iFOREST | INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

JHARKHAND RENEWABLE ENERGY POTENTIAL RE-ASSESSMENT

Focus on Solar, Wind and Biomass

August 2025

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August 2025

Citation: Deepak Singh Rathour, Ankit Kumar, Suhail Mir, Mandvi Singh. (2025). *Jharkhand Renewable Energy Potential Re-Assessment: Focus on Solar, Wind and Biomass*. International Forum for Environment, Sustainability & Technology (iFOREST) New Delhi. India

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List of Abbreviations

AGL	Above Ground Level
CUF	Capacity Utilization Factor
CWC	Central Water Commission
GPP	Gross Primary Production
GRID	Global Resource Information Database
GW	Giga Watt
GWA	Global Wind Atlas
GWh	Giga Watt Hour
ISRO	Indian Space Research Organisation
KT	Kilo Tonne
kV	Kilo Volt
kW	Kilo Watt
kWh	Kilo Watt hour
kWp	Kilo Watt peak
LULC	Land Use and Land Cover
MJ	Mega Joule
ML	Machine Learning
MNRE	Ministry of New and Renewable Energy
MODIS	Moderate Resolution Imaging Spectroradiometer
MT	Metric Tonne
MW	Mega Watt
MWp	Mega Watt Peak
NISE	National Institute of Solar Energy
NIWE	National Institute of Wind Energy
NRLD	National Register for Large Dams
NRSC	National Remote Sensing Centre
PV	Photovoltaic
RE	Renewable Energy
RPO	Renewable Purchase Obligation
sq. km	Square Kilometer
sq. m	Square Meter
SRTM	Shuttle Radar Topography Mission
TIFAC	Technology Information Forecasting and Assessment Council
UNEP	United Nations Environment Programme
WBIS	Water Bodies Information System

Summary

Jharkhand's renewable energy (RE) generation potential, including large hydro was estimated at 18.8 GW by the Ministry of New and Renewable Energy in 2014, representing only about 0.89 per cent of the national total. This perceived low potential has contributed to the slow pace of investment in the state's RE sector. These assessments for most technologies are over a decade old and rely heavily on broad estimations. There is a pressing need to revise these figures using updated datasets and more refined methodologies to assist policymakers, agencies, and investors in formulating a strategic and ambitious RE development plan for the state. In this context, iFOREST has undertaken a comprehensive evaluation of Jharkhand's RE potential, covering solar (ground-mounted and floating), wind energy, and biomass.

Solar

- Jharkhand receives over 300 days of continuous sunshine annually, translating to approximately 2,280 sunny hours annually. The state benefits from an average solar radiation of 5.0 kWh/m^2 and an average insolation of approximately 359 W/m^2. Although the average insolation is modest, the peak insolation reaches around 999 W/m^2, which is comparable to that of India's leading RE states.

Ground-mounted solar

- Contrary to MNRE's conservative estimation methedology of utilizing 3 per cent of wasteland for solar PV installations, a detailed assessment indicates a higher utilization potential of 9 per cent. This translates into a ground-mounted solar potential of 45,425 MW, covering 919 sq. km, which is more than double MNRE's estimated potential of 18,180 MW.
- The majority of this is concentrated in the districts of Giridih, Dumka, Deoghar, Hazaribagh, Saraikela-Kharsawan, Bokaro, and Palamu, collectively accounting for 49 per cent of the state's projected ground-mounted solar potential. Among these, Giridih contributes the highest share at 14.3 per cent of the potential, followed by Dumka, Deoghar, and Hazaribagh at 6.6, 5.8, and 5.7 per cent, respectively.
- A total of 16 major wasteland clusters across nine districts are identified in Jharkhand, with a total area of 252.98 sq. km and an estimated solar capacity of 5,157 MW, at the assumed land utilization levels.
- The analysis identified 79.69 sq. km of wasteland parcels near existing substations with the potential to also support approximately 3,938.46 MW of solar capacity, assuming full utilization of the available land within these parcels.

Floating solar

- An assessment of relatively accessible to utilize waterbodies across the state filtered for purpose, area, depth and age, reveals that the majority of suitable waterbodies for floating solar installations are located in the districts of Hazaribagh, Dhanbad, Bokaro, Palamu and Ramgarh resulting in an overall potential of 3,000 MW to 14,000 MW depending on different scenarios.
- The highest potential is concentrated in the Hazaribagh district, with up to 8,859 MW across five reservoirs under the high-potential scenario, followed by the Dhanbad district (770 MW across two reservoirs in a high potential scenario). The high potential of Hazaribagh is primarily due to the presence of Konar dam that can potentially host a large-scale floating solar plant of 8,649 MW.

Wind

- By mapping high wind speed locations and applying filters for climate risks and steep slopes, a theoretical wind energy potential of 11.98 GW has been identified at a hub height of 100 m above ground level (AGL) and 22 GW at a hub height of 150 m AGL. Approximately 0.89 GW of the potential at 150 m hub height is located in areas with high wind speeds ranging from 6 to 7 m/s.
- Focusing on wastelands, including those evaluated in the solar resource potential assessment, and applying a similar methodology, the wind energy potential is estimated at 403.2 MW and 15,296 MW at hub heights of 100 m and 150 m AGL, respectively. At 100m AGL, three districts—Gumla, Ranchi, and Sahibganj—contribute 81 per cent of the estimated potential, with Ranchi alone accounting for 49.2 per cent. However, at a higher hub height of 150 m AGL, the potential is more widely distributed. Giridih contributes the highest share at 29.9 per cent, followed by Hazaribagh with 20.7, Dumka at 8.6, and Ranchi at 6.7 per cent.

Biomass

- Based on district-wise crop residue data from the 'ISRO JAIVOORJA' portal, Jharkhand's cumulative biomass potential is estimated at 2,813 MW, significantly exceeding MNRE's assessment. Around one-third of this biomass potential is concentrated in the districts of Gumla, Ranchi, and West Singhbhum, with individual shares of 13, 10, and 9 per cent, respectively.

Overall, the re-assessment of Jharkhand's RE potential reveals significantly greater RE capacity than what was previously estimated by the MNRE. This enhanced potential is adequate to support the substantial addition of RE capacity within the state, aiding in long-term sustainable green growth in the state.

1. Introduction

Jharkhand has played a pivotal role in meeting India's energy needs. As of 2024, the state possesses approximately 91.8 billion tonnes of coal reserves, representing approximately 27 per cent of the nation's total reserves, making it the largest coal producer in the country. With the increasing energy demands both within the state and across the nation, Jharkhand is expected to maintain its position as a significant coal producer in the forseeable future. At the same time, India has set ambitious renewable energy (RE) targets, aiming for 500 GW of installed capacity by 2030 and achieving for net-zero emissions by 2070. These targets require intensified efforts nationwide and by individual state governments to decarbonise their energy mixes, essentially scaling RE capacity and promoting its integration into the subnational grids.

So far, Jharkhand has fallen behind other states in the development of RE. As of August 2025, the state has installed 435 MW of RE capacity, which constitutes less than 1 per cent of India's total RE capacity of 199,583 MW. Of this, 14.4 per cent is off-grid solar, 5.2 per cent is ground-mounted solar, 4.72 per cent is biopower, and lastly, 1 per cent is small hydro. The biopower capacity of 19.1 MW accrues entirely to non-bagasse based biomass cogeneration.

A key factor hindering investment momentum in Jharkhand's RE sector is the perception of limited potential. The Ministry of New and Renewable Energy's assessments estimate the state's RE potential at 18,870 MW, which represents approximately 0.89 per cent of the national total. This potential is mainly attributed to solar energy (18,180 MW), followed by large hydro (300 MW) and small hydro (228 MW)[1].

Table 1.1: Source-wise potential of RE capacity in Jharkhand , MNRE estimates

RE source	Estimated potential (MW)
Wind (at 150m AGL)	16
Small hydro	228
Biomass	146
Cogeneration-bagasse	-
Solar	18,180
Large hydro	300
Total	**18,870**

Source:MNRE

Aside from wind power potential (which has been frequently updated by the National Institute of Wind Energy), the current estimates of RE potential are based on assessments conducted over a decade ago, largely relying on broad generalizations. Consequently, these estimates significantly underrepresent the actual potential, thereby failing to inspire the necessary policy actions and investments from state decision-makers and RE investors.

To address this issue, a more detailed and up-to-date assessment of RE potential for each technology is essential. This should involve evaluating specific sites and clusters using more rigorous methodologies and the most recent datasets. Such a comprehensive assessment is crucial for guiding policymakers, implementing agencies, and investors in formulating a strategic and ambitious RE capacity plan for the state in the short to medium term. This strategy will be vital for Jharkhand to meet its Renewable Purchase Obligation (RPO) targets and achieve sustainable green energy growth.

While the excercise of updating the RE potential assessment has been initiated for multiple states by the central agencies, iFOREST has conducted an extensive re-assessment of multiple eastern region states including Jharkhand. The Re-assessment covers ground-mounted solar, floating solar, wind energy, and biomass. The subsequent chapters of this report present the findings of this re-assessment.

2. Solar

The solar power generation potential of a region is primarily influenced by two key factors: the intensity of insolation and the availability of land for solar installations. Historically, Jharkhand has been regarded as less suitable for solar energy generation due to its relatively lower insolation levels and limited availability of wasteland.

Contrary to these perceptions, Jharkhand enjoys over 300 days of continuous sunshine annually, translating to about 2,280 hours of sunlight per year. The state receives an average solar radiation of 5 kWh/m^2 and an average insolation of approximately 359 W/m^2.

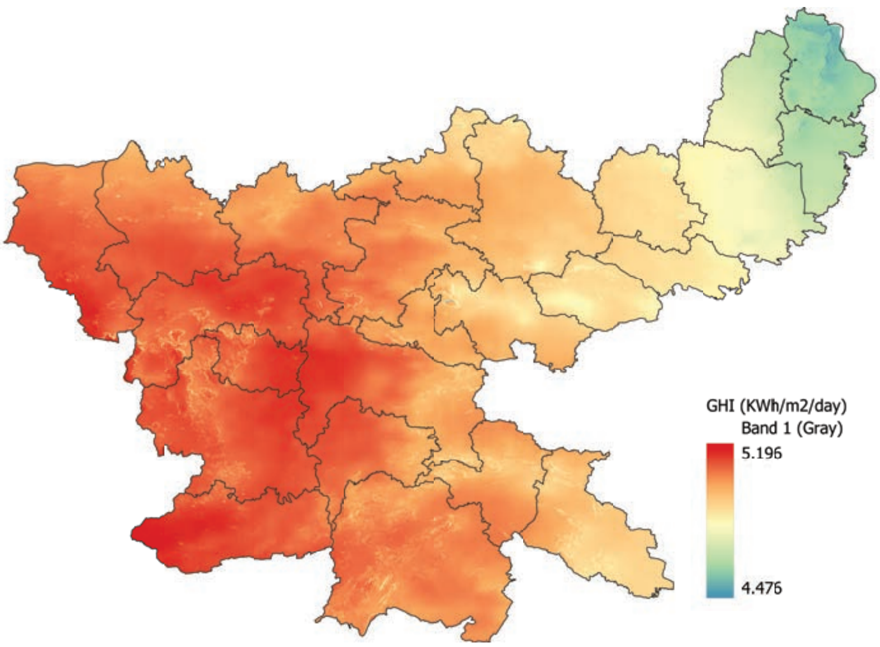
Table 2.1: Average and peak insolation levels for Jharkhand

State	Average (W/m^2)	Peak (W/m^2)
Jharkhand	359	999
Uttar Pradesh	465	889
Odisha	389	913
Madhya Pradesh	514	989
Gujarat	590	825
Germany	229	892

Source: NASA LaRC

Although Jharkhand shares the same longitude as other eastern states, its average solar radiation is relatively lower compared to states like Odisha, Bihar etc. This is primarily due to an extended monsoon season, lasting from June to September, which reduces the overall radiation levels relative to its eastern region counterparts. While Jharkhand's peak insolation of 999 W/m^2 is comparable to 'renewable energy (RE)-rich' states like Gujarat and Madhya Pradesh, its average insolation of 359 W per sq. m is lower than other 'low-RE' states like Odisha and Uttar Pradesh.[3] At the same time, note that, the average and peak insolation levels in Jharkhand are significantly higher than Germany, which is among the leaders in solar installations with an installed capacity of 103.8 GW[4].

Map 2.1: Solar insolation map of Jharkhand



Source: Global Solar Atlas

The National Institute of Solar Energy (NISE) estimates Jharkhand's solar power generation potential at 18.18 GW[5]. This estimate is based on a generalized approach that assumes 3 per cent of available wasteland can be used for solar photovoltaic (PV) installations. However, this method may underestimate the potential for more extensive land use in specific wasteland categories that could support greater solar coverage without significant ecological impact. For example, industrial and mining wastelands might be repurposed more extensively for solar projects within a state such as Jharkhand.

Moreover, land-neutral solar technologies, such as floating solar and rooftop solar, must also be considered. These technologies can be evaluated to minimize ecological impacts and offer alternatives to traditional ground-mounted installations. By utilizing these approaches, Jharkhand could expand its solar capacity without mounting pressure on its land resources, thus promoting more sustainable energy development.

2.1 Ground-mounted solar

In addition to adequate solar insolation, land availability is a crucial factor determining the potential and feasibility of ground-mounted solar PV project installations. Typically, the installation of 1 MW of solar capacity requires approximately five acres of land[6]. Given this land requirement intensity for ground-mounted solar projects, wastelands are considered most suitable for utility-scale ground-mounted solar projects. However, the current potential assessment methodology employed by NISE is overly simplistic, as it applies a uniform a 3 per cent utilization rate across all wasteland categories without taking into account the distinct characteristics of each category. This presents a methodological limitation, as certain categories of wasteland can support a higher degree of land diversion for solar power generation without causing significant ecological harm. To produce a more accurate assessment of Jharkhand's ground-mounted solar potential, it is crucial to analyse the state's specific land use patterns and wasteland categories. This approach will enable the development of a more nuanced and realistic estimate of the state's solar generation capacity, capturing the potential for increased land utilization in certain types of wastelands.

Re-assessment methodology

To re-assess Jharkhand's ground-mounted solar potential, recent district-wise wasteland data are categorized into various types and filtered to exclude unsuitable features such as a high propensity to floods, elevated terrain, and fire density, among others.

To accurately identify wasteland distribution, a pixel-based classification machine learning (ML) model applied to multispectral imageries from Sentinel-2 is designed[7]. The 2015-16 wasteland feature classes serve as a reference dataset for model training. This training process is further supplemented by manual verification. Additionally, closely identified manual training samples, derived from year-wise and seasonally varied Sentinel-2 imagery, are incorporated to enhance the model's accuracy and robustness.

BOX 2.1: WASTELAND MAPPING METHODOLOGY

Step 1 - Imagery Review: Sentinel-2 imageries at a 10-meter resolution have been reviewed across different seasons—Rabi, Kharif, and Zaid—to capture and analyse seasonal variations.

