iFOREST | INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

CHHATTISGARH RENEWABLE ENERGY POTENTIAL RE-ASSESSMENT

Focus on Solar, Wind and Biomass

September 2024

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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	Photo Voltaic
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

Chhattisgarh is estimated to possess a limited renewable energy (RE) generation capacity of 23,782 MW, including large hydro, which constitutes approximately 1.13% of the country's total RE potential. This perceived constraint on potential has been a significant factor in the relatively low investment activity in the state's RE sector. The existing assessments of RE potential for most technologies were conducted over a decade ago and rely largely on broad generalizations. To provide more accurate guidance for policymakers, implementing agencies, and investors, there is a need to revise these figures using new datasets and more detailed methodologies. In response to this need, iFOREST has undertaken a thorough re-assessment of Chhattisgarh's RE potential, focusing on ground-mounted solar, floating solar, wind energy, and biomass:

Ground-mounted solar

Chhattisgarh benefits from an average of 300 sunny days each year, translating to approximately 3,620 hours of sunshine annually. The state experiences an average solar radiation of 5.14 kWh/m^2 per day, with a peak value of 5.27 kWh/m^2 per day. Additionally, solar insolation levels are 389 W/m^2 on average, reaching a peak of 978 W/m^2. These insolation parameters indicate highly favourable conditions for photovoltaic (PV) installations in the region.

- In contrast to the MNRE's conservative estimate, which assumes the utilization of only 3% of wasteland for solar PV installations, a more detailed evaluation of suitable wasteland types indicates that up to 9% could be utilized, following the application of various climate and ecological filters. This revised assessment reveals a potential for solar ground-mounted installations amounting to 41,216 MW across an area of 834 sq. km, which is more than double the MNRE's projected potential of 18.27 GW. At the district level, Bolada Bazar, Surajpur, Korba, Raigarh, Jashpur, Manendragarh-Chirmiri-Bharatpur, and Raipur together account for approximately 50% of the estimated ground-mounted potential in the state. Specifically, Bolada Bazar, Surajpur, Korba, and Raigarh contribute to 9%, 8%, 7%, and 7% of the potential, respectively.
- Sixteen clusters of wasteland parcels, ranging from small to large, have been identified primarily in northern Chhattisgarh. These clusters are situated in the districts of Korba, Sarjuga, Surajpur, Balrampur, and Manendragarh-Chirmiri-Bharatpur, among others. The total area covered by these clusters is 375 sq. km. Within these clusters, the available wasteland parcels have the potential to support a solar capacity of 18,537 MW, based on the assumed level of land utilization.
- Further, a wasteland area of 70.30 sq. km is identified to be available near existing transmission substations, which can be prioritized for development. This land area can support nearly 3,474.42 MW of solar capacity (assuming 100% land utilization).

Floating solar

- Across the 258 dams existing in Chhattisgarh, the floating solar PV potential is estimated to be 4,792 MW in the low utilization scenario, 11,980 MW in the medium utilization scenario and 23,488 MW in the high utilization scenario.
- Most of the assessed potential capacity is in the Gariaband district (with a high scenario potential of 12,533 MW across two reservoirs), followed by the Dhamtari district (with a high scenario potential of 3,011 MW across 4 reservoirs). The high potential of Gariaband district is due to the presence of Sikasar Dam that can potentially host a large-scale floating solar plant of 12,474 MW.

Wind

- Through the mapping of high wind speed locations and subsequent filtering for climate risks and steep slopes, a theoretical wind energy potential of 14.8 GW has been identified at a hub height of 100 meters above ground level (AGL) if 100% of the identified land is utilized for setting up wind power turbines. At a hub height of 150 meters AGL, the potential increases to 61 GW. Notably, approximately 7.4 GW of this potential at 150 meters hub height is located in areas with wind speeds ranging from 6 to 7 m/s.

- Focusing specifically on wasteland areas, the wind energy potential is estimated at 5,584 MW at a hub height of 100 meters AGL and 19,273 MW at 150 meters AGL, using a similar assessment methodology. At 100 meters AGL, Narayanpur, Kondagaon, Balod, Bastar, Kanker, Bijapur, and Rajnandgaon together account for over 70% of the estimated potential. Narayanpur, Balod, Kondagaon, and Bastar contribute 16%, 14%, 12%, and 10% of the potential, respectively. At 150 meters AGL, the wind energy potential is also concentrated in several southern districts of Chhattisgarh. At this hub height Kondagaon, Gariaband, Narayanpur, and Kanker contribute 10%, 9%, 9%, and 8% of the potential share, respectively.

Biomass

- Based on district-wise crop residue data from the 'ISRO JAIVOORJA' portal, the cumulative biomass potential of Chhattisgarh is estimated at 4,272 MW, approximately ten times higher than the MNRE's assessment. The districts of Rajnandgaon, Janjgir–Champa, and Raigarh contribute nearly one-third of this potential, with shares of 23%, 9%, and 6%, respectively. Additional districts with significant biomass potential include Mahasamund, Dhamtari, and Jashpur, contributing 6%, 5%, and 4% of the total potential, respectively.

The reassessment of Chhattisgarh's RE potential reveals that the state has a significantly greater RE capacity than previously estimated by the MNRE. This increased potential is adequate to support the expansion of substantial RE capacity in the state, thereby enabling a long-term transition to green energy across both utility-scale and captive/industrial applications.

1. Introduction

Chhattisgarh is one of the richest bio-diverse areas in the country with around 6.34 million ha. area under forest cover, which is 46% of its total geographical area. The state plays a crucial role in meeting India's energy requirements. In 2022-23, the state produced 184.89 million tonnes (MT) of coal, accounting for over 20% of India's total coal production. Given the growing energy demand both within the state and nationally, Chhattisgarh is likely to maintain its position as a major coal producer in the coming years. Nonetheless, India has set ambitious targets for renewable energy, aiming for 500 GW of installed capacity by 2030 and achieving net-zero emissions by 2070.

In recent years, however, Chhattisgarh has lagged behind other states in renewable energy development. As of August 2024, the state has installed 1,735 MW of renewable energy (RE) capacity (including hydro), which constitutes less than 1% of India's total RE capacity of 199,583 MW. The current RE capacity in Chhattisgarh is comprised of 16% biopower, 45% ground-mounted solar, 4% small hydro, and 23% off-grid solar. The biopower capacity of 275 MW is predominantly from biomass/bagasse cogeneration.

A significant factor contributing to the lack of investment momentum in Chhattisgarh's RE sector is the perceived limited potential. The Ministry of New and Renewable Energy's assessments estimate the state's RE potential at 23,782 MW, which represents approximately 1.13% of the national total. This potential is mainly attributed to solar energy (18,270 MW), followed by wind (2,749 MW) and large hydro (1,311 MW)[1].

Table 1.1: Source-wise potential of RE capacity in Chhattisgarh

RE source	Estimated potential (MW)
Wind (at 150m agl)	2,749
Small hydro	1,098
Biomass	354
Cogeneration-bagasse	-
Solar	18,270
Large hydro	1,311
Total	**23,782**

Source: MNRE

Aside from the wind power potential, the current estimates of renewable energy (RE) potential across other technologies have been based on assessments conducted over a decade ago and are predominantly derived from broad generalizations. As a result, these estimates significantly underrepresent the actual potential, thereby failing to motivate necessary policy actions and investments from state decision-makers and RE investors.

To rectify this situation, a more detailed and granular assessment of RE potential for each technology is required. This should involve evaluating specific sites and clusters using advanced methodologies and updated datasets. Such a comprehensive assessment is crucial for guiding policymakers, implementing agencies, and investors in developing a strategic and ambitious RE capacity plan for the state in the short to medium term. This strategy will be vital for Chhattisgarh to meet its Renewable Purchase Obligation (RPO) targets and achieve sustainable green energy growth. In this context, iFOREST has undertaken an extensive re-assessment of Chhattisgarh's RE potential, encompassing ground-mounted solar, floating solar, wind energy, and biomass re-assessment.

2. Solar

Chhattisgarh has traditionally been viewed as less favourable for solar energy generation due to relatively lower insolation intensity and limited wasteland availability. However, the state benefits from over 300 days of sunshine and approximately 3,620 sunny hours annually. The average daily solar radiation in the state is 5.14 kWh per square meter (sq. m), with an average insolation of about 389 W per sq. m. The peak insolation reaches around 978 W per sq. m, which is comparable to that of renewable energy-rich states in India.[2]

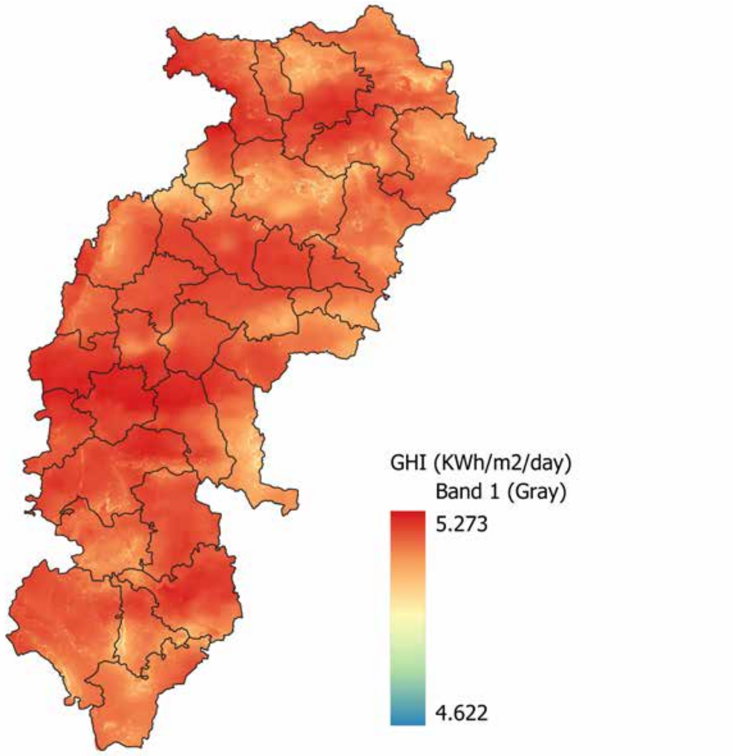
Despite being on the same latitude as the western states, the average radiation in Chhattisgarh is comparatively lower than its counterparts due to prolonged monsoon season for the period June to September. The insolation levels in the state are still comparable to states like Karnataka, which is among the leading states in the ground-mounted solar installation with a capacity of 7,906 MW (as of February 2024)[3]. Further, the average and peak insolation levels are significantly higher than Germany, which is among the leaders in solar installations with an installed capacity of 80 GW.

Table 2.1: Average and peak insolation levels for key states

State	Average (W per sq. m)	Peak (W per sq. m)
Chhattisgarh	389	978
Uttar Pradesh	465	889
Odisha	389	913
Madhya Pradesh	514	989
Karnataka	410	1,033
Gujarat	590	825
Germany	225	892

Source: NASA LaRC

Map 2.1: Solar insolation map of Chhattisgarh



Source: Global Solar Atlas

The National Institute of Solar Energy (NISE), the Ministry of New and Renewable Energy`s (MNRE) apex institute for research and development in the solar power sector, has estimated that Chhattisgarh has a solar power generation potential of about 18.27 GW[4]. The current assessment employs a generic methodology that assumes utilization of 3% of available wasteland for solar PV installations. This approach may not fully capture the potential for higher land utilization in specific wasteland categories, where solar panel coverage could exceed 3% without causing significant ecological disruption. For example, industrial and mining wastelands within the state could be extensively repurposed for solar installations.

Moreover, it is important to explore land-neutral solar technologies, such as floating and rooftop solar systems, which can be evaluated to minimize ecological impacts and offer alternatives to traditional ground-mounted installations. These technologies have the potential to increase solar capacity while reducing pressure on land resources, thereby supporting a more sustainable energy development strategy for the state.

2.1 Ground-mounted Solar

Along with sufficient solar insolation parameters, land availability is a key parameter defining the potential and feasibility for installation of ground-mounted solar projects. Typically, installing 1 MW of solar capacity requires five acres of land[5]. Given the land requirement intensity for ground-mounted solar projects, wastelands are considered most suitable for utility-scale ground-mounted solar projects.

The current potential assessment methodology employed by the NISE is overly simplistic, as it uniformly applies a 3% utilization rate for all states without accounting for the unique characteristics of each state. Certain categories of wasteland can accommodate a higher proportion of land diversion for solar power generation without causing significant ecological harm.

To achieve a more realistic assessment of Chhattisgarh's ground-mounted solar potential, it is crucial to analyse the state's specific land use patterns and wasteland classifications. This approach would allow for a more nuanced and realistic estimate of the state's solar generation capacity, taking into consideration the potential for increased land utilization in certain wasteland categories.

