturers typically warrant. Jaipur's increased heat due to UHI effect therefore shortens the effective economic life of every rooftop installation going into the future.

7.2. Udaipur: Lake-Buffered Cooling

Udaipur's mean surface temperature for the same period was 38°C — almost 10°C cooler than Jaipur. The city's lake system (Lake Pichola, Fateh Sagar) acts as a significant thermal regulator, keeping surface temperatures well below what would be expected for a Rajasthan city in peak summer. Hotspots exist near industrial zones and dense commercial areas in the east, but these are isolated rather than city-wide (Fig. 23).

The practical consequence is that rooftop panels in Udaipur operate closer to their rated efficiency during summer, experience lower long-term degradation rates compared to Jaipur and are less likely to need system oversizing to compensate for heat losses.

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[17] NCPRE and NISE study

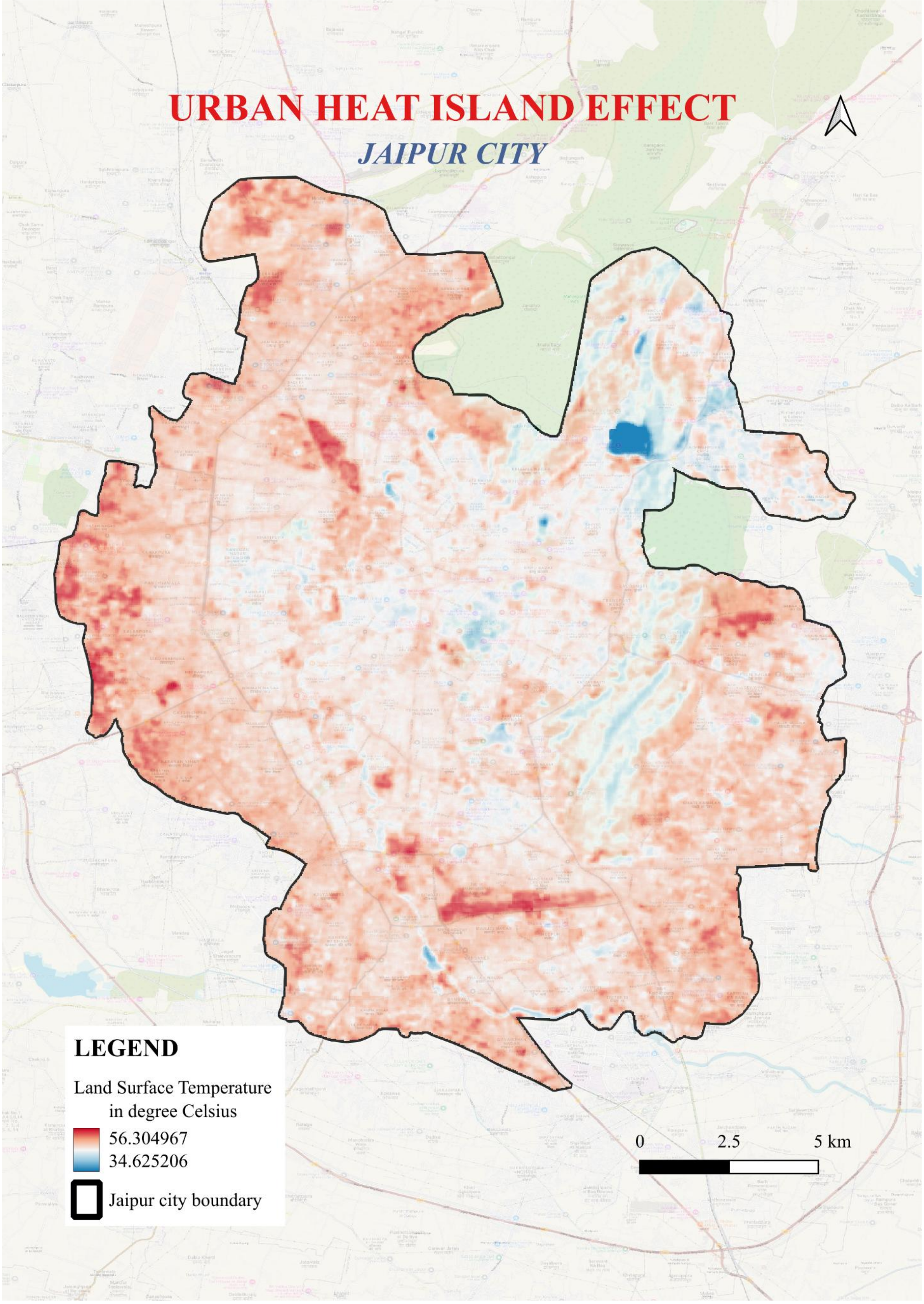

Figure 22: Urban Heat Island map of Jaipur city (April - May 2025). Red = hotter surfaces, Blue = cooler; Source: Author's Analysis