Step 2 - Mosaic Generation: A mosaic layer is generated using the Sentinel-2 L1C dataset, which consists of 13-band imagery. This imagery is downloaded from the Copernicus Data Space platform. An empty raster dataset is created using the 'Create Raster Dataset' tool, configured according to the Sentinel-2 MSI specifications, including 13 bands with a 10-meter resolution. The mosaic is generated using ArcGIS Enterprise Tooling, particularly ArcPro and the Deep Learning Toolkit. This process integrates the downloaded images into a single, comprehensive mosaic, facilitating detailed analysis and visualization.

Step 3 - Training Dataset: A training dataset is created by clipping 4 to 6 test regions from the mosaic layer. Supervised classification is then performed on these clipped regions to identify

Box 2.1 continued

the desired wasteland classes using the image classification tool. The training set is developed with reference to the National Remote Sensing Centre (NRSC) Wasteland Dataset of 2019 and is adjusted based on our understanding of both the latest and previous imagery. The initial output is in raster format, which is then converted to vector format. Following this conversion, the vector shapefile is edited to further refine the output, enhancing the data's accuracy and usability for subsequent analyses.

Step 4 - Seasonal Model Development: Distinct models have been developed for each agricultural season—Rabi, Kharif, and Zaid. Training samples specific to each season have been collected and used to train these models, using Sentinel-2 imagery paired with corresponding ground truth data. Each seasonal model is optimized to perform effectively during its respective season, capturing the unique characteristics and patterns relevant to that period.

Step 5 - Combined Model Integration: Once the seasonal models are trained and validated, they have been integrated into a single, unified model. During the inference phase, input imagery is processed through all three seasonal models. The output probabilities or predictions from each model have then been aggregated using ensemble methods such as averaging, weighted averaging, or stacking. This approach allows the combined model to deliver a comprehensive output that reflects an understanding of land types across all seasons, effectively leveraging the strengths of each individual seasonal model.

Step 6 - Training Chip Set Generation: A training chip set is generated using ArcGIS Enterprise Tooling, specifically ArcPro and the Deep Learning Toolkit. The input for this process will be the previously created mosaic layer. Additionally, a reference layer for annotation, which consists of the supervised classification vector output, is utilized. This setup enables precise and effective training of the models by leveraging the detailed spatial information provided by the mosaic and the accuracy of the classification vectors.

Step 7 - Training of Machine Learning Model: The pixel classification machine learning model is trained using the ArcGIS Deep Learning Toolset, with the datasets created for classifying wasteland areas.

Step 8 - Model Refinement: The Pixel Classifier Model available through the ArcGIS Deep Learning Toolset, is employed for model refinement. The input raster layer will be the mosaicked Sentinel-2 layer, which provides a comprehensive view of the terrain. Once the base model is created, testing and fine-tuning is conducted to enhance accuracy. This iterative adjustment process will continue until saturation is reached, where further adjustments no longer yield significant improvements in model performance. This method ensures the model's maximum effectiveness in analysing and interpreting satellite imagery.

It is important to note that, based on previous outputs for Land Use and Land Cover (LULC) products, an accuracy ranging from 85% to over 90% is typically achieved. This level of accuracy is influenced by multiple factors, including the quality of the available satellite imagery for specific regions. A significant factor affecting this quality is cloud cover, which can obscure the satellite's view and impact the precision of imagery analysis.

The mapped wasteland is further analysed to identify regions with high susceptibility to natural hazards such as floods, landslides and cyclones. The flood, cyclone and landslide-prone areas are identified using a database from the Global Resource Information Database (GRID) of the United Nations Environment Programme (UNEP)[8]. Additionally, regions of high elevation, which are more prone to landslides, are excluded from the wasteland dataset based on topographical data provided by the University of California, San Diego's Topography platform.[9] Finally, wasteland areas with steep slopes are dropped from the dataset using R studio.

BOX 2.2: MAPPING UNSUITABLE AREAS

Fire-Affected Areas: Fire-prone areas are identified as active fire density areas for the period 2003 to 2022, wherein the density of fires is reported as the count of fire per sq. km filtered for fire density greater than 0.1.

Flood Affected Areas: Flood-prone regions represent 25 years of modelled data for floods with water levels greater than 180 cm.

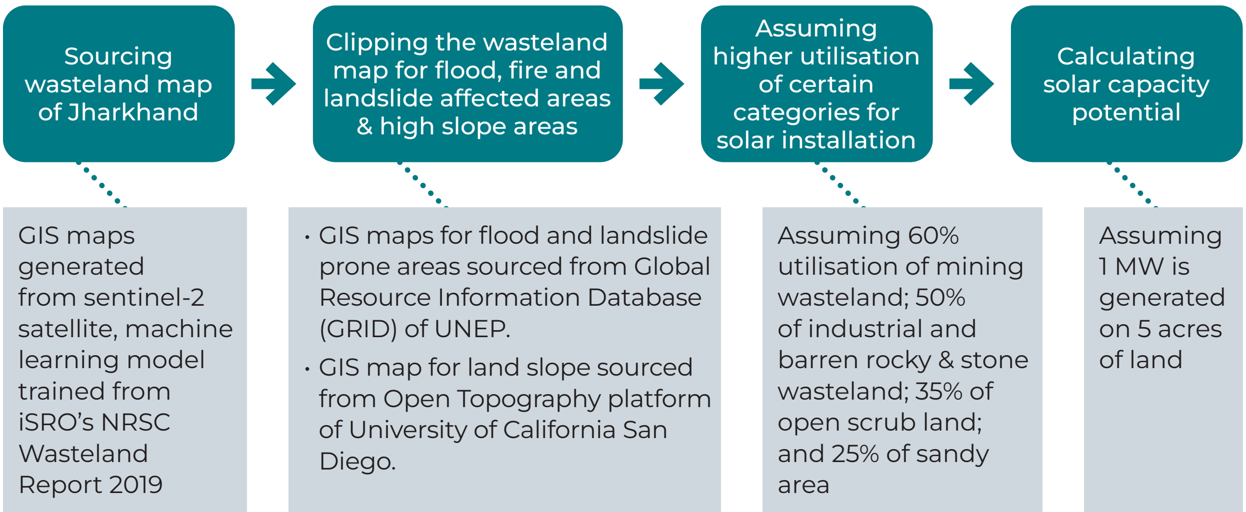
Landslide Affected Areas: Landslide-prone areas reflect the annual frequency of landslides triggered by precipitation. This is filtered for medium and high frequencies.

Steep areas: Areas with slopes greater than 8 degrees are considered undesirable for solar projects.

Utilisation factors are applied to different wasteland types based on their ecological sensitivity and accordance with land-use patterns for ground-mounted solar installations. For this assessment, it is assumed that 60 per cent of mining wasteland can be utilized for solar panel installation, along with 50 per cent of industrial and barren-rocky & stone wastelands, 35 per cent of open scrubland, and 25 per cent of sandy areas. These factors are used to estimate the feasible land area available for solar energy projects, taking into account the varying degrees of land usability.

Lastly, solar energy potential is calculated based on the industry standard that 1 MW of solar power generation requires five acres of land. This method yields a quantitative estimate of the solar potential that can be harnessed from the available wasteland, thereby facilitating strategic planning for solar deployment.

Figure 2.1: Ground-mounted solar potential re-assessment methodology



Source: iFOREST assessment

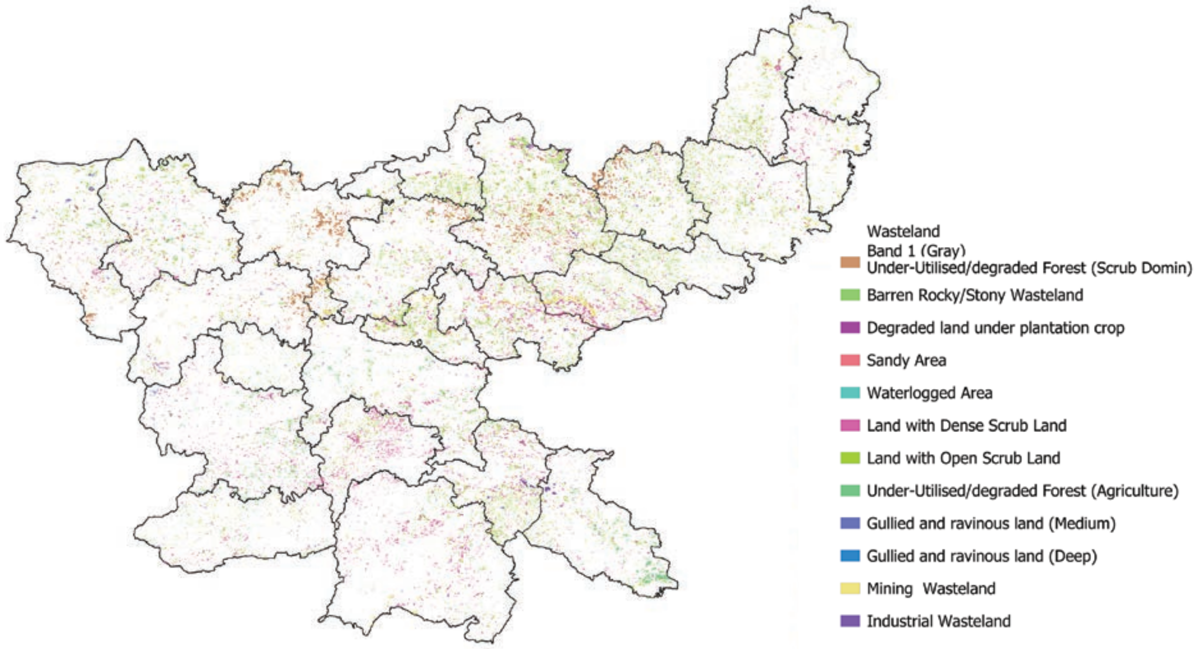
2.1.1 Potential re-assessment

Jharkhand is the fifteenth largest state in India, spanning over 79,706 sq km. According to India's Wasteland Atlas 2019, Jharkhand has 14.76 per cent (11,767.08 sq km) of its landmass designated as wasteland[10].

By extracting satellite imagery from Sentinel-2 and applying a machine learning algorithm, iFOREST mapped a wasteland area of about 10,691 sq. km across twelve categories in Jharkhand. The majority of this wasteland is classified as degraded forest, of which 40 per cent is scrub-dominated. This is followed by 20.42 per cent of open scrub land and 14.56 per cent of land with dense scrub.

Next, the wasteland area is analysed for exposure to floods, landslides and fires. Affected areas are deemed unsuitable for solar PV installations and hence dropped from the dataset of feasible area. The analysis finds, that of the 10,691 sq. km of wasteland area identified, about 87 sq. km is affected by floods, 345 sq km is affected by landslides and 282 sq km is vulnerable to fires. In addition, nearly 1,068 sq. km of the wasteland area (after dropping areas susceptible to floods, landslides and fires) has a slope too steep for solar installation consideration, which is also subsequently removed from the dataset.

Map 2.2: Wasteland map of Jharkhand



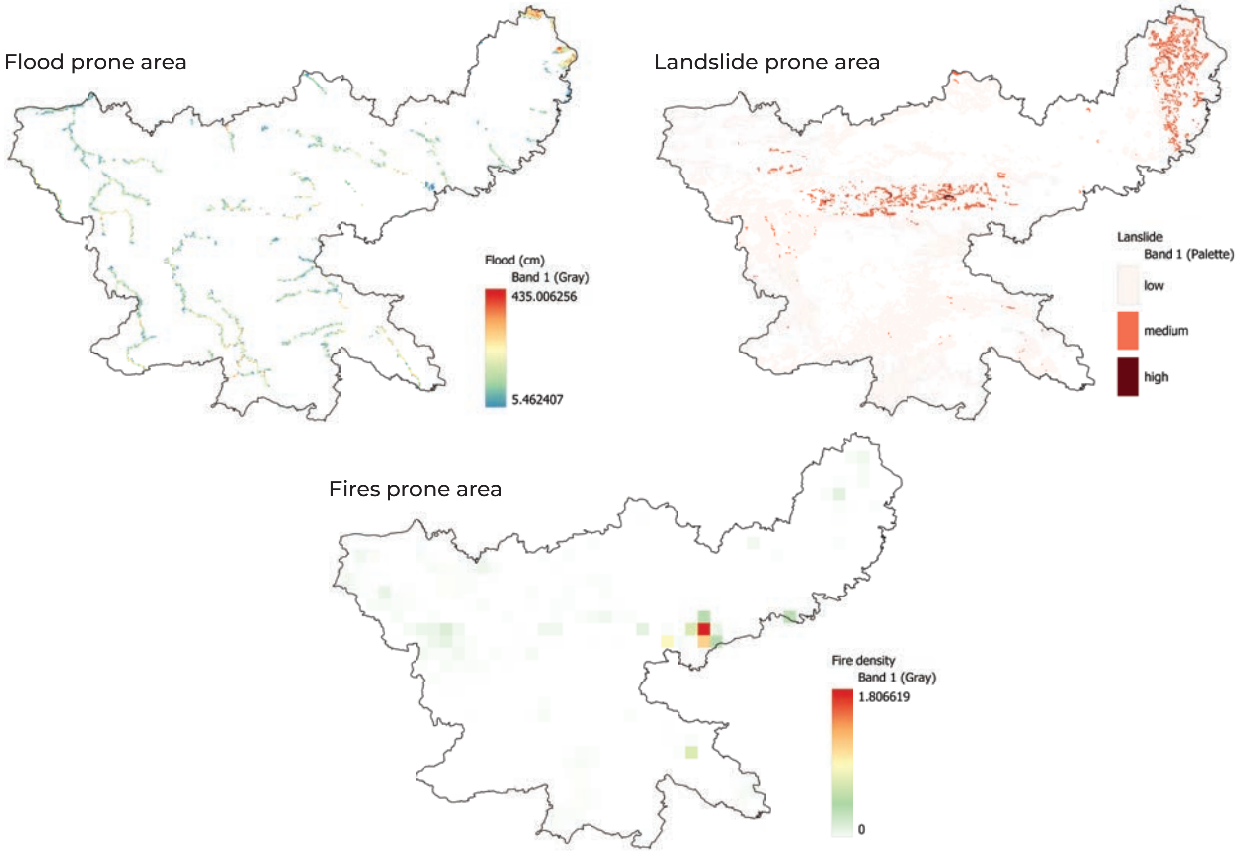
Source: iFOREST assessment based on Sentinel-2 satellite imagery

Table 2.2: Wasteland categories in Jharkhand

Type	Area (sq km)	Share (%)
Industrial wasteland	33.59	0.31
Mining wasteland	276.53	2.58
Sand area	0.02	0
Barren rocky and stone waste	354.05	3.31
Degraded land under plantation crop	5.46	0.05
Land with dense scrub	1,556	14.56
Gullied and ravenous land (medium)	107.70	1
Gullied and ravenous land (deep)	.30	0
Waterlogged area	11.04	0.10
Land with open scrub	2,184	20.42
Degraded forest (scrub dominated)	5,000.11	46.76
Degraded forest (agriculture)	1,161.72	10.86
Total wasteland area	**10,691**	**14.76**
Total geographic area	**79,706**	**-**