2.1.1 Re-assessment methodology

To reassess Chhattisgarh's ground-mounted solar potential, recent district-wise wasteland data has been categorized into various wasteland types. This data is then filtered to exclude areas with undesirable features, such as high flood propensity, elevated terrain, and high fire density. Updated land utilization factors, tailored to the ecological sensitivity of each wasteland category, are applied. The solar capacity potential is subsequently estimated based on industry standards and best practices.

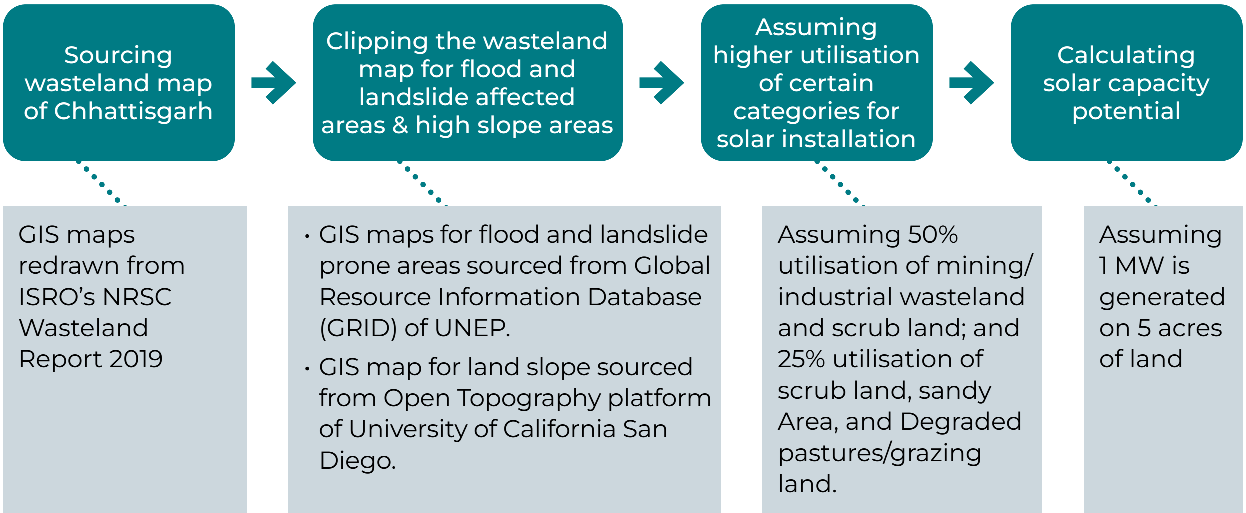
Updated wasteland in Chhattisgarh, across seven key categories, is mapped using 2019 satellite images procured from ISRO's National Remote Sensing Centre (NRSC)[6]. The mapped wasteland is then chipped for areas with high exposure to floods and landslides. The database for flood and landslide-prone areas is sourced from UNEP's Global Resource Information Database (GRID)[7]. Further, high-elevation areas are clipped based on data sourced from and University of California San Diego's Topography platform[8]. The process of identification and filtering of pixels with slopes higher than 8 degrees was executed using R software (R studio).

- Fire-prone areas were identified as active fire density areas for the period January 2022 to December 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-prone regions represent 25 years of modelled data for floods with water levels greater than 180 cm.
- Landslide-prone areas reflect the annual frequency of landslides triggered by precipitation. This was filtered for medium and high frequencies.
- A slope of 8 degrees or above is considered undesirable for solar projects.

For re-assessing solar potential on clipped wasteland, new utilization factors are assumed at 50% of barren rocky land and mining/industrial wastelands; and 25% of scrub land, grazing land, and sandy land. These factors are employed to estimate the feasible land area available for solar energy projects, considering the varying degrees of land usability.

For the identified wasteland areas, based on the higher utilization assumptions, the solar energy potential was calculated. The calculation assumed that 1 MW of solar power generation would require five acres of land, as per the current industry standard. This approach provided a quantitative estimate of the solar potential that could be harnessed from the available wasteland, facilitating strategic planning for solar deployment.

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



Source: iFOREST assessment

2.1.2 Potential re-assessment

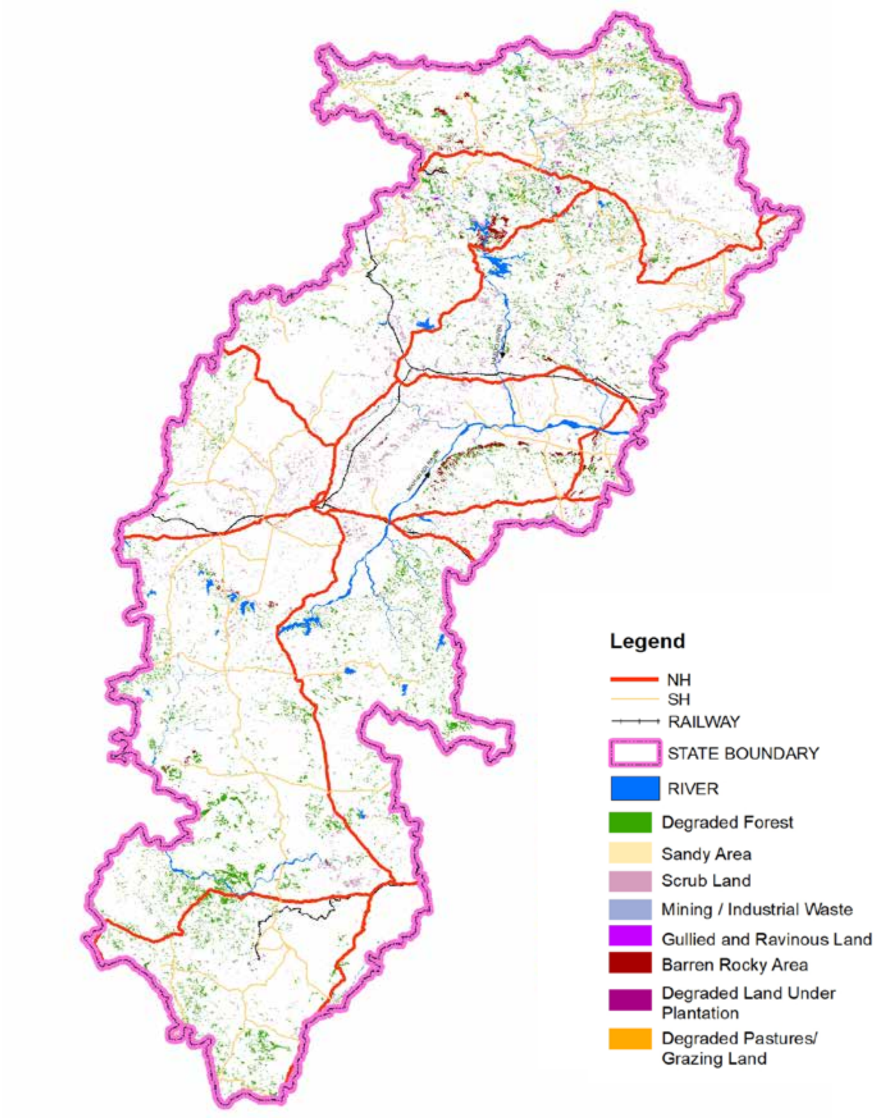
Chhattisgarh is the ninth largest state in India, spanning over 135,190 sq. km, with more than 45% (6,316 sq. km) of land mass covered under forests, 34% (4,681 sq. km) under agricultural use, 7.5% (1,029 sq. km) under non-agricultural use, and 6.4% (887 sq. km) under pasture and grazing land[9]. According to India's Wasteland Atlas 2019, Chhattisgarh has 6.8% (9,321 sq. km) of its landmass designated as wasteland.

Based on GIS maps redrawn from ISRO`s NRSC Wasteland Report 2019, iFOREST mapped a wasteland area of about 9,231 sq. km which is categorised into eight subcategories. More than 60% of the wasteland area comprises of degraded forests, followed by 29% of scrubland and 6.4% of barren rocky area. Mining and industrial wasteland comprise 1.44% of the mapped wasteland.

Following the mapping and identification of wastelands in Chhattisgarh, the wasteland is analysed for exposure to flooding, landslides and fire density which was deemed unsuitable for solar PV installations and is clipped from the feasible area for ground-mounted solar PV installation.

From the 9,231 sq. km of available wasteland in Chhattisgarh, 104.78 sq. km is clipped due to its exposure to flooding, 342.33 sq. km is removed due to high landslide probability, 823.37 sq. km is removed due to high fire probability. Further, nearly 242 sq. km of the clipped wasteland area (after accounting for floods, landslides and fires) is removed for solar installation consideration due to the high slope.

Map 2.2: Wasteland map of Chhattisgarh



Source: Based on ISRO's NRSC Wasteland Report 2019

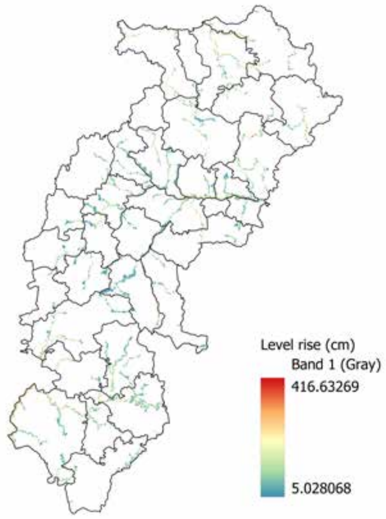
Table 2.2: Wasteland categories in Chhattisgarh

Type	Area (sq. km)	Share (%)
Barren rocky area	591.41	6.40
Degraded forest	5,695.25	61.69
Degraded pastures / Grazing land	0.62	0
Degraded land under plantation	16.93	0.18
Gullied and ravenous land	79.70	0.86
Mining / industrial waste	133.61	1.44
Sandy area	40.57	0.44
Scrub land	2,673.13	28.96
Total wasteland	9,231.25	
Total land area of Chhattisgarh	135,190	

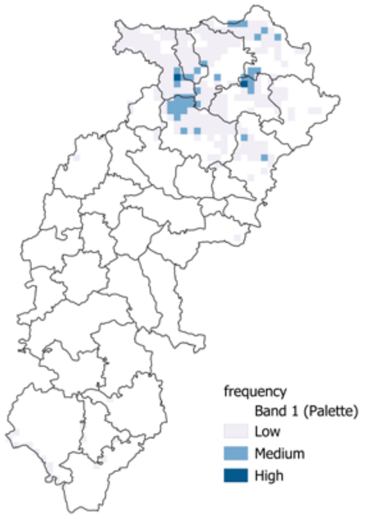
Source: iFOREST estimates based on National Remote Sensing Centre dataset

Map 2.3: Wasteland map clipped for undesired conditions

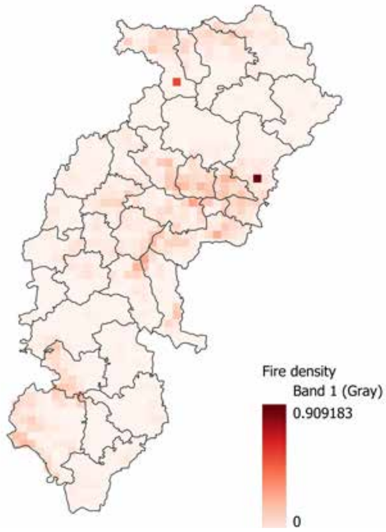
Flood Prone area



Landslide prone area



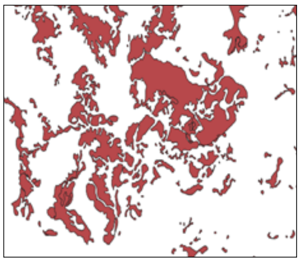
Fires occurrence area

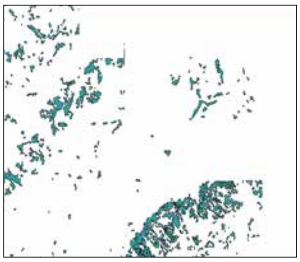


Source: iFOREST assessment

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

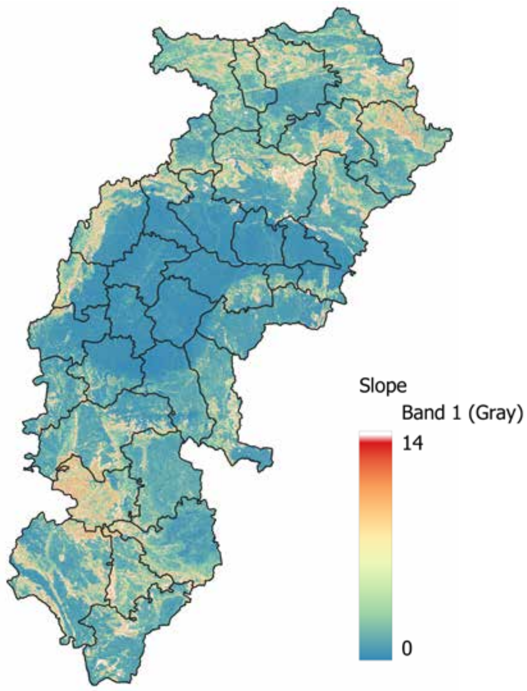
Total wasteland area → Wasteland area clipped for flood prone area → Clipped wasteland area clipped for landslide prone area → Clipped wasteland area clipped for fire occurrence area





Source: iFOREST Assessment

Map 2.5: Clipping for high slope area



Source: iFOREST Assessment

Following the mapping and analysis of wasteland area, and filtering out areas with undesirable properties, five wasteland categories—barren rocky land, scrub land, mining/industrial wasteland, sandy areas, and degraded pasture/grazing land—are identified as suitable for ground-mounted solar projects. These categories total 2,866.40 sq. km of the state's total wasteland area. By this analysis, approximately 70% of the wasteland area in Chhattisgarh (6,364.85 sq. km) is deemed unsuitable for solar projects.