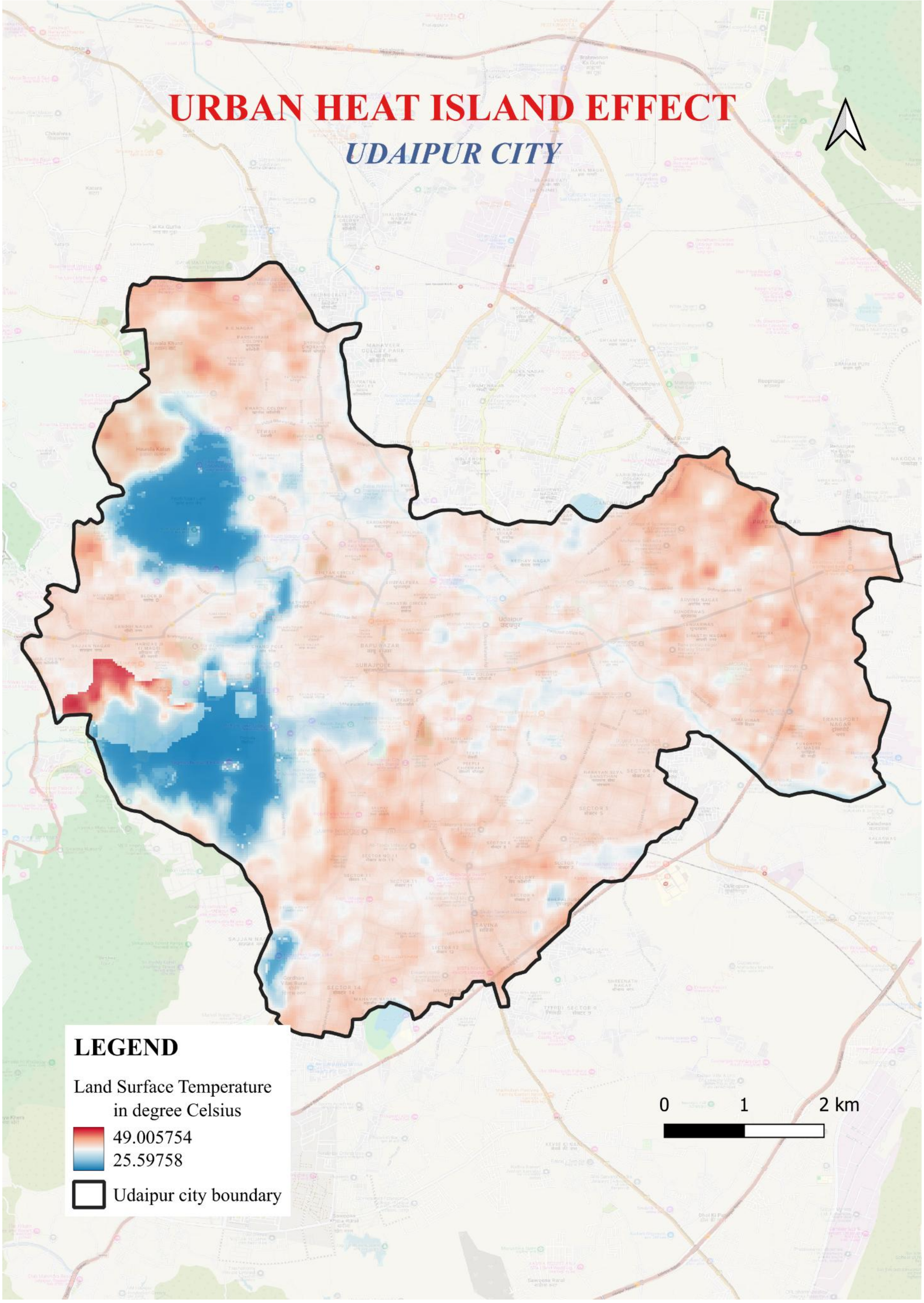

Figure 23: Urban Heat Island map of Udaipur city (April to May 2025). The lake system (blue) provides significant cooling; Source: Author's Analysis

8. Conclusion

IRRADIANCE DECLINE IS THE DOMINANT DRIVER

- The declining sunlight reaching both cities is the single most important long-term trend. It directly explains a generation loss of 56 kWh/kWp/year.
- Unlike a bad monsoon or an unusually hot summer, this is a structural and worsening driver that compounds year after year. Every generation benchmark set using historical (WMO 1991–2020) irradiance norms is now too optimistic.

RAINFALL IS NET NEUTRAL, BUT VOLATILITY IS RISING

- Rainfall has no statistically significant direct relationship with monthly generation, because the cloud-cover loss and panel-cleaning gain roughly cancel out.
- However, the rising frequency of wet days since 2010 has likely contributed to the irradiance decline through enhanced cloud cover, creating an indirect link between the two trends.
- More wet days also means more days of near-zero generation, which thereby increases output volatility.

WIND IS A MODEST AND ERODING BUFFER

- Wind provides a real but small cooling benefit for panels, concentrated in May–September when heat stress is highest.
- However, the 13–14% decline in wind speeds means this cooling offset is gradually diminishing, adding risk to a declining generation trend.

WINTER UNDERPERFORMS THE MOST

- The worst season that is underperforming is winter (December–February), with generation running 27–33% below ideal.
- This initially seems puzzling since winter is thermally benign. The explanation is that the generation benchmarks for winter embed irradiance values that have already declined post-2010. The low-angle winter sun, combined with fog, haze, and persistently below-normal irradiance, produces proportionally large shortfalls even from small absolute irradiance deficits.

MONSOON IS OVERPERFORMING

The monsoon overperformance (June–August exceeding benchmarks by 15–19%) results from a combination of panel cooling from moisture and wind, frequent rain events washing off accumulated dust, and the conservative GSA benchmark potentially overestimating monsoon suppression. The model may not fully account for how the post-2010 wetter climate has shifted some irradiance loss later into the monsoon rather than in June.