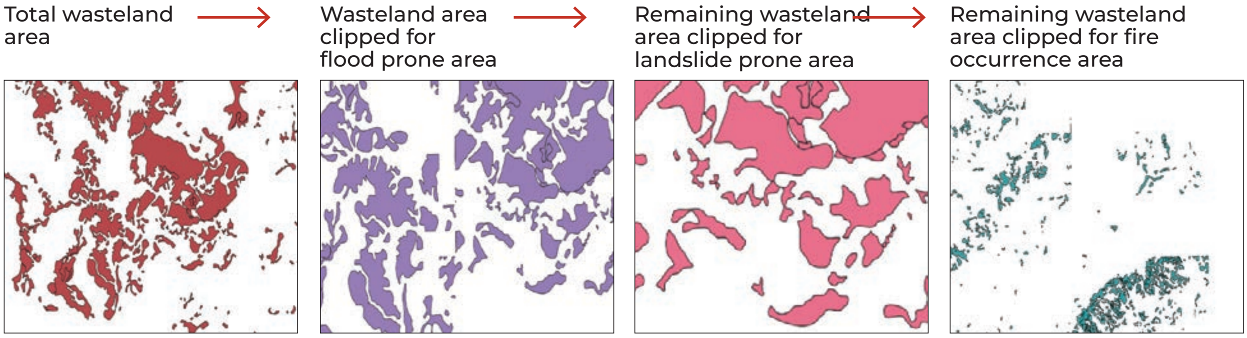
Source: iFOREST estimates based on Sentinel-2 satellite imagery

Map 2.3: Wasteland map clipped for undesired conditions



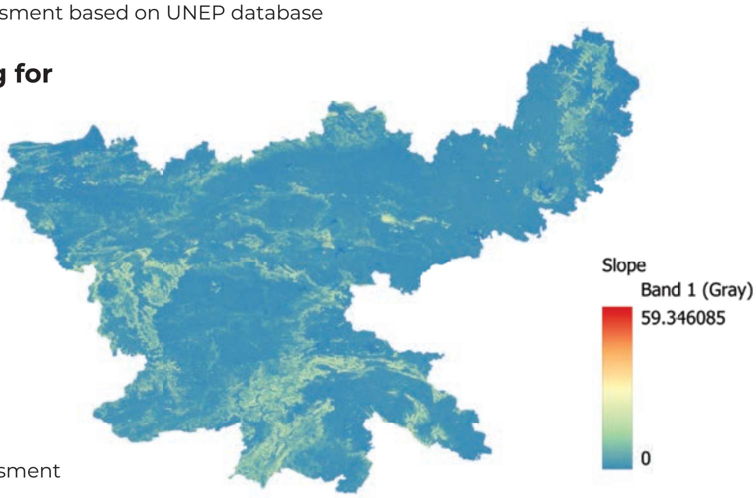
Source: iFOREST assessment based on UNEP database

Map 2.4: Reference image flood, landslide, and fire prone clipped area



Source: iFOREST Assessment based on UNEP database

Map 2.5: Clipping for high slope area



Source: iFOREST assessment

After mapping and analysing Jharkhand's wasteland, and excluding areas with undesirable properties, five specific wasteland categories have been identified as suitable for ground-mounted solar projects. These categories include

- barren rocky land,
- scrubland,
- mining wasteland,
- industrial wasteland, and
- sandy areas.

Together, these categories amount to 2,848.19 sq. km out of the total 10,691 sq. km of wasteland in Jharkhand. In other words, approximately 68 per cent (1,929 sq. km) of Jharkhand's wasteland is deemed unsuitable for ground-mounted solar PV projects.

- Post clipping, open scrublands are the largest available wasteland category with a land area of 2042.32 sq. km. These lands are characterized by shallow, skeletal soils and arid conditions with low vegetation cover. In the present study, only 35 per cent of such wasteland are considered for solar installations due to their relatively greater ecological significance.
- Barren rocky and stone wastelands are the second largest wasteland category with 202.22 sq. km of clipped wasteland area. These are land patches devoid of vegetation and soil cover with exposed rock surfaces. About 50 per cent of this land type is assumed to be utilised for solar installations.
- Industrial and mining wastelands, which are dump lands for mining debris or industrial waste, constitute the next highest subcategory with 24.15 sq. km and 151.92 sq. km of the final land area, respectively. A relatively high utilisation proportion of 50 per cent to 60 per cent is assumed for this category.
- Sandy areas, often found within river floodplains as sand sheets or sandbars, or as inland dunes shaped by wind, constitute the smallest portion of the final land area in Jharkhand (0.02 sq. km). A quarter of the available land is assumed to be utilized for solar development, due to their relatively higher ecological sensitivity.

Table 2.3: Wasteland category-wise ground-mounted solar installation potential

Usable wasteland category	Total area (sq. km)	Area after adjusting for floods, landslides, fires & steep slopes (sq. km)	Assumed land available for Solar (sq. Km)	Estimated potential (MW)
Industrial wasteland	33.59	24.15	12.07	596.97
Mining wasteland	276.53	151.92	91.15	4,505
Sand area	.02	.02	.005	.26
Barren rocky and stone waste	354.05	202.22	101.11	4,997
Land with open scrub	2,184	2,042.32	714.81	35,326
Total	**2,848.19**	**2,420.63**	**919.145**	**45,425.23**

Note: Assuming 60% utilisation of mining wasteland; 50% of industrial and barren rocky & stone wasteland; 35% of open scrubland; and 25% of sand area.
Source: iFOREST Assessment

The study identified 919 sq. km of wasteland across five categories in Jharkhand as potentially usable land for ground-mounted solar installations, with the potential to support a total of 45,425 MW of solar capacity.

Breakdown of Usable Wasteland:

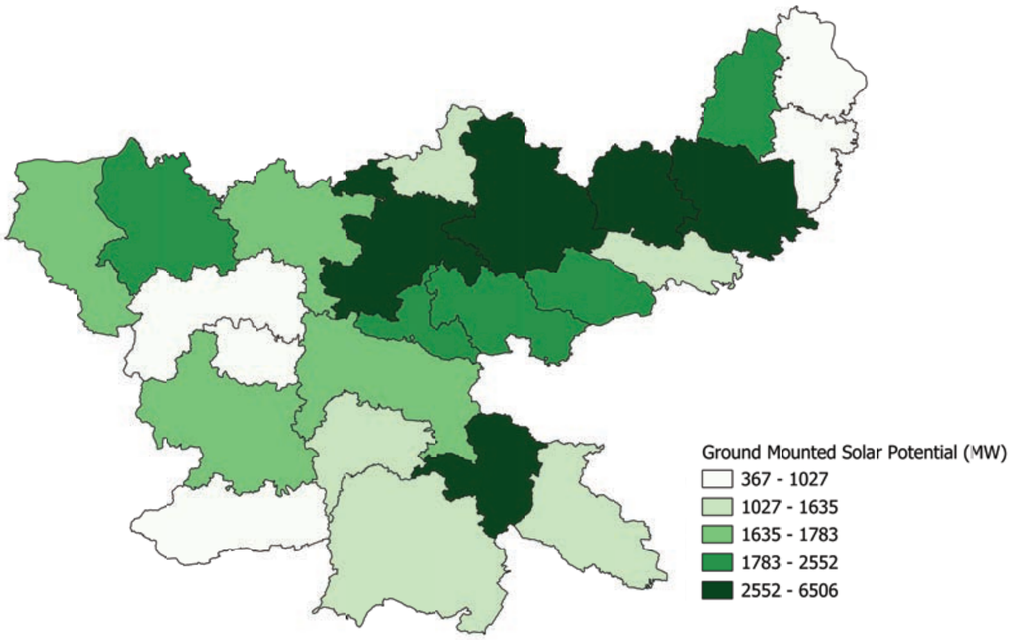
- **Scrub Lands:** Represent 77.8 per cent of the usable area, capable of supporting 35,326 MW of solar capacity.
- **Barren Rocky Lands:** Account for 11 per cent of the usable area, supporting 4,997 MW of solar capacity.
- **Mining Wastelands:** Covering 91.15 sq. km and making up 9.9 per cent of the usable area, these lands can accommodate 4,505 MW of solar capacity.

- **Industrial Wastelands:** Spanning 12.07 sq. km and accounting for around 1 per cent of the usable area, these wastelands can support 597 MW of solar capacity.
- **Sandy Areas:** Although a relatively large share of wasteland in this category can be utilised (25 per cent), their scarcity results in a usable area of only 0.005 sq. km, representing a negligible portion of the total estimated potential.

Primarily, the wasteland usable for ground-mounted solar PV is concentrated in the districts of Giridih, Dumka, Deoghar, Hazaribagh, Saraikela-Kharsawan, Bokaro, and Palamu. These seven districts together account for 49 per cent of the state's estimated ground-mounted solar potential. Giridih accounts for 14.3 per cent of the share followed by Dumka, Deoghar and Hazaribagh at 6.6, 5.8 and 5.7 per cent respectively.

Mining wastelands that can be repurposed for ground-mounted solar are mainly located in the Chatra (1,677 MW), Ramgarh (1,970 MW), Pakur (972 MW) and Hazaribagh (2,570 MW) districts. It is worth noting that the solar radiation and insolation levels in the western districts are comparable to those in the southern districts. In line with this, if a higher share of the wastelands is utilised (or low-productivity agricultural lands are identified) in the western districts of Jharkhand, the solar potential of the state would be revised upwards.

Map 2.6: Ground-mounted solar potential distribution



Source: iFOREST assessment

Table 2.4: District-wise, wasteland-wise ground-mounted solar potential (MW)

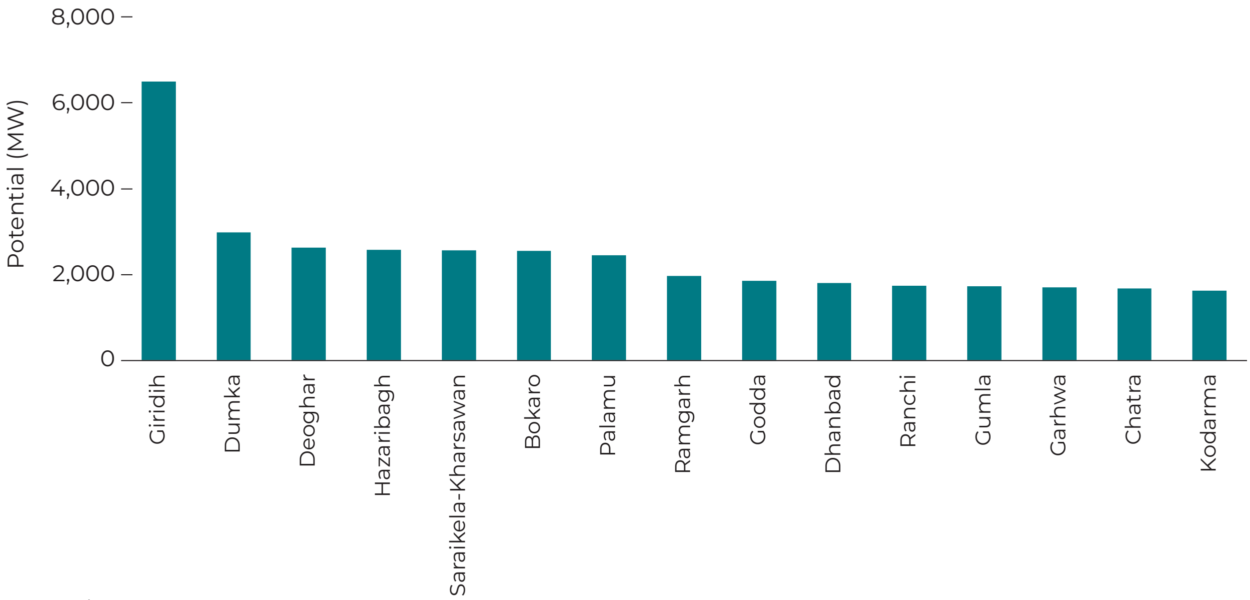
District	Barren Rocky & Stony Wasteland	Industrial Wasteland	Land with Open Scrub	Mining Wasteland	Potential
Giridih	138	46	6,247	75	6,506
Dumka	97	-	2,686	195	2,978
Deoghar	122	-	2,443	57	2,621
Hazaribagh	165	19	1,943	444	2,570
Saraikela-Kharsawan	76	256	2,191	38	2,562
Bokaro	38	52	2,047	408	2,546
Palamu	614	-	1,693	146	2,452
Ramgarh	119	-	1,290	561	1,970

Table 2.4 continued

District	Barren Rocky & Stony Wasteland	Industrial Wasteland	Land with Open Scrub	Mining Wasteland	Potential
Godda	255	-	1,513	77	1,845
Dhanbad	43	61	1,419	272	1,794
Ranchi	598	-	864	277	1,739
Gumla	1,518	-	87	122	1,727
Garhwa	324	-	1,344	26	1,695
Chatra	32	-	1,054	591	1,677
Kodarma	20	15	1,417	173	1,624
East Singhbhum	108	149	1,208	130	1,594
Jamtara	171	-	1,389	1	1,561
West Singhbhum	141	-	1,012	246	1,399
Khunti	73	-	956	21	1,050
Simdega	187	-	795	10	992
Pakur	86	-	413	473	972
Latehar	28	-	726	60	814
Lohardaga	30	-	309	33	372
Sahibganj	16	-	281	70	367
Total	**4,997**	**597**	**35,327**	**4,505**	**45,426**

Source: iFOREST Assessment

Figure 2.2: Top 15 districts for estimated ground-mounted solar potential



Source: iFOREST Assessment

2.2 High-potential wasteland clusters

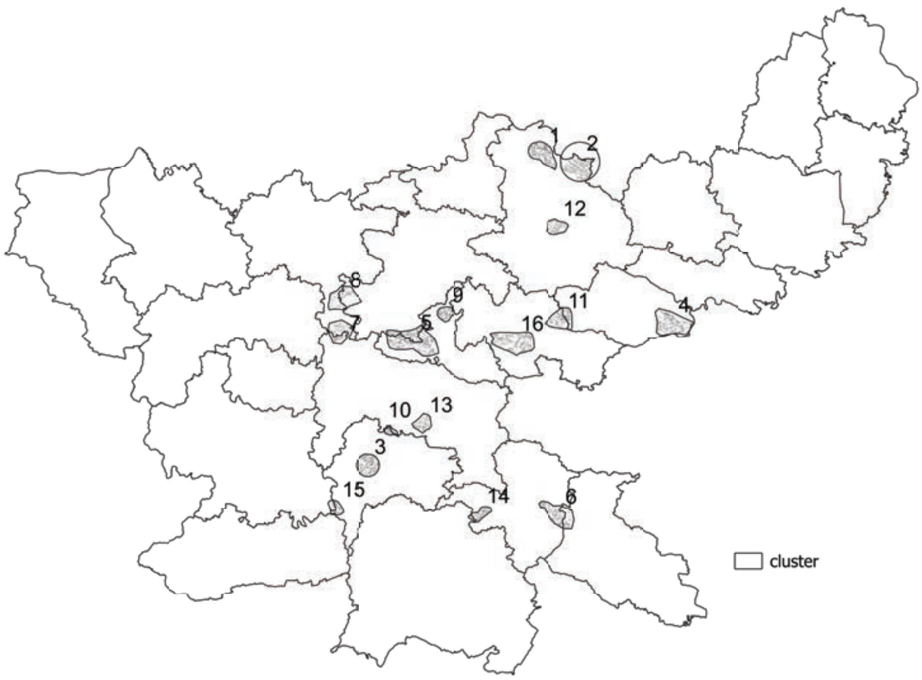
Large clusters of wasteland parcels are identified using the processed wasteland data for project development. Given the lack of an extensive consolidated wasteland area in Jharkhand, a cluster-based approach can help leverage economies of scale. After a preliminary identification of large, medium and small clusters, the analysis takes into account the proximity of these clusters to existing substations to determine high-priority clusters for project development. The distance of each cluster from the nearest substations is mapped and calculated using data from OpenStreetMap[11], with further verification conducted via Google Earth.