Among the identified suitable wasteland, 82% (2,370.58 sq. km) is categorized as scrubland, followed by barren rocky land, which accounts for 12% (369.10 sq. km). Scrublands typically have shallow, skeletal soils and sparse vegetation, while barren rocky lands are characterized by minimal vegetation and exposed rock surfaces. These two categories represent the largest share of usable wasteland for ground-mounted solar installations. In this study, 25% of scrub land and 50% of barren rocky land were considered suitable for solar projects.

Additionally, mining/industrial wasteland and sandy areas also contribute significantly to the suitable wasteland for solar projects, covering 100.45 sq. km and 26.11 sq. km, respectively. Mining/industrial wastelands, which include areas used for mining debris and industrial waste, and sandy areas, typically found in river floodplains or as sand dunes shaped by wind, can be utilized up to 50% and 25% respectively for ground-mounted solar installations.

Degraded pasture and grazing lands constitute the smallest share of usable wasteland in Chhattisgarh, totaling 0.16 sq. km, with an assumed potential utilization of up to 25% for ground-mounted solar installations.

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

Usable wasteland category	Total area (sq. km)	Area after clipping for flood, landslide, fire dense area & slope (sq. km)	Assumed land available for solar (sq. km)	Estimated potential (MW)
Barren Rocky	591.41	369.10	184.55	9,120.66
Scrub land	2,673.13	2,370.58	592.64	29,288.88
Mining/Industrial waste	133.61	100.45	50.22	2,482.32
Sandy area	40.57	26.11	6.52	322.61
Degraded pasture/ grazing land	0.62	0.16	0.04	1.977
Total		2,866.4	834	41,216.44

Note: Assuming 50% utilization of barren rocky wasteland; 50% of mining/industrial wasteland; 25% of degraded pastures/ grazing land, scrubland and sandy area.
Source: iFOREST Assessment

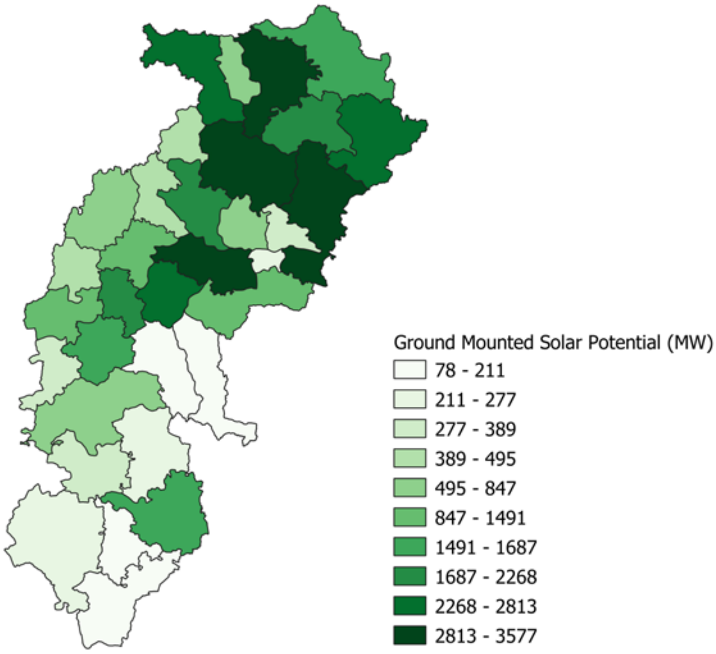
Using the study's methodology, 834 sq. km of wasteland across five categories are identified as suitable for ground-mounted solar projects. This area can support a total solar capacity of 41,216 MW across Chhattisgarh.

Within the 834 sq. km of usable land, scrub land and barren rocky land account for 71% and 22%, respectively. Specifically, scrub land can support 29,288 MW, while barren rocky land can accommodate 9,120 MW. Mining/industrial wasteland and sandy areas also contribute significantly, with mining/industrial wastelands supporting 2,482 MW and sandy areas supporting 322 MW.

The distribution of suitable wasteland and solar potential is predominantly concentrated in the northern districts of Bolada Bazar, Surajpur, Korba, Raigarh, Jashpur, Manendragarh-Chirmiri-Bharatpur, and Raipur. These districts collectively contribute to about half of the state's estimated ground-mounted solar potential, with Bolada Bazar, Surajpur, Korba, and Raigarh providing 9%, 8%, 7%, and 7% of the total potential, respectively. Conversely, the southern districts, including Sukma, Dantewada, Gariaband, Dhamtari, and Kondagaon, exhibit lower potential primarily due to limited wasteland availability.

The higher ground-mounted solar potential in the northern districts is largely attributed to the presence of extensive scrub land. Districts with substantial mining and industrial wasteland, such as Korba (3,075 MW) and Raigarh (2,850 MW) also show significant potential. Despite similar solar radiation and insolation factors in the southern districts, their solar potential could increase if a greater proportion of available wastelands or less productive agricultural lands were utilized.

Map: 2.6: Ground-mounted solar potential distribution in Chhattisgarh



Source: iFOREST Assessment

Table 2.4: District-wise estimated potential for ground-mounted solar across various land categories (MW)

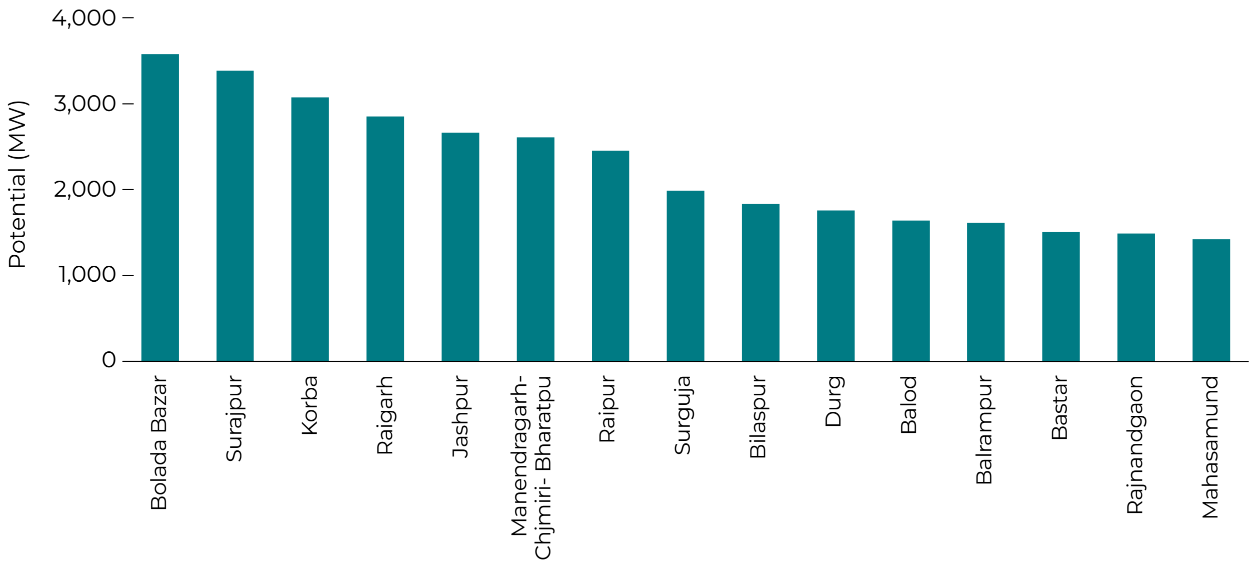
District	Barren rocky wasteland	Scrub land	Mining/ industrial waste	Sandy area	Degraded pastures / grazing Land	Potential
Balod	463	1,146	30	-	-	1,639
Balrampur	55	1,445	108	5	-	1,613
Bastar	235	1,252	16	-	-	1,503
Bemetara	-	1,188	84	-	-	1,272
Bijapur	212	58	1	-	-	272
Bilaspur	42	1,746	31	14	-	1,833
Bolada Bazar	1,572	1,732	215	58	-	3,577
Dantewada	6	32	46	-	-	83
Dhamtari	16	169	5	10	-	200
Durg	-	1,584	173	1	-	1,758
Gariaband	15	93	4	5	-	117
Gaurela-Pendra-Marwahi	36	427	-	-	-	462
Janjgair-Champa	5	682	113	47	-	847
Jashpur	804	1,824	34	2	-	2,664
Kabirdham	4	408	104	-	-	516
Kanker	134	560	2	-	-	695

Table 2.4 continued

District	Barren rocky wasteland	Scrub land	Mining/ industrial waste	Sandy area	Degraded pastures / grazing Land	Potential
Khairagarh-Chhuikhadan-Gandai	31	398	18	-	-	447
Kondagaon	2	250	-	-	-	252
Korba	916	1,553	518	87	-	3,074
Koriya	288	216	-	-	-	504
Mahasamund	495	917	4	4	-	1,420
Manendragarh-Chjmiri-Bharatpu	1,479	1,099	15	15	-	2,608
Mohla-Manpur	-	312	-	-	-	312
Mungeli	-	410	5	1	-	416
Narayanpur	255	29	-	-	-	284
Raigarh	773	1,633	439	3	2	2,850
Raipur	16	2,370	59	10	-	2,454
Rajnandgaon	65	1,423	1	-	-	1,488
Sarangarh-Bhilaigarh	134	122	-	-	-	256
Shakti	13	249	67	20	-	349
Sukma	13	66	-	-	-	78
Surajpur	995	2,104	270	16	-	3,385
Surguja	48	1,796	120	24	-	1,989
Total	9,121	29,289	2,482	323	2	41,217

Source: iFOREST Assessment

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



Source: iFOREST Assessment

2.2 High-potential wasteland clusters

For a comprehensive assessment of ground-mounted solar potential, large clusters of wasteland patches were identified for solar project development using the processed wasteland data. This analysis focused on the five wasteland categories deemed most suitable for solar projects. The distribution of these wasteland clusters, along with the locations of substations across the state, is evaluated to identify the most viable areas for large-scale solar installations. The assessment aimed to optimize the economic benefits of scale by prioritizing wasteland clusters for the initial phase of development. This approach ensures that the largest and most feasible clusters are utilized effectively, leveraging their potential for significant solar power generation. The distance of clusters from nearest substations is mapped and calculated using data from substations data from OpenStreetMap[10], and verified using Google Earth.

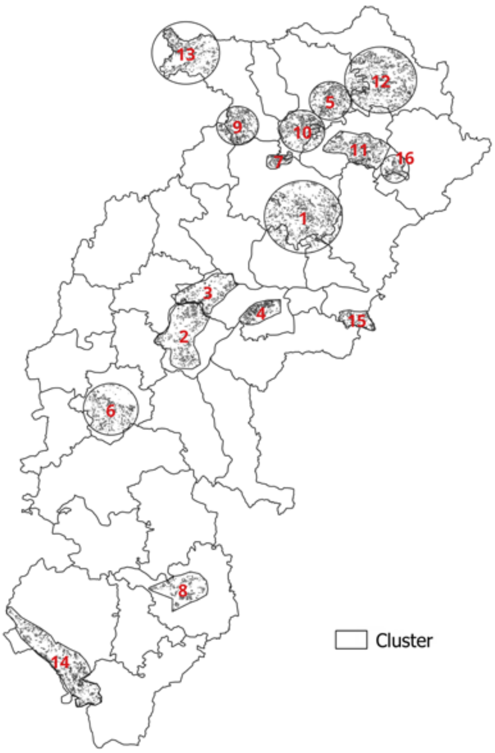
Our approach identified and shortlisted 16 major clusters across 10 districts in the state with a cumulative area of 375 sq. km which can support a total capacity of 18,537 MW (at the assumed land utilisation proportions based on wasteland categories). The clusters are shortlisted based on usable area, and each of these clusters has a usable area of over 10 sq. km.