The study led to the identification of 16 major wasteland clusters across nine districts in Jharkhand, with a total area of 252.98 sq. km and an estimated solar capacity of 5,157 MW. The selected clusters are located in the following districts:

- Three clusters, ranging from 55.67 to 25.32 sq. km, are situated in Ramgarh and Giridih districts.
- Three clusters, ranging from 15.92 to 22.81 sq. km, are found in Chatra & Hazaribagh, Bokaro, and Saraikela-Kharsawan.
- Ten smaller clusters are located in Khunti, Dhanbad, Chatra, Ranchi, Ramgarh, Gumla, Saraikela-Kharsawan, Bokaro, and Giridih districts.

These sites report an average solar insolation of 4.88 to 5.11 kWh/m²/day, with capacity utilization factors (CUF) ranging from 24.79% to 25.97%.

Map 2.7: Major wasteland clusters



Source: iFOREST assessment

Table 2.5: Main wasteland clusters and their potential

Sl. no	District	Longitude	Latitude	Potential (MW)	Distance from substation (km)	CUF (%)	No of Parcel across wasteland categories
1	Giridih	86.0588	24.61042	463.0	35.00	25.11	8 parcels of barren rocky & stony wasteland, 244 parcels of land with open scrub land
2	Giridih	86.24899	24.57082	550.4	9.80	25.18	1 parcel of barren rocky & stony wasteland, 173 parcels of land with open scrub land
3	Khunti	85.17155	23.03163	98.8	7.60	25.97	1 parcel of barren rocky & stony wasteland, 137 parcels of land with open scrub land
4	Dhanbad	86.71467	23.75111	294.1	5.18	24.79	2 parcels of industrial wasteland, 135 parcels of land with open scrub land, 13 parcels of mining wasteland
5	Ramgarh	85.4033	23.66289	1,129.7	5.63	25.50	2 parcels of barren rocky & stony wasteland, 295 parcels of land with open scrub land, 41 parcels of mining wasteland
6	Saraikela-Kharsawan	86.14195	22.77984	509.4	0.00	25.26	4 parcels of barren rocky & stony wasteland, 6 parcels of industrial wasteland, 107 parcels of land with open scrub land, 4 parcels of mining wasteland
7	Chatra & Ranchi	85.02866	23.70952	438.2	1.10	25.82	1 parcel of barren rocky & stony wasteland, 21 parcels of land with open scrub land, 12 parcels of mining wasteland
8	Chatra & Hazaribagh	85.04575	23.87592	354.1	5.33	25.93	1 parcel of barren rocky & stony wasteland, 53 parcels of land with open scrub land, 4 parcels of mining wasteland
9	Ramgarh	85.56389	23.80083	213.0	7.43	25.31	1 parcel of barren rocky & stony wasteland, 24 parcels of land with open scrub land, 6 parcels of mining wasteland
10	Khunti & Ranchi	85.2866	23.20437	18.6	11.33	25.83	1 parcel of barren rocky & stony wasteland, 8 parcels of land with open scrub land, 2 parcels of mining wasteland
11	Bokaro & Dhanbad	86.15357	23.77139	299.1	4.34	24.88	1 parcel of industrial wasteland, 76 parcels of land with open scrub land, 8 parcels of mining wasteland
12	Girdih	86.12951	24.24045	240.9	11.42	25.33	1 parcel of barren rocky & stony wasteland, 62 parcels of land with open scrub land
13	Ranchi	85.44934	23.24414	65.3	4.71	25.66	10 parcels of barren rocky & stony wasteland, 10 parcels of land with open scrub land, 1 parcel of mining wasteland
14	Saraikela-Kharsawan	85.74029	22.78331	109.9	7.85	25.64	71 parcels of land with open scrub land
15	Gumla & Khunti	85.00665	22.81536	4.4	10.34	25.85	3 parcels of barren rocky & stony wasteland, 4 parcels of land with open scrub land
16	Bokaro	85.91134	23.65672	368.2	12.47	25.36	221 parcels of land with open scrub land

Source: iFOREST Assessment

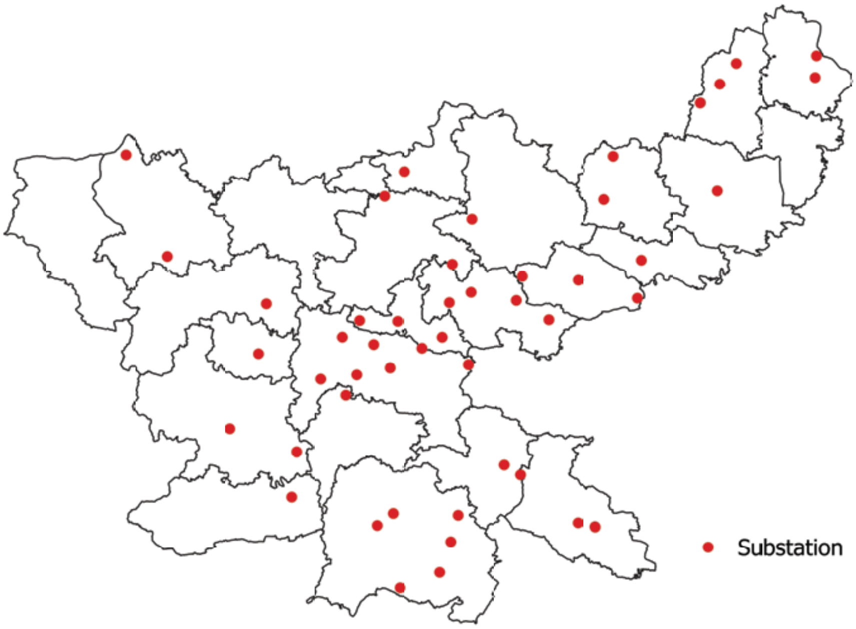
2.3 Wasteland parcels around existing substations

Building on the identification of major wasteland clusters suitable for ground-mounted solar projects, an additional analysis was conducted to pinpoint wasteland parcels located near existing substations. These sites are particularly beneficial for solar project development from a techno-commercial perspective, as their proximity to established transmission infrastructure can significantly reduce costs by eliminating the need for additional transmission infrastructure.

In this study, wasteland areas within a 5-kilometer radius of each of the 50 substations in Jharkhand were mapped. This analysis identified 79.69 sq. km of wasteland with the potential to support approximately 3,938.46 MW of solar capacity (assuming 100% land utilization within the identified wasteland parcels).

The assessment identified several high-capacity project locations, including three locations: that can support capacities of over 200 MW, twelve locations that can support 100 MW to 200 MW, and fifteen locations that can support 50 MW to 100 MW capacities.

Map 2.8: Wasteland around substations



Source: iFOREST assessment

Table 2.6: Main wasteland clusters around substations and their potential

Sl. no	District	Longitude	Latitude	Voltage (kV)	Usable land area (Sq. km)	Potential (MW)	CUF (%)
1	Saraikela-Kharsawan	86.15	22.78	25	5.90	291.71	23.67
2	Dhanbad	86.16	23.87	25	2.41	119.11	23.52
3	Dhanbad	86.79	23.75	25	2.57	126.90	23.15
4	Latehar	84.76	23.72	400	0.29	14.37	24.50
5	Lohardaga	84.72	23.44	25	0.45	22.10	24.52
6	Sahibganj	87.76	24.96	132	0.07	3.49	21.99
7	Sahibganj	87.77	25.07	132	0.78	38.32	21.93
8	Godda	87.13	24.82	400	1.14	56.14	22.86
9	Godda	87.13	24.81	132	1.09	53.66	22.87
10	Giridih	85.89	24.18	132	0.82	40.76	23.85

Table 2.6 continued

Sl. no	District	Longitude	Latitude	Voltage (kV)	Usable land area (Sq. km)	Potential (MW)	CUF (%)
11	East Singhbhum	86.47	22.52	132	1.09	53.99	23.54
12	East Singhbhum	86.56	22.50	132	1.52	74.97	23.58
13	East Singhbhum	86.56	22.50	132	1.56	77.18	23.58
14	Bokaro	86.13	23.74	220; 132	3.79	187.26	23.35
15	Hazaribagh	85.78	23.94	132	0.58	28.70	23.68
16	Ramgarh	85.72	23.54	132	1.26	62.46	23.91
17	Bokaro	85.76	23.72	400; 220	1.33	65.56	23.67
18	West Singhbhum	85.71	22.25	132	0.37	18.39	24.20
19	West Singhbhum	85.37	22.51	132	0.05	2.41	24.25
20	Ranchi	85.26	23.33	220; 132	2.35	116.33	24.25
21	Ranchi	85.87	23.39	25	1.16	57.47	23.81
22	Ramgarh	85.48	23.62	25	4.71	232.92	23.89
23	Ranchi	85.44	23.37	132	1.14	56.27	24.24
24	Ranchi	85.61	23.47	132	0.73	36.05	23.95
25	Palamu	84.00	24.53	25	0.27	13.57	23.90
26	Khunti	85.20	23.22	220	0.42	20.95	24.42
27	Kodarma	85.52	24.44	132	2.11	104.52	23.95
28	West Singhbhum	85.49	22.16	132	1.64	81.04	24.00
29	Gumla	84.56	23.03	132	0.77	38.17	24.40
30	Simdega	84.90	22.66	132	0.75	36.98	24.38
31	Gumla	84.93	22.91	132	0.41	20.46	24.41
32	Ranchi	85.06	23.31	765; 400	0.11	5.68	24.50
33	Godda	87.33	25.03	220; 132	3.11	153.71	22.45
34	Bokaro	85.88	23.78	400	2.28	112.54	23.45
35	Bokaro	86.31	23.63	220	1.24	61.45	23.64
36	Jamtara	86.81	23.96	132	3.11	153.60	23.39
37	Dhanbad	86.47	23.85	220	2.64	130.31	23.40
38	Saraikela-Kharsawan	86.06	22.84	400	4.31	213.24	23.76
39	Hazaribagh	85.41	24.31	132	2.02	99.94	24.10
40	Deoghar	86.61	24.29	132	2.47	122.26	23.46
41	Deoghar	86.66	24.52	220; 132	1.92	95.07	23.37
42	Godda	87.24	24.92	220	0.74	36.40	22.64
43	Dumka	87.23	24.34	220; 132	3.80	187.81	23.01
44	West Singhbhum	85.81	22.56	25	0.58	28.91	24.15
45	Ranchi	85.35	23.50	132	0.28	14.02	24.38
46	Ranchi	85.18	23.54	220; 132	0.32	15.75	24.51
47	Palamu	84.22	23.98	400; 220; 132	1.75	86.28	24.44
48	Ramgarh	85.27	23.63	400	3.47	171.38	23.99
49	West Singhbhum	85.77	22.42	25	1.33	65.63	24.12
50	West Singhbhum	85.46	22.57	25	0.65	32.24	24.28

Source: iFOREST assessment

2.4 Floating solar

In addition to re-assessing the potential for ground-mounted solar installations, it is essential to explore opportunities for land-neutral solar technologies such as floating solar, particularly on man-made reservoirs. This technology offers significant potential to enhancing solar capacity in regions with limited availability of large wasteland parcels. Additionally, it offers the benefits of creating hybrid RE plants (in combination with hydropower) and can potentially reduce water evaporation losses.

According to data from the National Register for Large Dams (NRLD) published by the Central Water Commission (CWC) of the Ministry of Jal Shakti, Jharkhand is home to 78 large dams.[12] Of these, 51 dams are considered for evaluation of floating solar potential, based on factors such as water availability and the accessibility of relevant data. These dams provide significant potential for floating solar installation even at low utilization assumptions.

Assessment methodology

A three-step methodology is adopted to estimate the floating solar potential of Jharkhand based on secondary data sets available for dams. This methodology focuses on four key parameters: purpose, age, depth, and area of the reservoir.

Step 1: Comprehensive identification of suitable waterbodies for floating solar:

The identification of reservoirs suitable for floating solar installations involved utilizing multiple authoritative sources to ensure comprehensive coverage across all categories. Primary data was sourced from the CWC's NRLD (2019), which provided an extensive inventory of waterbodies, particularly large reservoirs and dams. This data is further cross-verified using ISRO's Bhuvan Water Bodies Information System (India-WBIS), a satellite-based resource that offers detailed information on waterbody extents and characteristics[13]. The portal provided key information regarding the dams, including water availability, water spread area, reservoir area, and depth. Additionally, Google Earth was employed to visually inspect and validate the identified reservoirs, ensuring both accuracy and completeness in the dataset.

Step 2: Filtering and categorization of waterbodies:

The datasets are filtered using specific criteria to refine the selection of reservoirs most suitable for floating solar projects. These are categorized according to several key factors, including their utilization type, depth, age, and the area of the reservoir. Each category is evaluated to determine its suitability for floating solar based on these attributes, which influence both the technical feasibility and economic viability of solar deployment on water surfaces.

In line with industry practices, 4,000 sq. km water spread area and depths of less than 3 m are considered unsuitable for floating solar installations. Also, very old dams of over 50 years of age are excluded from the study, considering their higher environmental impact, as they inhabit relatively richer marine ecosystems.

Step 3: Calculation of area available for floating solar installation:

For each shortlisted category of reservoirs, the total area available for floating solar installation is assessed. The calculation is based on category-wise utilization assumptions, which considered the specific characteristics of each reservoir type, such as the proportion of the area that could be effectively utilized for solar panels without compromising other critical functions of the waterbody (e.g., irrigation, drinking water supply, or flood control).

Based on the parameters such as depth, area and usage of reservoirs, three utilization scenarios of high, medium and low are assumed. The utilization varied across reservoir types based on the purpose. While a reservoir level assessment is important to determine the actual area available for floating solar deployment, the utilization assumptions provide an indicative picture across multiple scenarios. The potential is then estimated by applying the utilization assumptions to each dam category across the three scenarios and age classifications, using an area requirement of 10,117 sq m per MWp.[14]

Table 2.7: Sources and tools used for estimating floating solar potential

Data/Parameter	Source/Tool
Reservoir data, 2019	CWC, NRLD
Reservoir mapping	Google Earth
Water occurrence, spread area and water level	IWRIS, ISRO Bhuvan WBIS
Waterbody utilization scenario	SIA assumptions

Source: iFOREST assessment

Table 2.8: Reservoir-type-based utilization scenario assumption for floating solar PV installation

Reservoir purpose	Code	Low utilization scenario	Medium utilization scenario	High utilization scenario
Irrigation and water supply	I/S	5%	10%	20%
Irrigation	I	10%	25%	50%
Flood control, hydroelectric, irrigation and water supply	I/H/S/C	1%	2%	2%
Hydroelectric	H	3%	5%	10%
Water supply	S	10%	25%	50%
Irrigation, flood control	I/C	5%	10%	10%
Irrigation, hydroelectric, navigation	I/H/N	2%	5%	10%
Irrigation, hydroelectric	I/H	2%	10%	10%
Irrigation, hydroelectric, water supply	I/H/S	2%	5%	5%
Irrigation, pisciculture	I/F	5%	10%	20%
Irrigation, pisciculture, water supply	I/F/S	5%	10%	20%
Irrigation, pisciculture, water supply, hydroelectric	I/H/S/F	2%	5%	5%
Irrigation, earth fill embankment	I/D	10%	25%	50%
Irrigation, hydroelectric, water supply, tourism, flood control	I/H/S/T/C	2%	5%	5%

Source: iFOREST assessment

Potential assessment

According to the NRLD dataset, Jharkhand is home to 78 large dams. After cleaning and verification, data from 51 of these dams were considered for suitable potential assessment.

The distribution of these dams is as follows:

- **Age:** Most of the dams are classified as middle-aged, between 20 and 50 years old.
- **Depth:**
  - 9 dams with low depth (10 to 15 meters)
  - 49 dams with medium depth (15 to 30 meters)
  - 20 dams with high depth (30 to 100 meters)

According to the NRLD report of 2019, 45 of these dams are dedicated solely to irrigation, while the remaining dams serve multiple purposes, including hydroelectric power generation, water supply, flood control, and tourism in addition to irrigation.

Table 2.9: Reservoirs in Jharkhand categorized by age and depth

	Young (age 0 to 20 years)	Middle (age 20 to 50 years)	Old (age 50 to 100 years)	Very old (age > 100 years)	under construction	Total
Very low depth (3 to 10 m)	0	0	0	0	0	0
Low depth (10 to 15 m)	0	4	2	0	3	9
Medium depth (15 to 30 m)	2	22	10	0	15	49
High depth (30 to 100 m)	3	3	5	0	9	20
Very high depth (>100m)	0	0	0	0	0	0
Total	**5**	**29**	**17**	**0**	**27**	**78**

Source: iFOREST assessment of NRLD dataset

The floating solar potential of the shortlisted reservoirs is assessed using three different utilization scenarios for dams serving various purposes. The majority of suitable reservoirs are concentrated in the districts of Hazaribagh, Dhanbad, Bokaro, Palamu and Ramgarh. According to the analysis, Jharkhand holds the potential to generate 3,014 MW, 7,795 MW and 14,009 MW of floating solar under the low, medium and high utilisation scenarios respectively.

Most of the assessed potential lies in the Hazaribagh district (with a high scenario potential of 8,859 MW across five reservoirs), followed by the Dhanbad district (with a high scenario potential of 770 MW across two reservoirs). The high potential of Hazaribagh district is due to the presence of Konar dam which can potentially host a large-scale floating solar plant of 8,649 MW. *(Refer to annexure A1 for waterbody-wise floating solar potential in Jharkhand).*

Table 2.10: Top 10 potential reservoir sites for floating solar installation

S. No	Name of Water Body	District	Type	Area (1000 sq m)	Effective area (1000 sq m)			Potential (MWp)		
					Low	Medium	High	Low	Medium	High
1	Konar	Hazaribag	I/D	175,000.0	17,500.0	43,750.0	87,500.0	1,729.8	4,324.4	8,648.8
2	Panchet Hill	Dhanbad	I/H/S/C	121,386.0	1,213.9	2,427.7	2,427.7	120.0	240.0	240.0
3	Maithon	Dhanbad	I/H/S/T/C	107,160.0	2,143.2	5,358.0	5,358.0	211.8	529.6	529.6
4	Tenughat	Bokaro	I/H	64,780.0	1,295.6	6,478.0	6,478.0	128.1	640.3	640.3
5	Gatalsud	Ramgarh	I/H/S	34,380.0	687.6	1,719.0	1,719.0	68.0	169.9	169.9
6	Batane	Palamu	I	13,360.0	1,336.0	3,340.0	6,680.0	132.1	330.1	660.3
7	Nalkari	Ramgarh	I	9,920.0	992.0	2,480.0	4,960.0	98.1	245.1	490.3
8	Nandini	Lohardaga	I	5,580.0	558.0	1,395.0	2,790.0	55.2	137.9	275.8
9	Sunder	Godda	I	4,970.0	497.0	1,242.5	2,485.0	49.1	122.8	245.6
10	Paras	Ranchi	I	3,760.0	376.0	940.0	1,880.0	37.2	92.9	185.8

Source: iFOREST assessment

2.5 Conclusion

The re-assessment of Jharkhand's solar potential reveals substantial opportunities for both ground-mounted and floating solar installations, far exceeding previous estimates. With over 300 days of sunshine and an average solar radiation of 5.0 kWh/m^2, the state has the potential to develop 45,425 MW of ground-mounted solar in wastelands, concentrated in districts like Giridih, Hazaribagh, and Dumka. Of this, 79.69 sq. km of wastelands near existing substations could support around 3,938 MW of solar capacity, allowing for more efficient power evacuation. Floating solar adds further promise, with the potential to generate up to 14,009 MW, particularly in waterbodies across Hazaribagh and Dhanbad. The Konar dam in Hazaribagh alone could support up to 8,649 MW of floating solar capacity. A more detailed assessment considering all water bodies, in addition to the major dams, would further increase the state's floating solar potential.

To fully realise this potential, a strategic approach is essential, one that prioritises clustered wasteland near transmission infrastructure and promotes the deployment of land-neutral technologies such as floating solar. Together, these measures could position Jharkhand as a significant contributor in India's RE growth.

3. Wind

Identifying and assessing high-quality wind sites is essential for accurately estimating the wind energy potential of a region. This evaluation involves several key parameters, including wind speed, direction, turbulence, air density, and shear, among others. Based on these factors, Jharkhand is assessed to have moderate potential for wind energy generation.

In India, wind resource assessments are conducted by the National Institute of Wind Energy (NIWE) under the Ministry of New and Renewable Energy (MNRE). This evaluation utilizes an advanced meso-micro coupled numerical wind flow model, complemented by data from 406 actual measurement sites across the country. The methodology also takes into account various land use and environmental factors to ensure a precise estimation of the wind energy potential.

At present, the total installed wind capacity in India stands at 47 GW, with no capacity installed in Jharkhand so far[15]. According to NIWE's assessment, wind energy potential for Jharkhand stands at 91 MW at 80m hub height, negligible at 120m hub height[16] and 16 MW for the 150m hub height[17] (most of it coming from 30 per cent cultivable land usage). The assessed wind potential for Jharkhand constitutes a minuscule fraction of less than 0.1 per cent of India's total wind energy potential across hub-heights.

A focus renewed on the state's wind energy potential is crucial at this stage as the best wind sites across the country become increasingly exhausted, and the techno-economic feasibility of moderate sites becomes increasingly warranted.

Table 3.1: NIWE's wind energy potential assessment for Jharkhand and India

Category	Jharkhand (MW)	India (MW)
Potential at 80m hub height	91	102,788
Potential at 120m hub height	-	695,508
-with 80% wasteland usage	-	340,112
-with 30% cultivable land usage	-	347,045
-with 5% forest land usage	-	8,351
Potential at 150m hub height	16	1,163,856
-with 80% wasteland usage	6	544,448
-with 30% cultivable land usage	9	607,288
-with 5% forest land usage	1	12,120

Source: NIWE

3.1 Methodology

Initial scoping for wind resource assessment is carried out by identifying wind-rich areas using satellite data. This identification is done using publicly available wind resource maps available at Global Wind Atlas (GWA 3.1)[18]. The GWA 3.1 portal is developed by the Technical University of Denmark (DTU Wind Energy) with support from the World Bank Group. It provides detailed data on wind power density and wind speed at multiple heights for all global locations. It is based on historical weather information and modelling, with an output resolution of 250 meters. The identified sites through the GWA 3.1 portal are further mapped on NASA's Shuttle Radar Topography Mission (SRTM) database[19] that provides a high resolution digital topographic database of the earth. The SRTM is used to filter out areas that are less techno-commercially feasibile..

The remaining areas include wastelands considered in the solar potential assessment. These have been included in estimating viable wind energy potential to account for the viability of hybrid RE projects. Notably, in practice up to 6 per cent of the land area used in wind installations cannot be used for solar in hybrid projects.

To identify the potential for wind energy at 100m and 150m above ground level (AGL), the analysis focuses on identifying areas with wind speeds greater than the threshold value of 5 m/s. Parallely, areas with high slopes (greater than 15 degrees), prone to landslide due to precipitation (medium, and high frequencies), affected by frequent fires (with active fire density for the year 2022), and affected by frequent cyclones are dropped from the dataset. This results in a dataset of potential areas (including wasteland areas) within the threshold wind speed (5 to 8 m/s) across the state.

The wind energy generation potential for the identified land areas is then estimated using a standard wind turbine model of GE 130 with a turbine diameter of 130 m, swept area of 13,273 sq. m and an annual power generation of 28.032 GWh at an air density of 1.225 kg/m^3. For spacing between wind turbines, a spacing density factor of 4.375 is considered. Accordingly, the formula 4.375 x 130 m x 4.375 x 130 m is applied to arrive at the area required for each turbine – approximately 323,476.6 sq. m. This methodology for estimating annual power generation and spacing factor is adapted from similar studies attempting to estimate wind energy potential in India[20].

Table 3.2: Parameters for wind energy potential

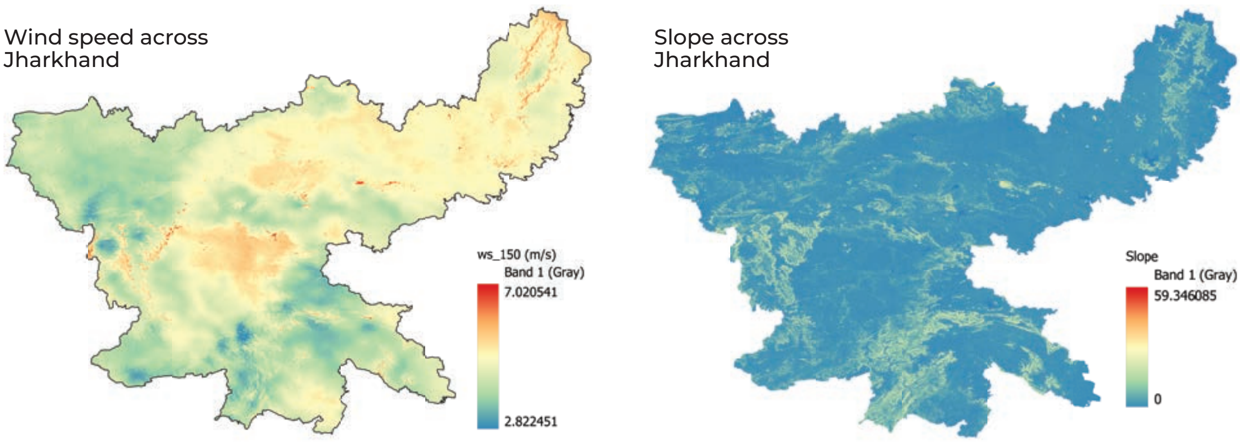
Model	GE 130
Diameter (m)	130
Swept area (sq. m)	13,273
Annual ideal power generation (GWh)	28.032
Air density (kg/m^3)	1.225
Turbine spacing density (sq. m/turbine)	323,476.6
Spacing factor	4.375

Source: Von Krauland, A. K., & Jacobson, M. Z. (2024). India onshore wind energy atlas accounting for altitude and land use restrictions and co-located solar. Cell Reports Sustainability

3.2 Potential re-assessment

Building on the wind resource map sourced from GWA 3.1, a total of 22,986 high wind speed sites (710 sites for 100 m hub height and 22,276 sites for 150 m hub height) are identified in Jharkhand, each with an average wind speed greater than 5 m/s. This is done by analyzing the 10-year average wind speed data at 100 m and 150m AGL. These sites are then mapped onto the SRTM database to filter out areas with steep slopes and high frequency of landslides, and fires.

Map 3.1: Identified wind sites and terrain



Source: iFOREST

After filtering for climate risks and high slopes, nearly 1,212 sq. km of area is identified as high potential sites at 100 m AGL. About 99 per cent of the identified area has an assessed wind speed of 5 to 6 m/s, while the remaining 1 per cent is distributed between wind speeds of 6-8 m/s. Further, at 150 m AGL, the potential area expanded to 2,139 sq. km. This includes 99.5 per cent area at a wind speed of 5 to 6 m/s and the remaining 0.5 per cent area distributed between wind speeds of 6-7 m/s and 7-8 m/s.

Table 3.3: Filtered area under threshold wind speeds

Wind Speed (m/s)	Area at 100 m AGL (Sq. km)	Area at 150 m AGL (Sq. km)
5 to 6	1,198.41	2,139.54
6 to 7	13.3	90.07
7 to 8	0.17	1.03
Total	**1,211.88**	**2,230.6**

Source: iFOREST assessment; Note - After filtering for high slopes and climate risks

The identified land area can potentially hold significant wind power generation capacity. At a hub height of 100 m AGL, an estimated 3,745 wind turbines can be installed, leading to a theoretical potential of 11.98 GW. Similarly, at a hub height of 150 AGL, 4,780 turbines can be installed leading to a potential of 22 GW. About 0.89 GW of potential is identified at high wind speeds of 6 to 7 m/s at a hub height of 150 m AGL.

Table 3.4: Estimated wind power potential across filtered areas with threshold speeds

Speed (m/s)	At the hub height 100 m			At the hub height 150 m		
	No. of turbines	Annual generation (GWh)	Potential (GW)	No. of turbine	Annual generation (GWh)	Potential (GW)
>5 and <6	3,704	14,511.24	11.85	60,970	25,907.14	21.1
>6 and <7	41	291.59	0.13	278.44	1,970.28	0.89
>=7	0	0	0	3	35.77	0.01
Total	3,745	14,802.8	11.98	61,252	27,913.19	22

Source: iFOREST assessment

Identifying the total area above the threshold wind speed gives a broad sense of the feasibility of wind energy installations in the state. Given that wind energy installations are considerably less sensitive to land categories and can be installed in non-wasteland areas (unlike solar projects which need to be prioritized over wastelands) estimates inclusive of all land types are necessary. At the same time, estimating wind energy potential on wastelands is crucial from a commercial standpoint due to the relative ease of developing projects thereupon and the substantial cost associated with acquiring land.