The identified clusters of wasteland suitable for solar project development are primarily located in northern Chhattisgarh, across districts such as Korba, Sarjuga, Surajpur, Balrampur, and Manendragarh-Chirmiri-Bharatpur. In central Chhattisgarh, significant and contiguous wasteland patches are found in the adjoining districts of Baloda Bazar and Raipur. The southern districts of Bastar and Bijapur also present substantial clusters of wasteland.

The largest identified cluster is in Korba district, which consists of 24 barren rocky land parcels and 2 scrubland parcels. This cluster has the potential to support up to 2,976 MW of solar capacity with an estimated Capacity Utilization Factor (CUF) of 26.25%.

The second-largest cluster is situated in Balrampur district and is predominantly comprised of scrubland, with 263 parcels identified. This cluster can support 2,248 MW of solar capacity at a CUF of 26.3%. Aggregation models can be employed to enhance the techno-economic feasibility of these projects.

Map 2.7: Major wasteland clusters in Chhattisgarh



Source: iFOREST Assessment

Table 2.5: Largest wasteland clusters and their potential in Chhattisgarh

Sl no	District	Longitude	Latitude	Useable land (sq. km)	Potential (MW)	CUF (%)	Distance from substation (km)	No of Parcel across wasteland categories
1	Korba	82.79896681	22.31192022	60.21	2,976.10	26.15	8.99	• 49 parcels of barren rocky area. • 50 parcels of mining & industrial waste. • 16 parcels of sandy area. • 397 parcels of scrub land.
2	Raipur	81.78208457	21.30504215	45.48	2,248.10	26.43	9.33	• 5 parcels of barren rocky area. • 15 parcels of mining & industrial waste. • 366 parcels of scrub land.
3	Bolada Bazar	81.98569228	21.67615459	35.98	1,778.40	26.49	0	• 12 parcels of barren rocky area. • 12 parcels of mining & industrial waste. • 191 parcels of scrub land.
4	Bolada Bazar	82.43888401	21.50277865	28.48	1,407.80	26.18	6.39	• 97 parcels of barren rocky area. • 1 parcel of mining & industrial waste. • 18 parcels of scrub land.
5	Surajpur	83.02734262	23.30136611	26.41	1,305.40	26.56	8.55	• 21 parcels of mining & industrial waste. • 2 parcels of sandy area. • 225 parcels of scrub land.
6	Balod	81.15956945	20.67402788	24.08	1,190.50	26.59	0	• 17 parcels of barren rocky area. • 7 parcels of mining & industrial waste. • 256 parcels of scrub land.
7	Korba	82.58870577	22.792431	23.68	1,170.60	26.25	14.57	• 24 parcels of barren rocky area. • 2 parcels of scrub land.
8	Baster	81.77343662	19.14208663	23.18	1,145.80	26.58	7.25	• 23 parcels of barren rocky area. • 2 parcels of mining & industrial waste. • 104 parcels of scrub land.
9	Manen-dragarh-Chjmiri-Bharatpu	82.23870484	23.08941145	20.03	990	26.56	9.76	• 29 parcels of barren rocky area. • 2 parcels of mining & industrial waste. • 201 parcels of scrub land.

Table 2.5 continued

Sl no	District	Longitude	Latitude	Useable land (sq. km)	Potential (MW)	CUF (%)	Distance from substation (km)	No of Parcel across wasteland categories
10	Surajpur	82.78917219	23.04275871	18.34	906.7	26.51	4.05	• 1 parcel of barren rocky area. • 8 parcels of mining & industrial waste. • 7 parcels of sandy area. • 197 parcels of scrub land.
11	Surguja	83.27329287	22.89406366	16.31	806.3	26.26	38.09	• 2 parcels of barren rocky area. • 9 parcels of mining & industrial waste. • 2 parcels of sandy area. • 164 parcels of scrub land.
12	Balrampur	83.45732549	23.47848216	11.35	561.3	26.28	18.76	• 3 parcels of barren rocky area. • 14 parcels of mining & industrial waste. • 10 parcels of sandy area. • 263 parcels of scrub land.
13	Manen-dragarh-Chjmiri-Bharatpu	81.7974154	23.70870776	10.69	528.8	26.5	60.76	• 22 parcels of barren rocky area. • 13 parcels of sandy area. • 163 parcels of scrub land.
14	Bijapur	80.72594935	18.53236193	10.38	513.2	26.22	37	• 28 parcels of barren rocky area. • 1 parcel of mining & industrial waste. • 9 parcels of scrub land.
15	Raigarh	83.25372299	21.43945546	10.24	506.1	25.91	11.5	• 22 parcels of barren rocky area. • 1 parcel of mining & industrial waste. • 36 parcels of scrub land.
16	Surguja	83.57539	22.72104535	10.17	502.6	26.28	15.55	• 15 parcels of barren rocky area. • 3 parcels of sandy area. • 60 parcels of scrub land.
Total				375.1	18,537.70			

Source: iFOREST Assessment

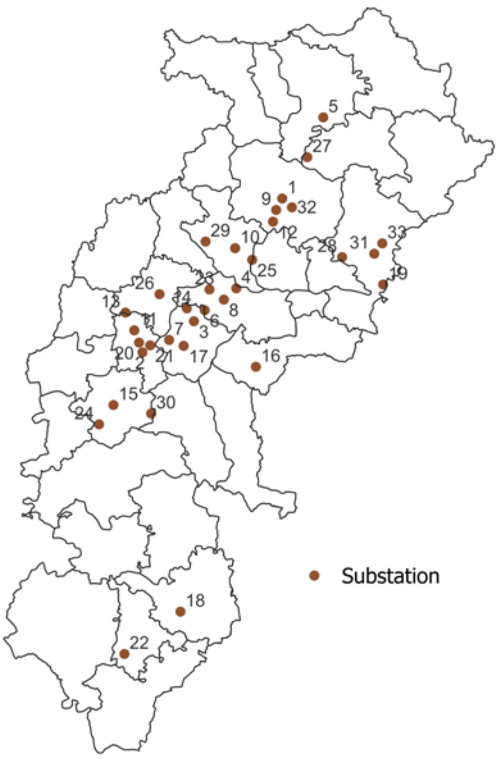
2.3 Wasteland parcels around existing substations

Following the identification of major wasteland clusters suitable for ground-mounted solar projects, another exercise of identifying wasteland parcels in the vicinity of existing substations is conducted to identify the most feasible wasteland to support solar projects. Solar projects in the vicinity of existing substations have a cost advantage as they typically do not require substantial additional transmission infrastructure.

In this study, wasteland clusters in a radius of 5 km from each of the 33 major transmission substations in the state were identified and mapped. A total area of 70.30 sq. km of wasteland is mapped which can support 3,474.42 MW of solar capacity (at 100% utilization), which is more than 8.4% of re-assessed solar potential for the state.

The assessment identified several high-capacity project locations, including three locations that can support capacities of over 175 MW, eleven locations that can support 105 MW to 170 MW, and ten locations that can support 80 MW to 100 MW capacities.

Map 2.8: Wasteland parcels around existing substations



Source: iFOREST Assessment

Table 2.6: Wasteland clusters for solar development around key substations in Chhattisgarh

Sl no	District	Longitude	Latitude	Voltage (kV)	Area (sq. km)	Potential (MW)	CUF (%)
1	Surajpur	82.60350182	22.48998672	400	4.21	208.27	27.65
2	Kanker	81.42042015	21.18582191	400	3.76	185.60	27.70
3	Raipur	81.85606211	21.44965239	400	3.64	179.87	27.77
4	Surajpur	82.2146537	21.72824885	132	3.39	167.74	27.80
5	Bemetara	82.95092701	23.1774544	220	3.39	167.36	27.60

Table 2.6 continued

Sl no	District	Longitude	Latitude	Voltage (kV)	Area (sq. km)	Potential (MW)	CUF (%)
6	Mahasamund	81.94727926	21.54351909	132	2.79	138.06	27.79
7	Mahasamund	81.64616248	21.29075471	132	2.79	137.80	27.73
8	Rajnandgaon	82.10963823	21.63320354	132	2.75	135.75	27.78
9	Surguja	82.55228191	22.39290866	132	2.47	122.08	27.71
10	Korba	82.20499211	22.06911821	220	2.31	114.05	27.83
11	Durg	81.35120898	21.3722931	400	2.29	113.28	27.70
12	Raipur	82.52567644	22.29344446	132	2.20	108.60	27.79
13	Mungeli	81.27645285	21.52298486	132	2.19	108.36	27.67
14	Raigarh	81.79601052	21.55857722	132	2.17	107.11	27.77
15	Bastar	81.17505484	20.73983546	132	1.84	90.89	27.60
16	Korba	82.38044619	21.06328941	132	1.82	89.88	27.70
17	Bolada Bazar	81.76940029	21.24079888	132	1.81	89.64	27.72
18	Raigarh	81.74200847	18.98825211	132	1.81	89.54	26.97
19	Mungeli	83.45812498	21.76093277	400	1.81	89.24	27.36
20	Kanker	81.39160661	21.26899437	400	1.72	85.00	27.70
21	Janjgair-Champa	81.48547513	21.24554893	400	1.72	85.00	27.72
22	Raigarh	81.26802145	18.629943	132	1.64	81.00	26.83
23	Durg	81.98784605	21.71914626	400	1.62	80.25	27.82
24	Balod	81.05325664	20.57601138	132	1.62	80.03	27.47
25	Bolada Bazar	82.34910025	21.97012591	132	1.57	77.44	27.84
26	Raigarh	81.56452903	21.67893351	220	1.52	74.95	27.77
27	Rajnandgaon	82.81576155	22.83984976	132	1.49	73.85	27.55
28	Surguja	83.11038585	21.99308511	132	1.43	70.91	27.58
29	Bilaspur	81.95434055	22.12514767	132	1.40	69.17	27.79
30	Balod	81.49372826	20.66723843	132	1.32	65.37	27.58
31	Bemetara	83.38251295	22.02224011	220	1.30	64.38	27.41
32	Korba	82.68610201	22.41482226	400	1.28	63.31	27.67
33	Bemetara	83.45064913	22.10947122	400	1.23	60.66	27.41
Total					70.30	3,474.34	

2.4 Floating Solar

In addition to the ground mounted and rooftop solar potential re-assessment, this study also evaluated the potential for land-neutral solar technologies, especially on the man-made reservoirs which can support substantial solar capacity enhancement with added advantages of hybrid RE plants along with hydropower and evaporation water-savings in several cases.

As per the National Register for Large Dam (NRLD)'s data on dams published by the Central Water Commission (CWC) of the Ministry of Jal Shakti[11], Chhattisgarh has 258 large dams, while 9 new dams are under construction. In the assessment exercise, 192 dams were evaluated for floating solar potential, considering factors such as water availability and data accessibility.

Data on these dams, including water availability, water spread area, reservoir area, and depth, is sourced from the India Water Resources Information System (India-WRIS) data portal. Several of these dams are selected for potential floating solar installations, considering various environmental impact scenarios. Despite conservative utilization assumptions, these dams present significant opportunities for floating solar projects.

2.4.1 Assessment methodology

A three-step methodology is adopted for the estimation of the floating solar potential of Chhattisgarh based on secondary data sets available for dams focusing 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 water bodies suitable for floating solar installations involves leveraging multiple authoritative sources to ensure comprehensive coverage across all categories of water bodies. Primary data is obtained from the Central Water Commission's National Register of Large Dams (NRLD, 2019), which offers an extensive inventory of water bodies, particularly large reservoirs and dams. This data is then cross-verified using the Indian Space Research Organisation's (ISRO) Bhuvan Water Bodies Information System (India-WBIS), a satellite-based resource that provides detailed information on the extent and characteristics of water bodies[12]. The portal provides key information regarding the dams, including water availability, water spread area, reservoir area, and depth. Additionally, Google Earth is employed to visually inspect and validate the identified waterbodies, ensuring accuracy and completeness in the dataset.

Step 2: Filtering and categorization of waterbodies:

The datasets are filtered based on specific criteria to refine the selection of water bodies deemed most suitable for floating solar projects. Water bodies are categorized according to several key factors, including utilization type, depth, age, and reservoir area. These factors are crucial for evaluating the feasibility and potential efficiency of floating solar installations. Each category is assessed to determine its suitability for floating solar, as these attributes impact both the technical feasibility and economic viability of deploying solar panels on water surfaces.

In line with industry practices, reservoirs with a spread area of less than 4,000 sq. km and depths of less than 3m are deemed unsuitable for floating solar installations.

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

For each shortlisted category of water bodies, the reservoir area is evaluated to determine the total area available for floating solar installations. This evaluation is based on category-specific utilization assumptions, which take into account the characteristics of each water body type. These assumptions consider the proportion of the reservoir area that could be effectively utilized for solar panels without disrupting other critical functions, such as irrigation, drinking water supply, or flood control.

Three utilization scenarios—high, medium, and low—are developed based on reservoir conditions, including depth, area, age, and usage. The utilization assumptions vary depending on the purpose of the reservoir. Although a detailed reservoir level assessment is crucial for determining the actual area available for floating solar deployment, these utilization scenarios provide a broad indication of potential across different conditions.

The potential for floating solar installations is then assessed based on these utilization assumptions for each reservoir category, across the three scenarios and age classifications. The calculation use an area requirement of 10,117 sq. m per MWp to estimate the potential solar capacity.[13]

Table 2.7: Data sources and tools 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

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

Reservoir purpose	Low utilization scenario	Medium utilization scenario	High utilization scenario
Irrigation and water supply	5%	10%	20%
Irrigation	10%	25%	50%
Flood control, hydroelectric, irrigation and water supply	1%	2%	2%
Hydroelectric	3%	5%	10%
Water supply	10%	25%	50%
Irrigation, flood control	5%	10%	10%
Irrigation, hydroelectric, navigation	2%	5%	10%
Irrigation, hydroelectric	2%	10%	10%
Irrigation, hydroelectric, water supply	2%	5%	5%
Irrigation, pisciculture	5%	10%	20%
Irrigation, pisciculture, water supply	5%	10%	20%
Irrigation, pisciculture, water supply, hydroelectric	2%	5%	5%
Irrigation, earth fill embankment	10%	25%	50%
Irrigation, hydroelectric, water supply, tourism, flood control	2%	5%	5%

Source: iFOREST assessment

2.4.2 Potential assessment

In Chhattisgarh, the NRLD dataset indicates the presence of 258 large dams, including 9 dams that are currently under construction. After data cleaning, 192 of these dams are selected for potential floating solar assessment.

Among the 192 shortlisted dams, most are medium age, ranging from 20 to 50 years old. The classification includes 95 dams with low depths (10 to 15 m), 91 dams with medium depths (15 to 30 m), and 6 dams with high depths (30 to 100 m). Given that medium and high-depth reservoirs are most favourable for floating solar installations, 95 dams with medium to high depths which are not very old are further shortlisted for detailed assessment.

Based on varying utilization assumptions, the floating solar potential is estimated to be 4,792 MW in a low utilization scenario, 11,980 MW in medium scenario and 23,488 MW in a high scenario.

Most of this potential is concentrated in the Gariaband district, which has a high scenario potential of 12,533 MW across two reservoirs. This significant potential is largely attributed to the Sikasar Dam, which could potentially accommodate a large-scale floating solar plant of up to 12,474 MW. Following Gariaband, the Dhamtari district also shows considerable potential with 3,011 MW across four reservoirs under the high scenario.

Table 2.9: Number of reservoirs in Chhattisgarh 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)	Total
Very low depth (3m to 10m)	0	0	0	0	0
Low depth (10m to 15m)	8	77	8	2	95
Medium depth (15m to 30m)	15	71	4	1	91
High depth (30m to 100m)	0	4	1	1	6
Very High Depth (>100m)	0	0	0	0	0
Total	23	152	13	4	192

Source: iFOREST assessment based on

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

Name Of Water Body	District	Type	Area (1,000 sq. m)	Effective area (1,000 sq. m)			Potential (MWp)		
				Low	Medium	High	Low	Medium	High
Sikasar	Gariaband	Irrigation	2,52,400.0	25,240.0	63,100.0	1,26,200.0	2,494.8	6,237.0	12,474.1
Kharang	Bilaspur	Irrigation	38,074.0	3,807.4	9,518.5	19,037.0	376.3	940.8	1,881.7
Maniyari	Mungeli	Irrigation	25,270.0	2,527.0	6,317.5	12,635.0	249.8	624.4	1,248.9
Sondur Sondur	Dhamtari	Irrigation	24,160.0	2,416.0	6,040.0	12,080.0	238.8	597.0	1,194.0
Kosarteda	Bastar	Irrigation	15,870.0	1,587.0	3,967.5	7,935.0	156.9	392.2	784.3
Kodar Project Modak	Mahasamund	Irrigation	13,880.0	1,388.0	3,470.0	6,940.0	137.2	343.0	686.0
Ghunghutta Tank	Koriya	Irrigation	12,657.0	1,265.7	3,164.3	6,328.5	125.1	312.8	625.5
Paralkot Paralkot	Kanker	Irrigation	11,370.0	1,137.0	2,842.5	5,685.0	112.4	281.0	561.9
R.S. Sagar	Dhamtari	Irrigation, Pisciculture, Water supply, Hydroelectric	95,400.0	1,908.0	4,770.0	4,770.0	188.6	471.5	471.5
Ghongha Tank	Bilaspur	Irrigation	7,880.0	788.0	1,970.0	3,940.0	77.9	194.7	389.4

Source: iFOREST assessment

2.5 Conclusion

Chhattisgarh, characterized by over 300 days of sunshine annually and average solar radiation of 5.14 kWh per sq. m, possesses favourable solar resources. The solar radiation parameters suggest Chhattisgarh has comparable solar potential with states that have managed to develop significant solar capacity. As the demand for solar energy capacity grows in the coming decades, the state's solar potential will become increasingly important. To address this, a strategic approach should be adopted to optimize the utilization of available wastelands, focusing on clusters of land patches and proximity to existing substations. Additionally, substantial solar capacities can be achieved through the deployment of land-neutral solar technologies. This includes both large-scale and small-scale solar PV projects, which can be integrated effectively across the state. Such a strategy will enhance the development of solar resources, contributing to the national RE goals.

3. Wind

Evaluating high-quality wind sites is essential for accurately determining a region's wind energy potential. This requires analysing factors such as wind speed, direction, turbulence, air density, and shear. In Chhattisgarh, the overall potential for wind energy generation is limited due to generally low wind speeds, with only a few identified locations providing suitable conditions for wind energy development.

The National Institute of Wind Energy (NIWE) has determined the wind energy potential for Chhattisgarh at various hub heights. NIWE's assessment methodology utilizes an advanced meso-micro coupled numerical wind flow model, complemented by data from 406 actual measurement sites across the country. The evaluation also incorporates various land use and environmental factors to provide a comprehensive analysis of the wind energy potential.

At present, the total installed wind capacity in India stands at 47 GW, with no capacity installed in Chhattisgarh so far[14]. According to NIWE's assessment, wind energy potential for Chhattisgarh stands at 349 MW at 120 meter (m) hub height with a major chunk of it (or 269 MW) coming from potential with 30% cultivable land usage[15]. Similarly, for the 150m hub height, the estimated wind potential is 2,749 MW, most of it coming from 30% cultivable land usage[16]. Overall, the assessed wind potential for Chhattisgarh constitutes a minuscule fraction of less than 0.3% of India's total wind energy potential.

A focus 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 enhanced. This study focuses on identifying high wind potential sites in Chhattisgarh based on secondary sources of wind speed and terrain data.

Table 3.1: NIWE assessed wind energy potential for Chhattisgarh and India

Category	Chhattisgarh (MW)	India (MW)
Potential at 120m hub height	349	695,508
-with 80% wasteland usage	21	340,112
-with 30% cultivable land usage	269	347,045
-with 5% forest land usage	59	8,351
Potential at 150m hub height	2,749	1,163,856
-with 80% wasteland usage	194	544,448
-with 30% cultivable land usage	2,074	607,288
-with 5% forest land usage	482	12,120

Source: NIWE

3.1 Assessment methodology

Initial scoping for wind resource assessment is done 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)[17]. The GWA 3.1 portal has been 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[18] to filter areas that offer lower techno-commercial feasibility. The database provides a high-resolution digital topographic database of the earth.

The assessment focused on identifying areas with wind speeds exceeding the threshold value of 5 m/s (minimum speed for wind turbines to operate). Concurrently, areas with high slopes (greater than 15 degrees), those prone to landslides due to precipitation (medium and high frequencies), and regions affected by frequent fires (based on active fire density for 2022) are excluded from consideration. For estimating wind energy potential at hub heights of 100 meters and 150 meters above ground level (AGL), the analysis involved identifying the total clipped area with wind speeds within the threshold range of 5 m/s to 8 m/s. This included examining both the general potential area and the wasteland areas across all districts.

The energy generation potential for the identified land areas is then assessed using a standard wind turbine model of GE 130 with a turbine diameter of 130 m, swept area of 13,273 sq. m and annual power generation of 28.032 GWh at air density of 1.225 kg/m3.

For spacing between wind turbines, a spacing density of 4.375 is considered and turbine spacing density i.e., the area required for each turbine including spacing between turbines is calculated using the formula – 4.375 x 130m x 4.375 x 130m to arrive at 323,476.6 sq. m. The methodology for annual power generation and spacing factor are adapted from similar studies attempting to estimate wind energy potential in India[19].

Table 3.2: Parameters for wind energy generation estimation

Model	GE 130
Diameter (m)	130
Swept area (Sq. m)	13273
Annual ideal power generation (GWh)	28.032
Air density (kg/m3)	1.225
Turbine spacing density (sq. m/turbine)	323476.6
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 available from the GWA 3.1, a total of 3,816 high wind speed sites are identified in Chhattisgarh. This includes 820 sites at a 100m hub height and 2,996 sites at a 150m hub height, each with an average wind speed exceeding 5 m/s. These sites were then mapped using the NASA SRTM database to filter out areas with high slopes (greater than 15 degrees), where wind turbine installation is typically less techno-commercially feasible.

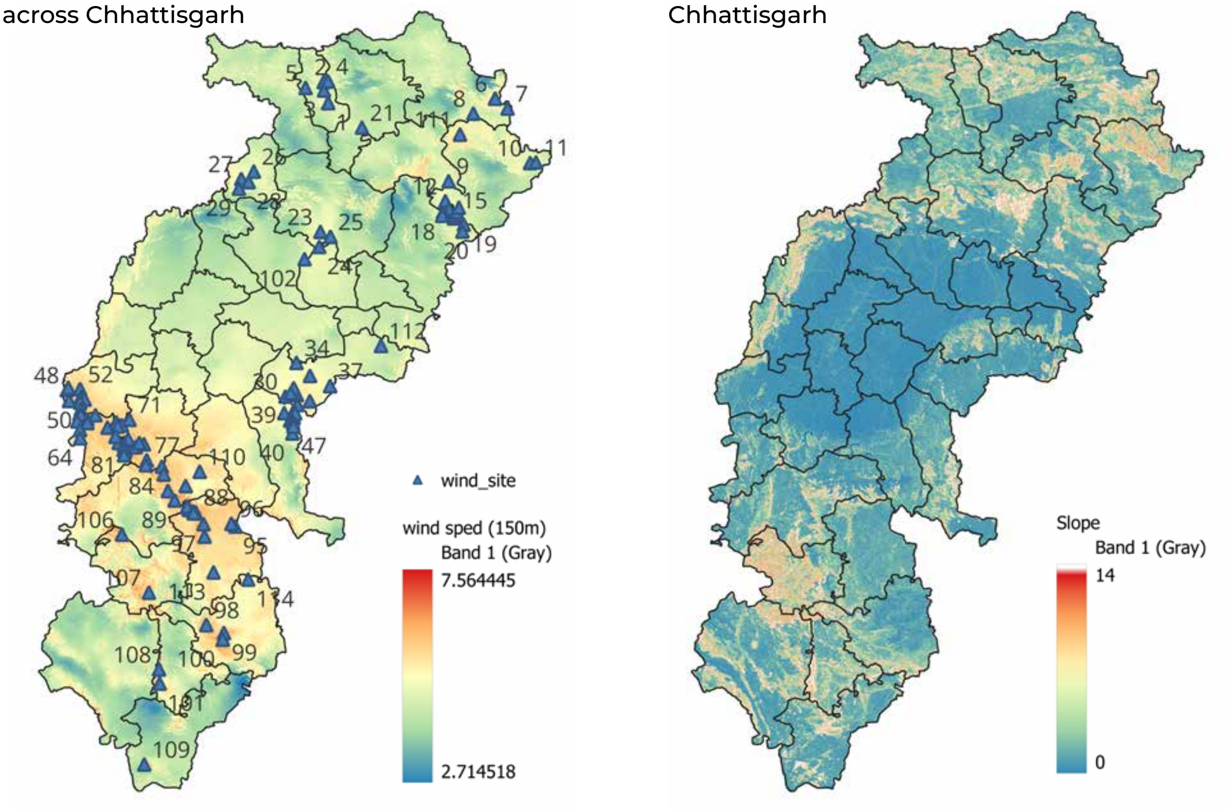
In Chhattisgarh, several sites with wind speeds exceeding 7 m/s at 150m AGL are found in high-slope areas within the districts of Dantewada, Narayanpur, Janjgair-Champa, Sukma, and Kanker. These locations were excluded from further consideration due to low techno-economic feasibility.