Windspeed on wastelands in Jharkhand

The wasteland area under the threshold windspeed of 5 m/s is calculated at 100 m and 150 m AGL, which is further processed for high slope, and high frequency of landslides, fires and cyclones. At a hub height of 100 m AGL, a total of 85 potential land parcels are identified, aggregating to an area of 59.05 sq. km. Further, a hub height of 150 m AGL, 2,945 potential land parcels are identified, aggregating to an area of 1,404.67 sq. km. This amounts to a wasteland-based wind energy potential of 403.2 MW and 15,296 MW at 100 m and 150 m AGL, respectively.

The majority of the wasteland-based wind energy potential is localized in a few districts in the state. Of the assessed potential at 100 m AGL, three districts of Gumla, Ranchi and Sahibganj account for 81% of the estimated potential with Ranchi`s share being 49.2 per cent. However, the potential is more widespread at a higher hub height of 150 m AGL. Girdih accounts for the highest potential with a share of 29.9 per cent, followed by Hazaribagh with a 20.7 per cent share, Dumka (8.6 per cent) and Ranchi (6.7 per cent).

Table 3.5: Wasteland area under threshold wind speed

Wind speed (m/s)	Wasteland area at 100 m AGL (Sq. km)	No. of wasteland parcels at 100 m	Wasteland area at 150 m AGL (Sq. km)	No. of wasteland parcels at 150 m
5 to 6	59.05	85	1402.7	2,939
6 to 7	0	0	1.97	6
7 to 8	0	0	0	0
Total	**59.05**	**85**	**1,404.67**	**2,945**

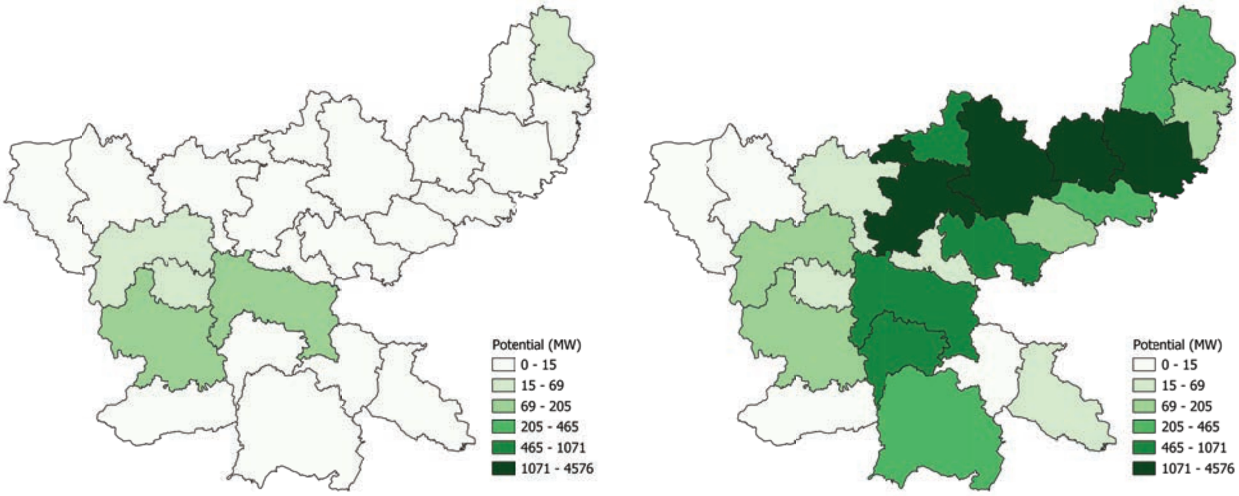
Source: iFOREST assessment

Table 3.6: District-wise wind energy potential at 100m and 150m AGL on wastelands

District	Potential at 100m (MW)	Potential at 150m (MW)
Bokaro	9.6	550.4
Chatra	-	16.0
Deoghar	3.2	1,596.8
Dhanbad	-	112.0
Dumka	3.2	1,321.6
East Singhbhum	-	16.0
Garhwa	-	6.4
Giridih	-	4,576.0
Godda	3.2	220.8
Gumla	76.8	188.8
Hazaribagh	3.2	3,164.8
Jamtara	-	457.6
Khunti	3.2	480.0
Kodarma	-	793.6
Latehar	16.0	83.2
Lohardaga	16.0	67.2
Pakur	6.4	70.4
Palamu	-	-
Ramgarh	9.6	38.4
Ranchi	198.4	1,020.8
Sahibganj	51.2	243.2
Saraikela-Kharsawan	-	9.6
Simdega	-	-
West Singhbhum	3.2	262.4
Total Potential (MW)	**403.2**	**15,296.0**

Source: iFOREST assessment

Map 3.2: Distribution of wind energy potential at 100 m and 150 m AGL



Source: iFOREST assessment

High-potential wasteland parcels

To prioritize and rank wasteland parcels most feasible for wind energy installations, some of the largest wasteland parcels are also identified along with the available area and estimated annual generation potential. At 100 m AGL, three larger parcels with the potential to set up 19.2 MW, and 16 MW projects are identified. At, 150 m AGL, ten land parcels are identified, with a potential to set up wind power plants of 50 MW to 330 MW capacity.

Table 3.7: Top ten wasteland parcels at 100m AGL

District	Area (sq m)	No. of turbine	Total Annual generation (GWh)	Potential (MW)
Sahibganj	2,045,328.2	6	23.4	19.2
Gumla	1,721,917.0	5	19.9	16.0
Ranchi	1,621,735.5	5	18.7	16.0
Gumla	1,213,350.6	4	15.2	12.8
Ranchi	1,147,719.6	4	16.3	12.8
Ranchi	859,936.3	3	12.0	9.6
Ranchi	916,749.0	3	11.4	9.6
Bokaro	657,305.9	2	8.4	6.4
Gumla	518,100.8	2	7.7	6.4
Gumla	610,472.1	2	8.8	6.4

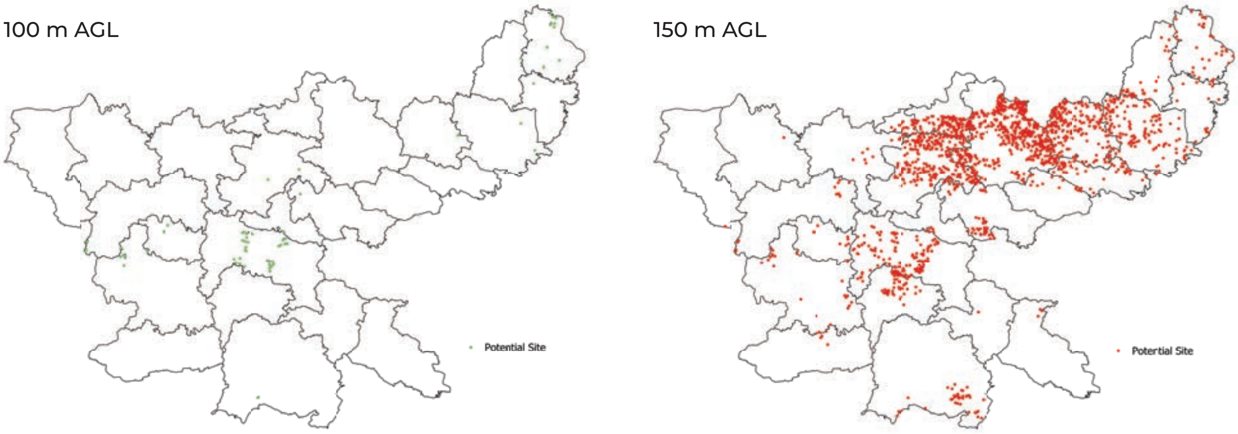
Source: iFOREST assessment

Table 3.8: Top ten wasteland parcels at 150 m AGL

District	Area (sq. m)	No. of turbine	Total Annual generation (GWh)	Potential (MW)
Hazaribagh	33,733,034.6	104	396.3	332.8
Hazaribagh	17,110,937.8	53	198.9	169.6
Giridih	11,271,050.4	35	139.0	112.0
Hazaribagh	11,478,773.1	35	132.6	112.0
Hazaribagh	9,532,273.9	29	123.7	92.8
Giridih	7,414,819.7	23	87.1	73.6
Hazaribagh	6,913,063.1	21	90.3	67.2
Hazaribagh	6,353,197.9	20	76.2	64.0
Giridih	6,060,103.7	19	73.0	60.8
Deoghar	5,752,016.0	18	69.5	57.6

Source: iFOREST

Map 3.3: High potential wasteland parcels at 100 m and 150 m AGL



Source: iFOREST assessment

3.3 Conclusion

The current official estimate for wind power generation in Jharkhand is limited to approximately 16 MW at 150 m AGL. However, satellite-based data assessments indicate a much higher potential of 11.98 GW at a hub height of 100 m AGL and 22 GW at a hub height of 150 m AGL. Focusing on wastelands, multiple land parcels can be identified where utility-scale projects could potentially be established. This underscores the need for further ground-level assessments in the state to evaluate project bankability. Such assessments are crucial as wind power becomes increasingly significant in India's energy mix, particularly as the country moves toward a net-zero scenario and as the best wind sites are being exhausted, shifting the focus toward the development of moderate sites.

4. Biomass

Biomass energy potential largely hinges on the amount of surplus crop residue and its calorific value. Assessing this potential involves key factors such as the area of land under cultivation, the types of crops grown, and the cultivation seasons.

Jharkhand has a cultivable area of 3.8 million hectares, with a net sown area of 2.5-2.6 million hectares, receiving an average annual rainfall of 1,300 mm. The state primarily grows paddy, wheat, maize, pulses, oilseeds, and horticultural crops. From 2007 to 2021, paddy productivity increased from 20 to 30 quintals per hectare, while production rose from 3.2 to 4.4 million tons. The area under pulses expanded from 0.47 to 0.59 million hectares, and pulse production grew from 0.41 to 0.59 million tons. Additionally, the Rabi cropping area increased from 0.59 to 0.61 million hectares.[21]

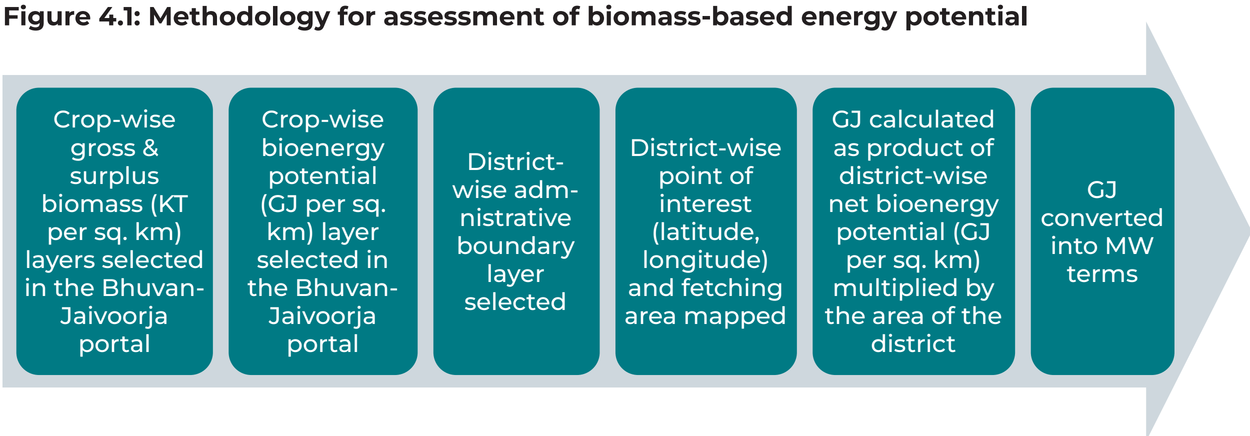
According to the Ministry of New and Renewable Energy (MNRE), the biomass power potential of Jharkhand is estimated to be 132.95 MW. So far, about 14.4% of this potential is harnessed with 20.14 MW of biomass-based capacity installed in the state as of August 2025 all of which is non-bagasse-based cogeneration[22].

However, with the expanding food grain production in the state, the potential of biopower generation is constantly expanding. A re-assessment based on updated datasets is warranted to reflect these changes more accurately.

4.1 Methodology

The re-assessment of biomass-based renewable energy generation potential is conducted using updated datasets on gross and surplus residue production sourced from the Bhuvan-Jaivoorja portal[23]. The portal is jointly developed by the Technology Information Forecasting and Assessment Council (TIFAC), Department of Science and Technology, and the National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO). The portal helps generate geospatial maps of surplus and gross residue potential of crops across all districts in India. Potential crop masks are built for each of the districts in the state using multi-temporal satellite data, which are then transformed into crop fractions at a resolution of 1 km grid based on the MODIS satellite sensor's gross primary production (GPP) dataset. Subsequently, the surplus biomass data is converted into biomass energy potential using the heating value/calorific value specific to each crop residue.

Figure 4.1: Methodology for assessment of biomass-based energy potential



Note: MW=GJ.(0.277777778/365/24/0.8)
Source: iFOREST assessment

Table 4.1: Crop-wise productivity and heating value for crop residue-based bioenergy production

Crops	Yield (kg/ha)	Dryness factor (%)	Residue type	Heating value (MJ/kg)
Rice	2,730	0.86	Straw	15.54
			Husk	15.54
Wheat/Maize/Ragi	3,195	0.86	Straw	17.15
			Husk	17.39
Cotton	547	0.80	Stalk	17.40
			Husk	16.70
			Boll Shell	18.30
Sugarcane	72,268	0.83	Bagasse	20.00
			Top and leaves	20.00

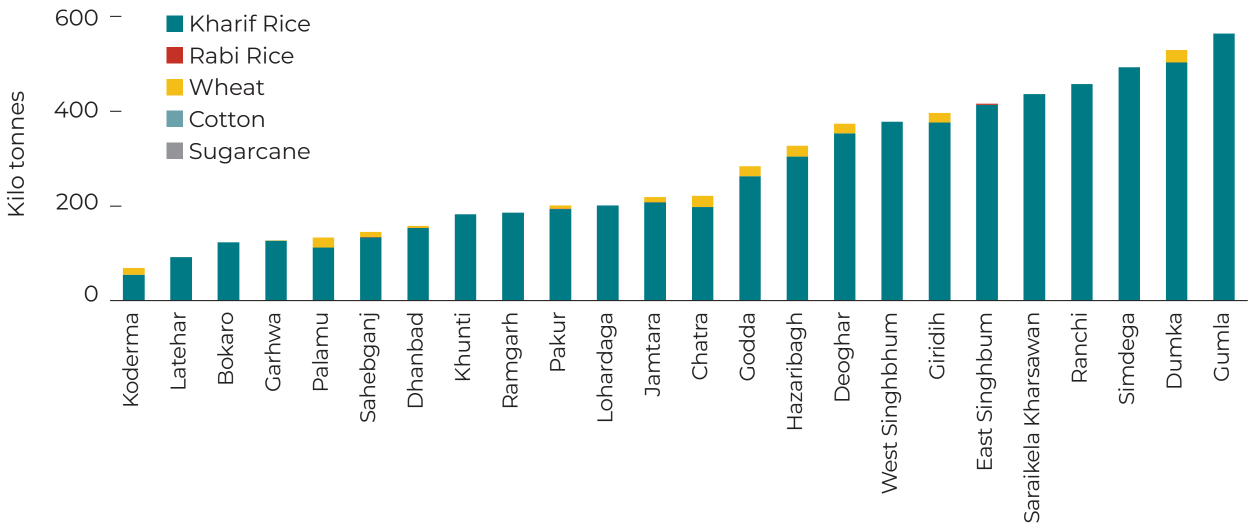
Source: Chakraborty A. et al. (2022). Developing a spatial information system of biomass potential from crop residues over India: A decision support for planning and establishment of biofuel/ biomass power plant, Renewable and Sustainable Energy Reviews, Volume 165 ISSN 1364-0321

4.2 Potential re-assessment

Using the Bhuvan-Jaivoorja portal, the gross and surplus biomass generation in Jharkhand are estimated to be 6,709 kilo tonnes (KT) and 1,296.7 KT, respectively. Kharif rice constitutes 97% of the total gross and surplus biomass generation in the state, while wheat constitutes roughly 3%. Marginal amounts of biomass from wheat is being generated in the districts of East Singhbum, Dumka, Jamtara, Pakur, Dhanbad and Sahebganj. Overall, Gumla district leads in gross and surplus biomass generation at 8% and 9% of the total generation respectively; followed by Dumka district at 8% share and Simdega district with 7.3% share in gross biomass.

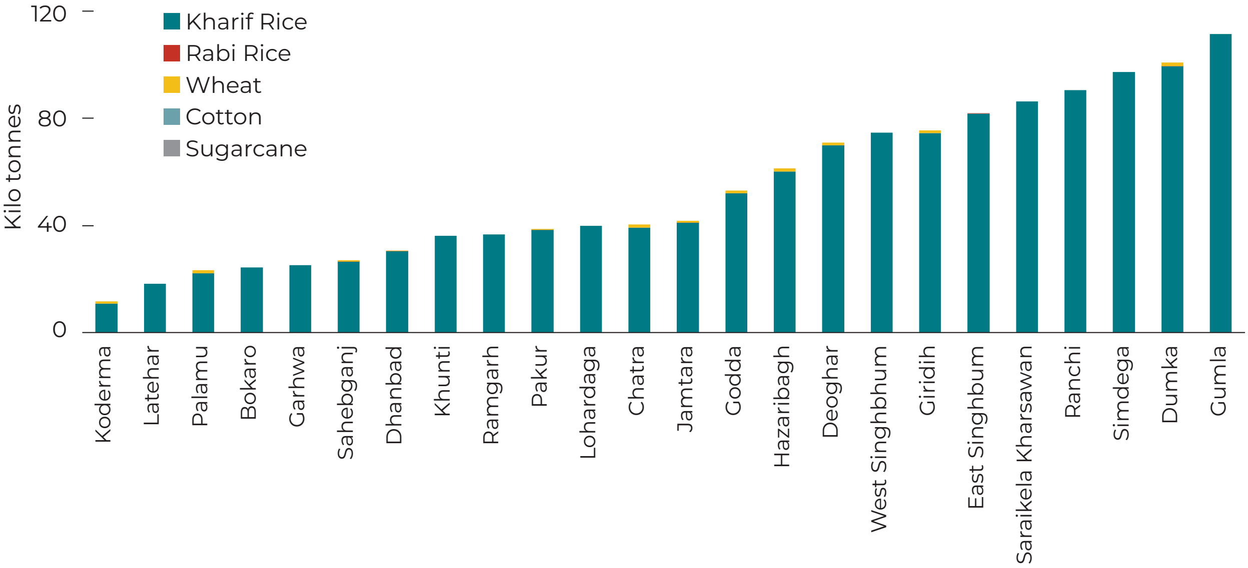
This assessment indicates that Jharkhand's cumulative biomass potential could be approximately 2.81 GW, significantly higher than the MNRE's suggested potential of 132.95 MW and the current installed capacity of just 19.1 MW. This implies a substantial underutilization of the state's biomass energy potential.

Figure 4.2: District-wise and crop-wise yearly gross biomass generation



Source: iFOREST assessment

Figure 4.3: District-wise and crop-wise yearly surplus biomass generation

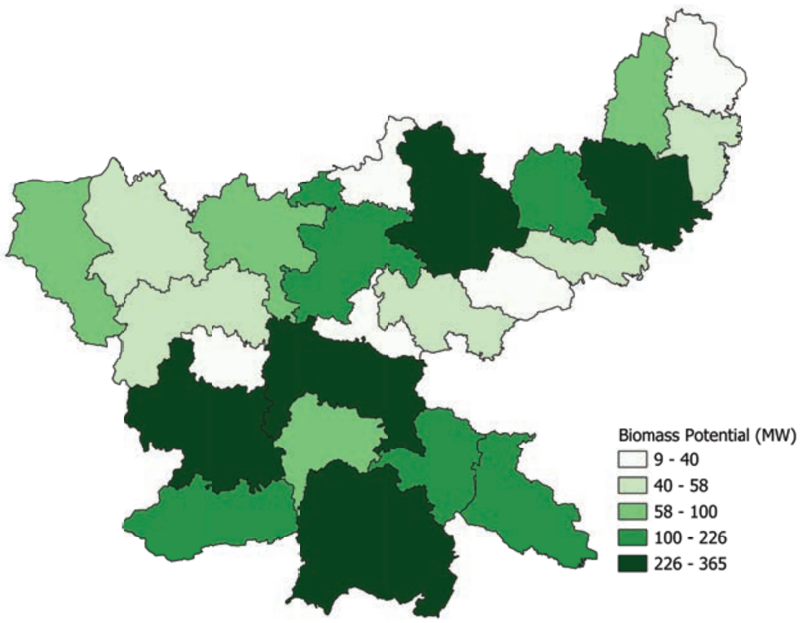


Source: iFOREST assessment

Following the overall potential estimation for biomass energy in the state, a district wise analysis indicates that more than 70 per cent of the potential is concentrated in 10 districts including Gumla, Ranchi, West Singhbum, Dumka, Giridih, Simdega, East Singhbum, Hazaribagh, Saraikela Kharsawan and Deoghar.

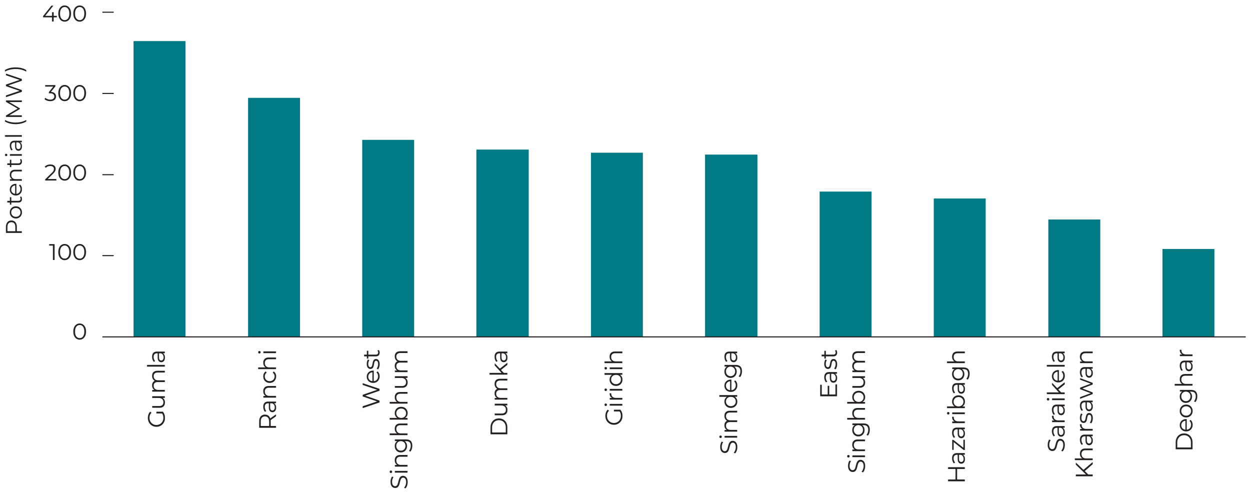
Approximately one third of the total biomass potential is concentrated in the three districts of Gumla, Ranchi and West Singhbum with individual shares of 13 per cent,10 per cent and 9 per cent respectively. Other high-potential districts include Dumka, Giridih and Simdega each contributing to 8 per cent share of the total potential. (Refer to annexure A4 for the detailed district-wise biomass potential)

Map 4.1: Spread of biomass potential across state



Source: iFOREST

Figure 4.4: Top ten districts with biomass potential



Source: iFOREST

4.3 Conclusion

Jharkhand's biomass potential has been re-assessed using updated district-wise crop residue surplus data from ISRO's JAIVOORJA portal, revealing a cumulative potential of 2,813 MW. This estimate is nearly twenty times greater than the potential previously assessed by the MNRE and several times higher than the state's the current installed capacity. Given the growing demand for biopower, not only for electricity generation but also for biofuel production, it is essential to re-assess and reconsider the state's untapped biomass potential. This sector also has significant co-benefits related to rural livelihood generation and improved air quality through reduced open burning of agricultural residues. Moving forward, a detailed site-specific techno-economic analysis will be required to convert this assessed theoretical potential into actual energy generation, taking into account the seasonality and spatial distribution of resources.

5. Way forward

The present study indicates that Jharkhand's potential for renewable energy (RE) generation is substantially higher than earlier estimates in the solar, wind and biomass categories. The difference in results arises due to the use of updated datasets and methodologies tailored to fit the state's distribution of land and water resources. For instance, the difference in estimated wind resources arises in part due to the use of the Global Wind Atlas 3.1 portal whose underlying global weather dataset differs substantially (in terms of length, width and inputs) from the one used by the National Institute of Wind Energy (NIWE)[24,25,26]. At the same time, like MNRE estimates, the results are indicative; an accurate picture can emerge only through on-ground validation.

Table 5.1: Comparison of MNRE and iFOREST estimates for RE potential

RE Source	MNRE (MW)	iFOREST (MW)
Solar	18,180	59,434
Wind (150m agl)	16	15,296
Biomass	146	2,813

Note: iFOREST solar assessment includes floating solar
Source: iFOREST assessment

The present study intends to change investor perceptions surrounding RE development in Jharkhand. Like many of its eastern region counterparts, Jharkhand has long been regarded as a 'low-RE' state with minimal potential for electricity generation from clean and renewable sources. Narratives like these risk and undermine the transition to a sustainable and 'green' model of economic development in the state. This study challenges that notion by presenting compelling evidence of Jharkhand's substantial RE potential across solar, wind, and biomass sectors.

At present, the Government of Jharkhand has set a target for 4,000 MW solar energy capacity by 2027[27]. While this target is a step in the right direction, the findings of this report suggest significant scope for setting a more ambitious target in the years ahead. Further, in line with the announced trajectory for renewable purchase obligations, the state government must prioritise similar targets for wind, DRE and energy storage. These measures will be critical for ensuring a balanced, resilient, and future-ready energy mix.

More importantly, there is an urgent need to accelerate the implementation of the RE policy. Since the announcement of the Jharkhand State Solar Policy, 2022, the state has added approximately 100 MW of RE capacity[28]. While this demonstrates an increase in the rate of growth of RE in the state, the capacity addition falls substantially short of the policy target. To scale the development of local RE, the state government must build the capacity of its nodal agency and reconsider its roles and responsibilities going forward. Unlocking the newly re-assessed renewable energy potential and translating it into measurable outcomes will require a robust institutional framework capable of executing the state's policy vision effectively.

Annexures

Table A1: Waterbody wise floating solar potential in Jharkhand

Sr. No	Name of Dam	Latitude	Longitude	District	Year of Com-pletion	Height above Lowest Foundation Level (m)	Reservoir Area sq. m	PV Potential Low scenario (MWp)	PV Potential Mid scenario (MWp)	PV Potential High scenario (MWp)
1	Konar	“23° 55 ‘ 45”” “	“85° 45 ‘ 41”” “	Hazaribag	1955	57.60	175,000,000.00	1,729.76	4,324.40	8,648.81
2	Panchet Hill	“23° 40 ‘ 51”” “	“86° 44 ‘ 50”” “	Dhanbad	1959	45.00	121,386,000.00	119.98	239.96	239.96
3	Maithon	“23° 47 ‘ 7”” “	“86° 48 ‘ 43”” “	Dhanbad	1957	56.08	107,160,000.00	211.84	529.60	529.60
4	Tenughat	“23° 43 ‘ 31”” “	“85° 50 ‘ 10”” “	Bokaro	1978	50.61	64,780,000.00	128.06	640.31	640.31
5	Gatalsud	“23° 27 ‘ 25”” “	“85° 33 ‘ 17”” “	Ramgarh	1971	40.24	34,380,000.00	67.96	169.91	169.91
6	Batane	“24° 25 ‘ 39”” “	“84° 15 ‘ 37”” “	Palamu	1990	24.08	13,360,000.00	132.05	330.14	660.27
7	Nalkari	“23° 36 ‘ 55”” “	“85° 17 ‘ 29”” “	Ramgarh	1968	36.00	9,920,000.00	98.05	245.13	490.26
8	Nandini	“23° 23 ‘ 19”” “	“84° 50 ‘ 19”” “	Lohardaga	1987	17.08	5,580,000.00	55.15	137.89	275.77
9	Sunder	“24° 56 ‘ 37”” “	“87° 23 ‘ 27”” “	Godda	1976	35.67	4,970,000.00	49.13	122.81	245.63
10	Paras	“23° 15 ‘ 29”” “	“84° 54 ‘ 46”” “	Ranchi	1985	24.39	3,760,000.00	37.17	92.91	185.83
11	Sonua	“22° 37 ‘ 10”” “	“85° 23 ‘ 15”” “	Pashchimi Singhbhum	2009	36.32	3,522,000.00	34.81	87.03	174.06
12	Malay	“23° 55 ‘ 7”” “	“84° 16 ‘ 59”” “	Palamu	1985	28.80	3,460,000.00	34.20	85.50	171.00
13	Latratu	“23° 13 ‘ 25”” “	85° 4 ‘ 32”	Ranchi	1988	39.33	3,410,000.00	33.71	84.26	168.53
14	Danro	24° 1 ‘ 0”	83° 33 ‘ 1”	Garhwa	1985	22.38	3,360,000.00	33.21	83.03	166.06
15	Buksa	“24° 15 ‘ 46”” “	85° 9 ‘ 19”	Chatra	1982	18.78	3,160,000.00	31.23	78.09	156.17
16	Chinda	“22° 35 ‘ 35”” “	“84° 31 ‘ 19”” “	Simdega	1984	17.62	2,120,000.00	20.95	52.39	104.77
17	Baranadi	24° 7 ‘ 4”	87° 24 ‘ 1”	Dumka	1967	19.51	2,110,000.00	20.86	52.14	104.28
18	Anjanwa	“24° 12 ‘ 25”” “	85° 17 ‘ 4”	Hazaribagh	1981	16.25	2,100,000.00	20.76	51.89	103.79
19	Torlow	“22° 16 ‘ 2”” “	“85° 53 ‘ 17”” “	Pashchimi Singhbhum	1990	22.25	2,024,300.00	20.01	50.02	100.04
20	Palna	“22° 56 ‘ 39”” “	“85° 56 ‘ 13”” “	Saraikela Kharsawan	1987	28.66	1,559,000.00	15.41	38.52	77.05
21	Tapkara	“22° 47 ‘ 9”” “	84° 41 ‘ 5”	Gumla	1988	24.23	1,430,000.00	14.13	35.34	70.67
22	Janasai	“22° 45 ‘ 10”” “	“85° 38 ‘ 18”” “	Pashchimi Singhbhum	1981	19.21	1,250,000.00	12.36	30.89	61.78
23	Murahir	“22° 38 ‘ 36”” “	“86° 29 ‘ 46”” “	Purbi Singhbhum	1987	25.30	1,242,200.00	12.28	30.70	61.39
24	Chirka	“24° 0 ‘ 30”” “	“83° 37 ‘ 50”” “	Garhwa	1985	22.13	1,190,000.00	11.76	29.41	58.81
25	Pandarwa	0° 0 ‘ 0”	0° 0 ‘ 0”	Garhwa	1983	21.80	1,070,000.00	10.58	26.44	52.88