For the 3,816 sites deemed feasible for wind energy development, the capacity utilization factor (CUF) was calculated based on standard turbine models (GE 130) and the average wind speeds over 10 years for both 100m and 150m heights AGL.

Map 3.1: Identified wind sites and terrain for Chhattisgarh

Wind speed across Chhattisgarh

Slope across Chhattisgarh



Source: iFOREST assessment

After filtering for climate risks and high slopes, approximately 10,384 square kilometers (sq. km) of land area is identified as having high potential for wind energy development at a hub height of 100m AGL. Within this area, about 96% land area has wind speeds ranging from 5 to 6 m/s, 3.5% of the area has wind speeds between 6 and 7 m/s, and the remaining area features wind speeds from 7 to 8 m/s. At a hub height of 150m AGL, the potential area expands to 41,629 sq. km. Of this area, 93% land area has wind speeds of 5 to 6 m/s, 7% area has wind speeds between 6 and 7 m/s, and a very small fraction falls within the 7 to 8 m/s range.

Table 3.3: Filtered area under threshold wind speeds in Chhattisgarh

Wind Speed (m/s)	Area at 100m AGL (sq. km)	Area at 150m AGL (sq. km)
5 to 6	10,002.01	38,585.63
6 to 7	366.21	2,982.4
7 to 8	15.86	60.57
Total	10,384.08	41,628.6

*After filtering for high slopes and climate risks
Source: iFOREST assessment

The identified land area in Chhattisgarh has substantial potential for wind power generation. At a hub height of 100m AGL, it is estimated that approximately 32,101 wind turbines could be installed, yielding a theoretical wind power potential of 14.8 GW. At a higher hub height of 150m AGL, the number of installable turbines increases to about 128,691, leading to a potential capacity of 61 GW. Notably, approximately 7.4 GW of this potential is associated with high wind speeds of 6 to 7 m/s at 150 meters 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	30,920	1,21,111.8	13.8	1,19,284	4,67,223.6	53.3
>6 and <7	1132	8,010.8	0.9	9220	65,240.0	7.4
>=7	49	550.9	0.1	187	2,104.0	0.2
Total	32101	1,29,673.6	14.8	1,28,691	5,34,567.6	61.0

Note: Potential estimated at a peak scenario of 100% utilization
Source: iFOREST estimates

Identifying the total area with threshold wind speeds provides a broad indication of the feasibility for wind energy installations in Chhattisgarh. Unlike solar projects, which are often prioritized for wastelands due to land acquisition and ecological considerations, wind energy installations can be developed in a wider range of land categories, including non-wasteland areas. However, due to higher costs associated with land acquisition and the overall complexity of installation, focusing on estimating wind energy potential specifically for wastelands remains crucial. This approach helps in optimizing land use and cost-effectiveness while ensuring that the most suitable areas are utilized for wind energy development.

Wind potential on wastelands

The assessment of wind energy potential on wastelands in Chhattisgarh has been detailed for both 100m and 150m AGL. At a hub height of 100m AGL, 820 potential land parcels, covering a total area of 527.97 sq. km, are identified over the threshold wind speed of 5 m/s. At 150m AGL, this number increased to 2,996 potential land parcels, aggregating to 1,824.50 sq. km. These areas represent a wind energy potential of 5,584 MW at 100m AGL and 19,273.60 MW at 150m AGL.

The wind energy potential on wastelands in Chhattisgarh is substantial, with the majority of the potential concentrated in a few districts, particularly in the southern region of the state. For the 100m AGL height, the top seven districts—Narayanpur, Kondagaon, Balod, Bastar, Kanker, Bijapur, and Rajnandgaon—collectively account for over 70% of the estimated potential. Individually, Narayanpur contributes 16%, Balod 14%, Kondagaon 12%, and Bastar 10% of this potential. At 150m AGL, the potential is similarly concentrated, with Kondagaon, Gariaband, Narayanpur, and Kanker contributing 10%, 9%, 9%, and 8%, respectively. The top ten districts at this height collectively account for nearly 75% of the wind energy potential in the state.

Table 3.5: Wasteland area under threshold windspeed in Chhattisgarh

Wind speed (m/s)	Wasteland area at 100m AGL (sq. km)	No. of wasteland parcels at 100m	Wasteland area at 150m AGL (sq. km)	No. of wasteland parcels at 150m
5 to 6	507.7	797	1,607.15	2,724
6 to 7	20.27	23	215.79	268
7 to 8	0	0	1.56	4
Total	527.97	820	1,824.50	2,996

Source: iFOREST estimates

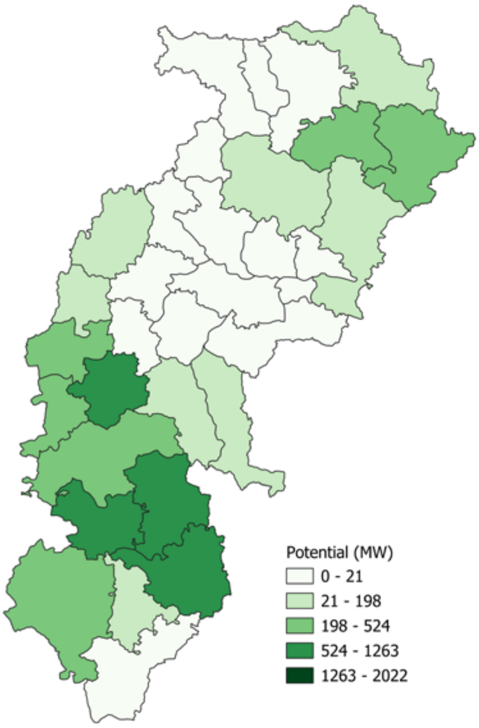
Table 3.6: District-wise wind energy potential at 100m and 150m AGL on wastelands

District	Potential at 150m (MW)	Potential at 100m (MW)
Balod	1,468.80	771.20
Baloda Bazar	198.40	3.20
Balrampur	307.20	108.80
Bastar	1,376.00	531.20
Bijapur	768.00	364.80
Bilaspur	0.00	0.00
Dantewada	195.20	64.00
Dhamtari	1,017.60	150.40
Durg	112.00	0.00
Gariaband	1,763.20	92.80
Gaurela-Pendra-Marwahi	185.60	6.40
Janjgair-Champa	44.80	0.00
Jashpur	502.40	227.20
Kabirdham	227.20	44.80
Kanker	1,584.00	457.60
Khairagarh-Chhuikhadan-Gandai	230.40	25.60
Kondagaon	2,022.40	662.40
Korba	320.00	54.40
Koriya	35.20	0.00
Mahasamund	886.40	16.00
Manendragarh-Chjmiri- Bharatpu	9.60	0.00
Mohla-Manpur	1,171.20	256.00
Mungeli	3.20	3.20
Narayanpur	1,737.60	908.80
Raigarh	262.40	86.40
Raipur	611.20	0.00
Rajnandgaon	1,324.80	416.00
Sarangarh-Bhilaigarh	6.40	0.00
Shakti	0.00	0.00
Sukma	25.60	3.20
Surajpur	19.20	0.00
Surguja	857.60	329.60
Total	19,273.60	5,584.00

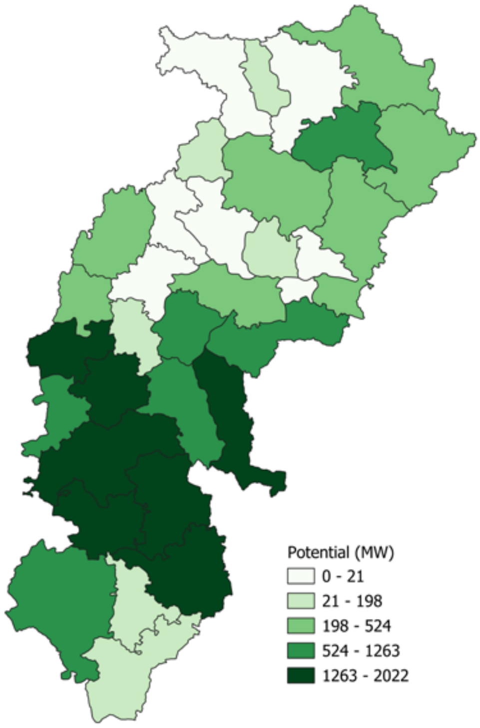
Source: iFOREST estimates

Map 3.2: Distribution of wind energy potential on wastelands in Chhattisgarh at 100 m and 150 m AGL

At 100m



At 150m



Source: iFOREST estimates

High-potential wasteland parcels

To systematically prioritize and rank wasteland parcels for wind energy installations, an analysis is conducted to identify the largest available parcels, including their area and estimated annual generation potential. At a hub height of 100m AGL, ten potential parcels are evaluated, with two notably large parcels having the capacity for wind projects of 147.2 MW each, respectively, with one exhibiting a CUF exceeding 22%. At a hub height of 150m AGL, ten parcels are similarly assessed, showing potential for wind power installations ranging from 76 MW to 157 MW, with CUF values between 14% and 26%.

Table 3.7: Top ten wasteland parcels for wind project development at 100m AGL

District	Area (sq. m)	CUF (%)	No. of turbine	Annual generation (GWh)	Potential (MW)
Bijapur	14,798,169	22.70	46	292.74	147.20
Bastar	15,018,504	16.03	46	206.64	147.20
Narayanpur	12,115,637	18.07	37	187.42	118.40
Surguja	7,291,655	17.03	23	109.77	73.60
Narayanpur	7,239,406	16.03	22	98.83	70.40
Kanker	6,504,721	19.16	20	107.41	64.00
Narayanpur	6,617,532	16.03	20	89.85	64.00
Bastar	5,037,826	19.16	16	85.93	51.20
Narayanpur	4,829,081	20.29	15	85.32	48.00
Jashpur	4,924,966	15.07	15	63.36	48.00

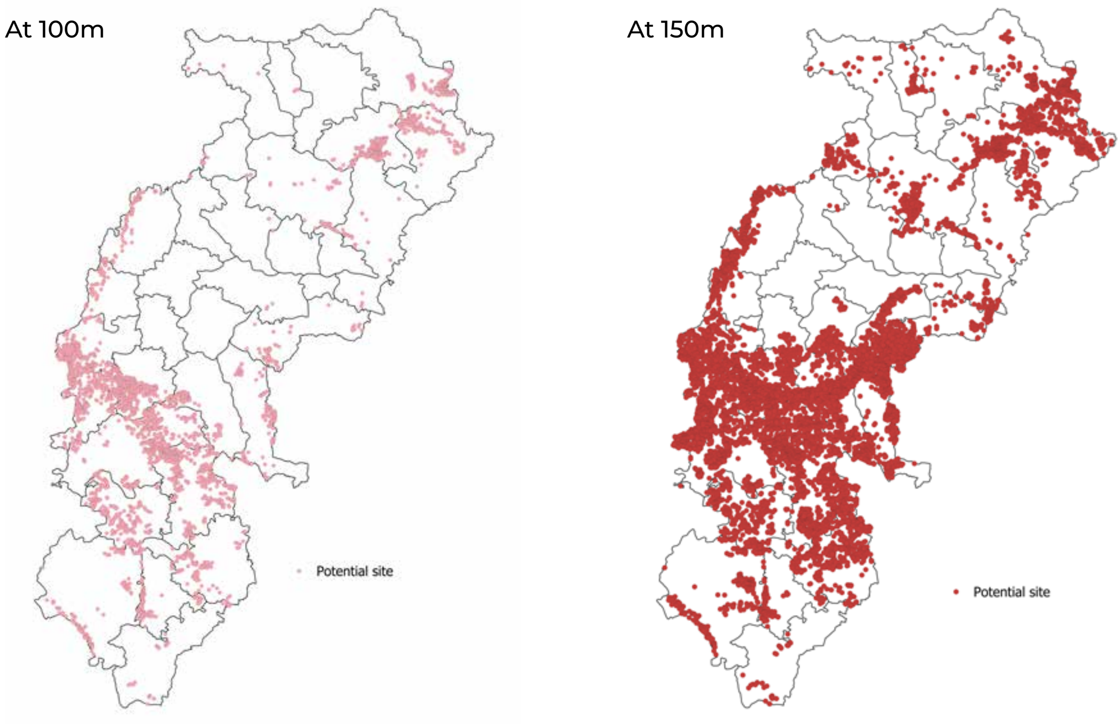
Source: iFOREST estimates

Table 3.8: Top ten wasteland parcels for wind project development at 150 m AGL

District	Area (sq. m)	CUF (%)	No. Of turbine	Annual generation (GWh)	Potential (MW)
Bastar	15,730,113	22.70	49	311.83	156.8
Narayanpur	15,051,488	20.29	47	267.35	150.4
Bijapur	14,806,551	26.46	46	341.19	147.2
Gariaband	14,081,193	15.07	44	185.84	140.8
Narayanpur	13,076,494	23.98	40	268.89	128
Kondagaon	12,165,393	17.03	38	181.36	121.6
Gariaband	10,923,441	17.03	34	162.27	108.8
Surguja	9,765,828	14.15	30	119.00	96
Narayanpur	8,002,397	22.70	25	159.10	80
Korba	7,811,454	13.27	24	89.31	76.8

Source: iFOREST estimates

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



Source: iFOREST assessment

3.3 Conclusion

Current official estimates place Chhattisgarh's wind power generation potential at 2,749 MW at a hub height of 150m AGL. However, satellite-based data analysis indicates a significantly higher potential, reaching several gigawatts at elevated hub heights. Even when focusing solely on wasteland areas, numerous land parcels emerge as viable candidates for utility-scale wind projects. This highlights the need for comprehensive ground-level assessments to evaluate the feasibility and bankability of these projects. Such evaluations are becoming increasingly critical as wind power gains prominence in India's energy portfolio, particularly as the nation progresses towards its net-zero targets and as the availability of optimal wind sites diminishes, shifting focus toward the development of sites with moderate wind potential.

4. Biomass

The potential for biomass energy primarily depends on the quantity of surplus crop residue and its calorific value. Assessing this energy potential involves key factors such as the amount of land under cultivation, the types of crops grown, and the seasonal variations in cultivation.

Chhattisgarh has 4.78 million hectares (ha) or 35% of its total land area under cultivation with rice, wheat, millets, pulses, and oilseeds as its main produces. Rice is the state's staple crop and is grown on over 70% of the gross cultivated area. This is followed by Wheat, which is grown as a rabi crop in about 20% of the cultivated area. Millets, pulses, and oilseeds also form major agricultural produce in the state.[20] At present around 1.47 million ha. area is the net irrigated area of the state, which is about 32% of the net sown area.[21]

The agriculture sector (at constant prices) grew by 7.8% in 2022-23, against 4.1% growth in 2021-22. In 2023-24, revenue expenditure on agriculture and allied activities is estimated to increase by 70% over the budgeted estimate.[22]

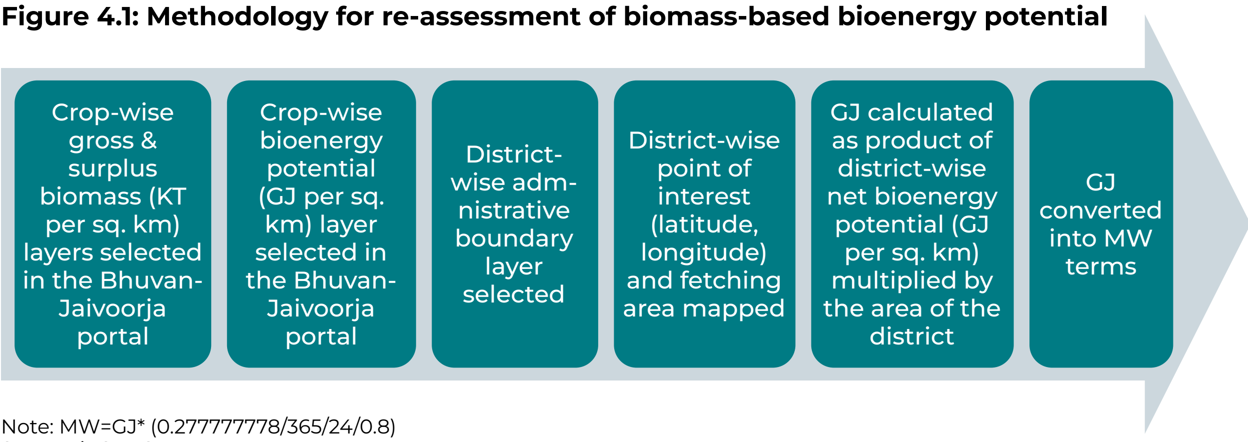
According to the Ministry of New and Renewable Energy (MNRE), the biomass power potential of Chhattisgarh is estimated to be 377 MW. So far, about 73% of this potential has been harnessed with 275 MW of biomass-based capacity installed in the state as of March 2024. This comprises 272.09 MW of bagasse-based cogeneration, 2.50 MW of non-bagasse-based cogeneration and 0.41 MW of waste-to-energy off-grid generation[23].

However, with the expanding food grain production in the state, the potential of biopower generation is constantly expanding and needs re-assessment based on updated datasets.

4.1 Re-assessment methodology

The re-assessment of biomass-based renewable energy (RE) generation potential is conducted using updated datasets on gross and surplus residue production sourced from the Bhuvan-Jaivoorja portal[24]. The portal, developed by the Technology Information Forecasting and Assessment Council (TIFAC), the Department of Science and Technology, and the National Remote Sensing Centre (NRSC) of the Indian Space Research Organisation (ISRO), generates geospatial maps detailing both surplus and gross residue potential for crops across all districts in India. To estimate this potential, crop masks for each district are created using multi-temporal satellite data. These masks are then converted into crop fractions with a resolution of 1 km, leveraging the Moderate Resolution Imaging Spectroradiometer (MODIS) gross primary production (GPP) dataset. Subsequently, the surplus biomass data was translated into biomass energy potential by applying the heating or calorific values specific to each type of crop residue.

Figure 4.1: Methodology for re-assessment of biomass-based bioenergy potential



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

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

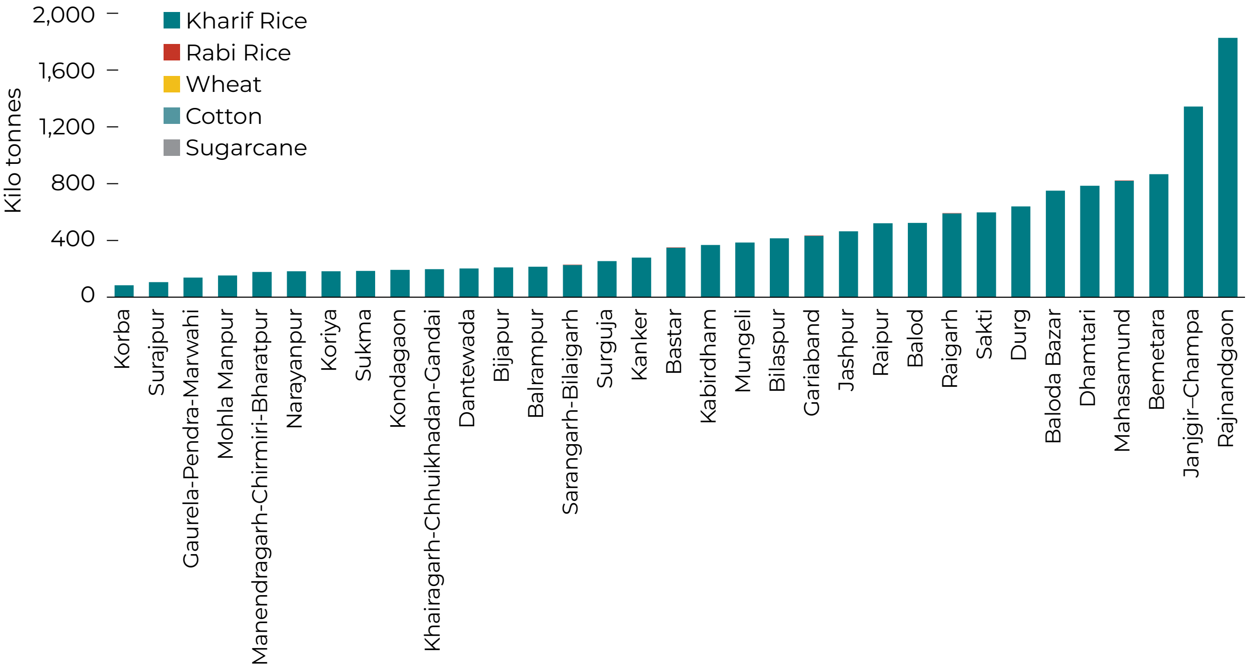
Crops	Yield (kg/ha)	Dryness factor (%)	Residue type	Heating value (MJ/kg)
Rice	2,730	0.86	Straw	15.54
			Husk	15.54
Wheat/Maize/Ragi	3,195	0.86	Straw	17.15
			Husk	17.39
Cotton	547	0.80	Stalk	17.40
			Husk	16.70
			Boll Shell	18.30
Sugarcane	72,268	0.83	Bagasse	20.00
			Top and leaves	20.00

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

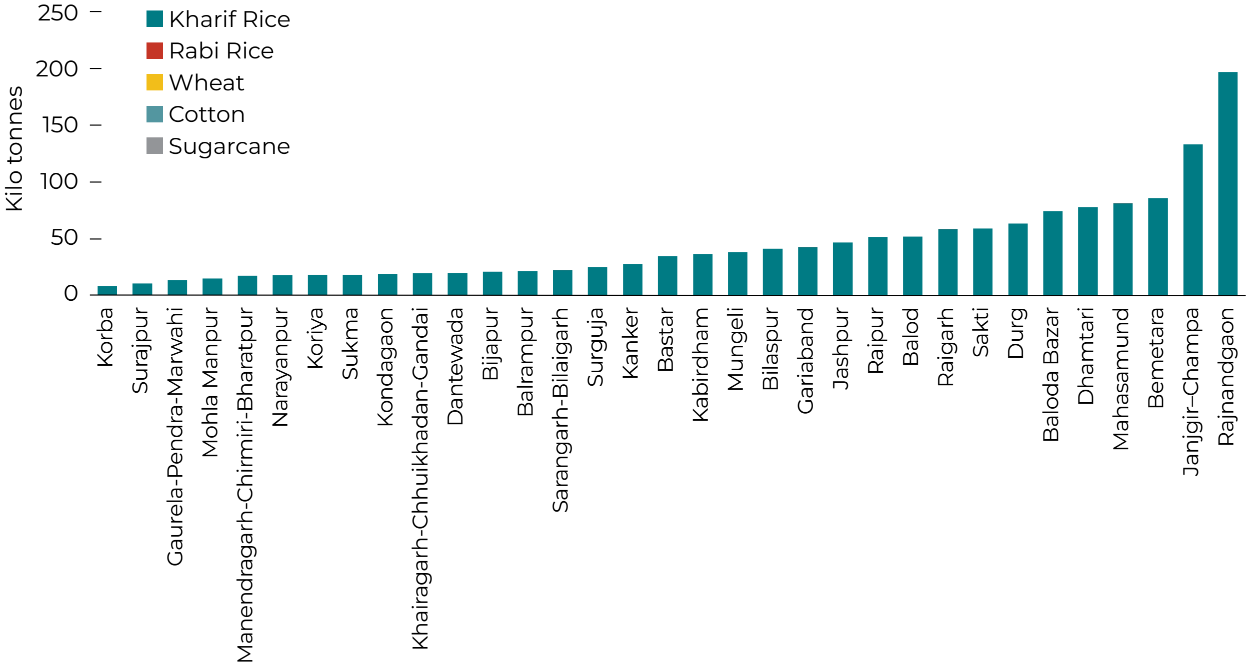
Using the Bhuvan-Jaivoorja portal, the gross and surplus biomass generation in Chhattisgarh is assessed to be 14,668.8 kilo tonnes (kt) and 1,469.3 kt, respectively. Notably, Kharif rice accounts for 99.9% of the total gross and surplus biomass generation, while Rabi rice contributes the remaining 0.1%. Among the districts, Rajnandgaon leads with 12.5% of the total gross biomass generation and 13.4% of surplus biomass generation. It is followed by Janjgir–Champa with 9.2% of the gross biomass and Bemetara with 6% of the gross biomass generation.