Annexure A1 continued

Sr. No	Name of Dam	Latitude	Longitude	District	Year of Com-pletion	Height above Lowest Foundation Level (m)	Reservoir Area sq. m	PV Potential Low scenario (MWp)	PV Potential Mid scenario (MWp)	PV Potential High scenario (MWp)
26	Lotia	24° 9 ‘ 7”	“85° 23 ‘ 13”” “	Hazaribagh	1978	19.51	1,060,000.00	10.48	26.19	52.39
27	Masaria	“23° 12 ‘ 20”” “	“84° 33 ‘ 35”” “	Gumla	1983	21.54	740,000.00	7.31	18.29	36.57
28	“Nakti (Chaibasa) “	“22° 44 ‘ 2”” “	“85° 30 ‘ 13”” “	Pashchimi Singhbhum	2010	37.60	720,600.00	7.12	17.81	35.61
29	Butan-Duba	“23° 57 ‘ 1”” “	84° 5 ‘ 11”	Palamu	1985	22.56	630,000.00	6.23	15.57	31.14
30	Jamunia	“24° 0 ‘ 25”” “	“85° 45 ‘ 32”” “	Hazaribagh	1954	17.36	610,000.00	6.03	15.07	30.15
31	Kairabani	“24° 10 ‘ 11”” “	“87° 26 ‘ 24”” “	Dumka	1967	18.59	550,000.00	5.44	13.59	27.18
32	Boudha	“24° 1 ‘ 46”” “	“85° 39 ‘ 49”” “	Hazaribagh	1978	15.85	480,000.00	4.74	11.86	23.72
33	Temarain	“23° 59 ‘ 53”” “	84° 0 ‘ 11”	Palamu	1973	12.80	340,000.00	3.36	8.40	16.80
34	“Chatania Ghat “	“24° 27 ‘ 3”” “	“83° 33 ‘ 52”” “	Garhwa	1980	19.82	310,000.00	3.06	7.66	15.32
35	Jaipur	“23° 10 ‘ 19”” “	“84° 16 ‘ 45”” “	Gumla	1985	22.56	280,000.00	2.77	6.92	13.84
36	Sitaram Pur	“22° 46 ‘ 21”” “	86° 6 ‘ 21”	Saraikela-kharsawan	1964	16.77	63,700.00	0.63	1.57	3.15
37	Ramrekha	“22° 43 ‘ 6”” “	“84° 20 ‘ 20”” “	Simdega	2010	28.35	50,000.00	0.49	1.24	2.47
38	Upper Shankh	“23° 16 ‘ 5”” “	“84° 13 ‘ 15”” “	Gumla	2008	39.69	48,000.00	0.09	0.47	0.47
39	Dhansingtoli	0° 0 ‘ 0”	0° 0 ‘ 0”	Gumla	2009	25.60	40,000.00	0.40	0.99	1.98
40	Buchaopa	“23° 29 ‘ 55”” “	“84° 56 ‘ 43”” “	Ranchi	1957	24.02	20,000.00	0.20	0.49	0.99

Source: iFOREST assessment

Table A2: Top ten sites for wind generation in Jharkhand (150 m agl)

Sr. No	Latitude	Longitude	District	Area (sq. m)	Wind speed (m/s)	CUF (%)	Annual generation (GWh)
1	23.35308209	84.10608138	Lohardaga	344877.8195	6.326451898	28.11171084	7.880274782
2	24.06285186	87.06164863	Sahibganj	438750.6803	6.157607079	25.92045164	7.266021004
3	23.55874858	84.46550528	Lohardaga	208956.9061	6.099615812	25.19498423	7.062657979
4	24.05662531	86.027497	Latehar	182849.7582	6.092282772	25.10422418	7.037216123
5	23.54411227	84.5319602	Lohardaga	376677.7439	6.058216413	24.685447	6.919824503
6	24.04817399	86.02521678	Latehar	415345.2618	6.055513382	24.65241958	6.910566256
7	23.86313725	84.75197931	Bokaro	194326.7702	5.96214211	23.42724733	6.567125971
8	24.43494343	83.53181538	Sahibganj	252825.2144	5.944907856	23.2246766	6.510341344
9	25.25352047	87.71059346	Sahibganj	605960.124	5.939106305	23.15674904	6.491299891
10	24.28901057	86.03377727	Latehar	341886.2762	5.89977169	22.60056383	6.335390053

Source: iFOREST Assessment

Table A3: Top ten sites for wind generation in Jharkhand (100 m agl)

Sr. No	Latitude	Longitude	District	Area (sq. m)	Wind speed (m/s)	CUF (%)	Annual generation (GWh)
1	23.35308209	84.10608138	Lohardaga	344877.8195	5.877660871	22.34741174	6.264426458
2	23.55874858	84.46550528	Lohardaga	208956.9061	5.646419287	19.63842356	5.505042892
3	24.06285186	87.06164863	Sahibganj	438750.6803	5.609886987	19.25970302	5.398879952
4	24.04817399	86.02521678	Latehar	415345.2618	5.564325889	18.71108627	5.245091702
5	24.05662531	86.027497	Latehar	182849.7582	5.56132555	18.68083498	5.236611662
6	23.54411227	84.5319602	Lohardaga	376677.7439	5.560224851	18.66974523	5.233502983
7	23.86313725	84.75197931	Bokaro	194326.7702	5.548010826	18.54698103	5.199089722
8	22.2767766	85.12540714	West Singhbhum	257180.0943	5.420914888	17.22441951	4.828349276
9	24.28901057	86.03377727	Latehar	341886.2762	5.39290905	16.88312988	4.732678967
10	23.38170328	85.47869416	Lohardaga	233094.6561	5.376387715	16.72843886	4.689315981

Source: iFOREST Assessment

Table A4: District wise biomass potential in Jharkhand

District	Surplus biomass over fetch area (Kilo tons)					total	Bioenergy potential over fetch area (Giga Joule/sq. km)					Total (GJ/sq.km)	Potential (MW)
	Kharif Rice	Rabi Rice	Wheat	Cotton	Sugarcane		Kharif Rice	Rabi Rice	Wheat	Cotton	Sugarcane		
Bokaro	24.26	-	-	-	-	24.26	376.04	-	-	-	-	376.04	42.60
Chatra	39.05	-	1.18	-	-	40.23	605.33	-	20.59	-	-	625.92	67.10
Deoghar	69.90	-	1.03	-	-	70.93	1,083.49	-	17.99	-	-	1,101.47	108.20
Dhanbad	30.26	0.03	0.21	-	-	30.50	468.97	0.49	3.70	-	-	473.16	38.90
Dumka	99.57	0.01	1.30	-	-	100.88	1,543.27	0.22	22.59	-	-	1,566.08	230.70
East Singhbum	81.83	0.13	-	-	-	81.96	1,268.44	1.95	-	-	-	1,270.39	178.90
Garhwa	25.03	-	-	-	-	25.03	388.03	-	0.03	-	-	388.06	62.20
Giridih	74.49	-	1.02	-	-	75.51	1,154.65	-	17.71	-	-	1,172.37	226.80
Godda	51.95	-	1.08	-	-	53.03	805.23	-	18.77	-	-	823.99	68.90
Gumla	111.54	-	-	-	-	111.54	1,728.90	-	-	-	-	1,728.90	364.60
Hazaribagh	60.16	-	1.16	-	-	61.32	932.45	-	20.23	-	-	952.68	170.60
Jamtara	41.00	0.02	0.56	-	-	41.58	635.48	0.25	9.67	-	-	645.39	46.10
Khunti	36.07	-	-	-	-	36.07	559.03	-	-	-	-	559.03	57.90
Koderma	10.73	-	0.72	-	-	11.45	166.30	-	12.51	-	-	178.81	9.30
Latehar	18.12	-	-	-	-	18.12	280.85	-	-	-	-	280.85	40.70
Lohardaga	39.79	-	-	-	-	39.79	616.70	-	-	-	-	616.70	36.40
Pakur	38.20	0.05	0.34	-	-	38.59	592.16	0.82	5.86	-	-	598.83	42.90
Palamu	22.07	-	1.12	-	-	23.19	342.10	-	19.55	-	-	361.65	57.60
Ramgarh	36.66	-	-	-	-	36.66	568.19	-	-	-	-	568.19	27.30
Ranchi	90.61	-	-	-	-	90.61	1,404.45	-	-	-	-	1,404.45	294.50
Sahebganj	26.35	0.01	0.58	-	-	26.94	408.45	0.15	10.12	-	-	418.72	28.30
Saraikela Kharsawan	86.41	-	-	-	-	86.41	1,339.37	-	-	-	-	1,339.37	144.70
Simdega	97.40	-	-	-	-	97.40	1,509.76	-	-	-	-	1,509.76	224.80
West Singhbhum	74.70	-	-	-	-	74.70	1,157.89	-	-	-	-	1,157.89	242.80
Total	1,286.15	0.25	10.30	-	-	1,296.70	19,935.53	3.88	179.32	-	-	20,118.70	2,812.88

Source: iFOREST Assessment

References

1. Ministry of Statistics and Programme Implementation, Government of India. “Energy statistics India 2024”. https://mospi.gov.in/sites/default/files/publication_reports/Energy_Statistics_2024/Chapter1-Reserves_and_Potential_for_Generation.pdf
2. The World Bank Group. Global solar Atlas. (2024). https://globalsolaratlas.info/map
3. Department of Industry, Commerce & Enterprises, Government of Jharkhand (2022). https://wbindustries.gov.in/Climate.html
4. https://www.mercomindia.com/germany-installs-3-8-gw-solar-capacity-in-q1-2025-down-11-62-yoy
5. https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=2003561s
6. Solar Energy Corporation of India. Frequently asked questions. Government of India. https://www.seci.co.in/upload/static/files/FAQ.pdf
7. Copernicus Data Space Ecosystem. https://dataspace.copernicus.eu/explore-data/data-collections/sentinel-data/sentinel-2
8. United Nation Environment Programme GRID. (March 2024). https://wesr.unepgrid.ch/?project=MX-YBJ-YYF-08R-UUR-QW6&language=en&theme=color_light
9. Shuttle Radar Toporaphy Mission (SRTM GL3) Global 90m. Open Topography. (2024). https://portal.opentopography.org/raster?opentopoID=OTSRTM.042013.4326.1&minX=69.87304863519967&minY=5.944806404565696&-maxX=96.65039417333901&maxY=33.85292909485128
10. Department of Land Resources, Government of India. 2020. ‘Wasteland Atlas of India – 2019’. https://dolr.gov.in/wasteland-atlas-of-india-2019/
11. A web-based data filtering tool for OpenStreetMap (2024). https://overpass-turbo.eu/
12. NATIONAL REGISTER OF LARGE DAMS –2019, GOVERNMENT OF INDIA *CENTRAL WATER COMMISSION DAM SAFETY ORGANISATION *NEW DELHI* JUNE 2019. https://prsindia.org/files/bills_acts/bills_parliament/2019/National%20Register%20of%20Large%20Dams,%202019.pdf
13. ISRO. National Remote Sensing Center. Water Bodies Information System. Technical Document (2016). Govt. of India. https://bhuvan-wbis.nrsc.gov.in/static/media/WBIS_V3_TechnicalDocument.7ddd29063cb3dd644478.pdf
14. Karmendra Kumar Agrawal, Shibani Khanra Jha, Ravi Kant Mittal, Sanjay Vashishtha,(2022). Assessment of floating solar PV (FSPV) potential and water conservation: Case study on Rajghat Dam in Uttar Pradesh, India, Energy for Sustainable Development,66,287-295, https://doi.org/10.1016/j.esd.2021.12.007.
15. State-wise installed capacity of Renewable Power as on 31.07.2024. MNRE https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/08/20240809720591974.pdf
16. India’s Wind Potential Atlas at 120m agl, NIWE https://niwe.res.in/assets/Docu/India’s_Wind_Potential_Atlas_at_120m_agl.pdf
17. Indian Wind Potential Map at 150m agl, NIWE. https://maps.niwe.res.in/media/150m-report.pdf
18. https://globalwindatlas.info/en
19. https://www.earthdata.nasa.gov/sensors/srtm
20. Von Krauland, A. K., & Jacobson, M. Z. (2024). India onshore wind energy atlas accounting for altitude and land use restrictions and co-located solar. Cell Reports Sustainability.
21. State Agricultural Management & Extension Training Institute (SAMETI) https://www.sameti.org/state_profile.php
22. MNRE, State-wise installed capacity of Renewable Power as on 31.03.2024 https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/05/20240524405410771.pdf
23. https://bhuvan-app1.nrsc.gov.in/bioenergy/index.php#
24. Global Wind Atlas, Technical University of Denmark. ‘Methodology’. https://globalwindatlas.info/en/about/method
25. European Centre for Medium-Range Forecasting, European Union. ‘ECMWF Reanalysis v5 (ERA5)’. https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5
26. National Institute of Wind Energy, Government of India. 2023. ‘India’s wind potential atlas at 150m agl’. https://maps.niwe.res.in/media/150m-report.pdf
27. Department of Energy, Government of Jharkhand. 2022. ‘Jharkhand State Solar Policy’. api.jreda.com/all-uploaded-img/img/6360e972de5e0.pdf
28. Ministry of New and Renewable Energy, Government of India. 2024. ‘Physical achievement’. https://mnre.gov.in/physical-progress/

Notes

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