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

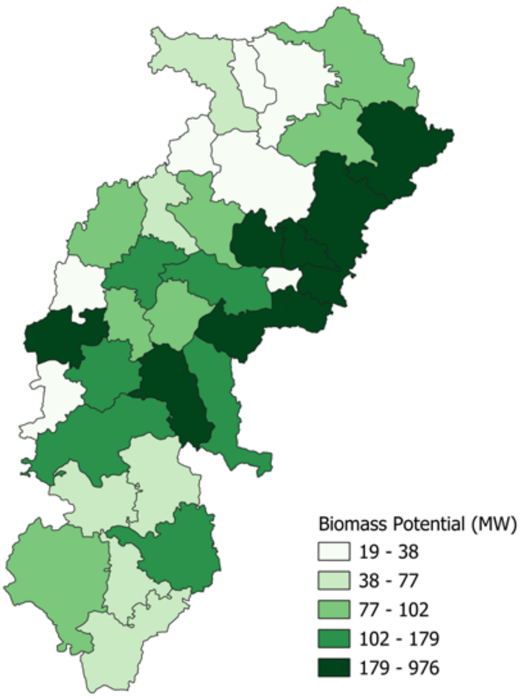


Source: iFOREST assessment

Using the conversion methodology described, the total surplus biomass generation in Chhattisgarh could support an estimated biomass energy capacity of approximately 4,272 MW. This re-estimated potential significantly surpasses MNRE's estimated potential of 377 MW and the current installed capacity of 275 MW.

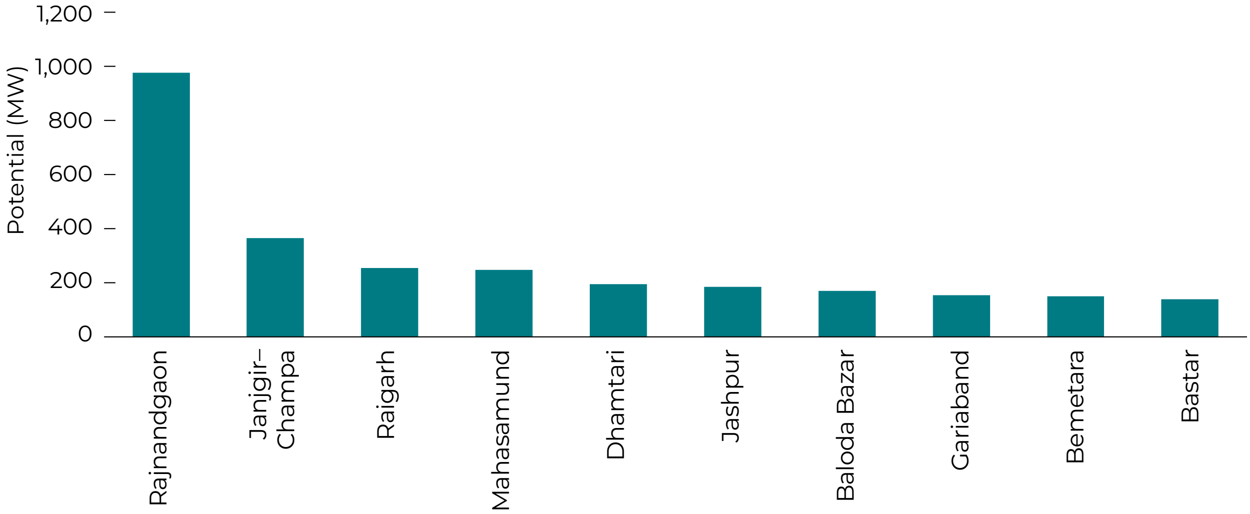
District-wise analysis reveals that over 60% of the biomass potential is concentrated in ten districts: Rajnandgaon, Janjgir–Champa, Bemetara, Mahasamund, Dhamtari, Baloda Bazar, Jashpur, Gariaband, Raigarh, and Bastar, which are predominantly situated in the central region of the state. Rajnandgaon accounts for the highest reassessed potential with 23% share, followed by Janjgir–Champa and Raigarh with shares of 9%, and 6%, respectively. (Refer to annexure A4 for the detailed district-wise biomass potential).

Map 4.1: Spread of biomass potential across state



Source: iFOREST estimates

Figure 4.4: Top ten districts with Biomass potential in Chhattisgarh



Source: iFOREST estimates

4.3 Conclusion

Chhattisgarh's biomass potential is re-evaluated using the latest district-wise crop residue surplus data from ISRO's JAIVOORJA portal, revealing a cumulative capacity of 4,272 MW. This revised estimate is over ten times the potential previously assessed by the MNRE and more than fifteen times the current installed capacity. Given the increasing demand for biopower, which includes both electricity generation and biofuel production, there is a pressing need to revisit and update the state's biomass potential. Additionally, this sector has significant benefits for rural livelihoods and local air pollution control. Moving forward, a detailed site-specific techno-economic analysis will be essential to translate this theoretical potential into practical, operational generation capacity, considering factors such as seasonality and spatial distribution.

Annexures

A1: Waterbody-wise floating solar potential in Chhattisgarh

Sl. No	Name of the dam	Longitude of dam	Latitude of dam	District	Year of completion	River basin	Height above lowest foundation (m)	Reservoir area (1,000 sq m)	Effective PV area for low scenario (1,000 sq m)	Effective PV area for mid scenario (1,000 sq m)	Effective PV area for high scenario (1,000 sq m)	PV potential low scenario (MWp)	PV potential mid scenario (MWp)	PV potential high scenario (MWp)
1	Maniyari	81°35'167"	22°25'15"	Mungeli	1930	Mahanadi	Maniyari	34.2	25,270.0	2,527.0	6,317.5	12,635.0	249.8	624.4
2	Kharang	82°13'12"	22°17'21"	Bilaspur	1931	Mahanadi	Kharang	21.3	38,074.0	3,807.4	9,518.5	19,037.0	376.3	940.8
3	Dhara	80°49'30"	21°17'00"	Rajnandgaon	1961	Mahanadi	Local	15.3	1,145.0	114.5	286.3	572.5	11.3	28.3
4	Kedar Nala Tank	82°54'00"	21°34'00"	Sarangarh-bhilaigarh	1971	Mahanadi	Kedar	20.1	2,015.0	201.5	503.8	1,007.5	19.9	49.8
5	Khadgawan Tank	82°22'23"	23° 05'02"	Manen-dragarh-chjmiri-Bharatpu	1971	Mahanadi	Local Nalla	15.0	87.0	8.7	21.8	43.5	0.9	2.2
6	Paralkot Paralkot	80°38'00"	20°08'00"	Kanker	1973	Godavari	Katri	25.2	11,370.0	1,137.0	2,842.5	5,685.0	112.4	281.0
7	Basantpur Tank	83°14'20"	23°53'05"	Balrampur	1975	Ganga	Local Nalla	15.0	74.0	7.4	18.5	37.0	0.7	1.8
8	Jhalpi Tank	83°34'15"	23°44'30"	Balrampur	1976	Ganga	Local Nalla	22.0	106.0	10.6	26.5	53.0	1.1	2.6
9	Sagasoti Tank	83°09'14"	23°37'08"	Surajpur	1975	Ganga	Local Nalla	1,267.0	203.0	20.3	50.8	101.5	2.0	5.0
10	Bilaspur Tank	83°16'00"	21°59'00"	Raigarh	1976	Mahanadi	Local	15.2	704.0	70.4	176.0	352.0	7.0	17.4
11	Gobari Tank	82°41'00"	23°39'45"	Surajpur	1976	Mahanadi	Local Nalla	16.2	1,025.0	102.5	256.3	512.5	10.1	25.3
12	Jagannath-pur T.	83°12'30"	23°22'30"	Surajpur	1976	Ganga	Local Nalla	16.1	690.0	69.0	172.5	345.0	6.8	17.1
13	Kunwarpur Tank	83°02'00"	22°58'05"	Surguja	1976	Ganga	Local Nalla	24.4	2,926.0	292.6	731.5	1,463.0	28.9	72.3
14	Pirha Tank	82°46'48"	22°49'12"	Surguja	1976	Ganga	Local Nalla	17.0	176.0	17.6	44.0	88.0	1.7	4.4
15	Torenga Tank	82°01'15"	20°17'20"	Dhamtari	1976	Mahanadi	Local Nalla	15.1	1,975.0	197.5	493.8	987.5	19.5	48.8
16	Agariya Tank	81°44'00"	22°18'00"	Mungeli	1977	Mahanadi	Local	16.9	455.0	45.5	113.8	227.5	4.5	11.2
17	Mayana	81°17'00"	20°25'00"	Kanker	1977	Mahanadi	Local	22.2	1,563.0	156.3	390.8	781.5	15.5	38.6
18	Camatpur Tank	81°45'00"	22°20'00"	Mungeli	1977	Mahanadi	Pass Local	16.9	453.0	45.3	113.3	226.5	4.5	11.2
19	Sikasar	82°19'00"	20°31'00"	Gariaband	1977	Mahanadi	Pairi river	31.7	2,52,400.0	25,240.0	63,100.0	1,26,200.0	2,494.8	6,237.0
20	R.S. Sagar	81°34'00	20°37'00"	Dhamtari	1979	Mahanadi	Mahanadi	30.5	95,400.0	1,908.0	4,770.0	4,770.0	188.6	471.5
21	Mankeshwari	81°27'30"	20°15'00"	Kanker	1980	Mahanadi	Local	15.2	275.0	27.5	68.8	137.5	2.7	6.8
22	Putta Tank	83°09'07"	22°55'01"	Surguja	1980	Ganga	Local Nalla	17.9	290.0	29.0	72.5	145.0	2.9	7.2
23	Tamdand Tank	82°25'30"	23°04'00"	Manen-dragarh-chjmiri-Bharatpu	1980	Mahanadi	Local Nalla	17.0	214.0	21.4	53.5	107.0	2.1	5.3
24	Jhumka Tank	82°31'38"	23°15'34"	Koriya	1984	Mahanadi	Local Nalla	29.8	3,505.0	350.5	876.3	1,752.5	34.6	86.6
25	Kodar Project Modak	82°10'40"	21°11'50"	Mahasamund	1981	Mahanadi	Kodar hom	23.3	13,880.0	1,388.0	3,470.0	6,940.0	137.2	343.0
26	Inawker Nawkerra Tank	83°59'20"	22°30'00"	Jashpur	1981	Mahanadi	Local	18.9	63.0	6.3	15.8	31.5	0.6	1.6

Annexure A1 continued

Sl. No	Name of the dam	Longitude of dam	Latitude of dam	District	Year of completion	River basin	Height above lowest foundation (m)	Reservoir area (1,000 sq m)	Effective PV area for low scenario (1,000 sq m)	Effective PV area for mid scenario (1,000 sq m)	Effective PV area for high scenario (1,000 sq m)	PV potential low scenario (MWp)	PV potential mid scenario (MWp)	PV potential high scenario (MWp)
27	Banjaridand Tank	82°26'00"	23°12'00"	Manen-dragarh-chjmiri-Bharatpu	1982	Mahanadi	Local Nalla	17.9	673.0	67.3	168.3	336.5	6.7	16.6
28	Gatatola Tank	80°49'10"	21°02'59"	Rajnandgaon	1982	Mahanadi	Local	15.0	58.0	5.8	14.5	29.0	0.6	1.4
29	Katangi Tank	83°14'30"	21°34'50"	Raigarh	1982	Mahanadi	Local	19.5	110.0	11.0	27.5	55.0	1.1	2.7
30	Kinkari Nala T.	83°17'58"	21°27'17"	Raigarh	1982	Mahanadi	Kinkari	17.7	3,578.0	357.8	894.5	1,789.0	35.4	88.4
31	Lohakhan Tank - 1 Comandan	83°10'20"	21°57'49"	Raigarh	1981	Mahanadi	Local	15.5	210.0	21.0	52.5	105.0	2.1	5.2
32	Inagoi Tank Basof Tank	83°03'10"	22°08'45"	Raigarh	1982	Mahanadi	Local	18.5	175.0	17.5	43.8	87.5	1.7	4.3
33	Ipachawal Tank	83°45'00"	23°35'00"	Balrampur	1982	Ganga	Local Nalla	19.0	97.0	9.7	24.3	48.5	1.0	2.4
34	Putka Nalla Tank	83°05'30"	21°32'48"	Raigarh	1982	Mahanadi	Putka	20.1	1,195.0	119.5	298.8	597.5	11.8	29.5
35	Huon MASARRA TANK	82°30'45"	23°17'35"	Koriya	1984	Mahanadi	Local Nalla	15.3	130.0	13.0	32.5	65.0	1.3	3.2
36	Sawla Tank	82°17'59"	23°25'48"	Manen-dragarh-chjmiri-Bharatpu	1984	Mahanadi	Local Nalla	15.3	410.0	41.0	102.5	205.0	4.1	10.1
37	Chanti Tank	81°42'30"	23°41'30"	Manen-dragarh-chjmiri-Bharatpu	1985	Mahanadi	Local Nalla	16.6	113.0	11.3	28.3	56.5	1.1	2.8
38	Ganeshpur Tank	82°15'00"	23°20'00"	Manen-dragarh-chjmiri-Bharatpu	1985	Mahanadi	Local Nalla	19.0	550.0	55.0	137.5	275.0	5.4	13.6
39	Paniyajob	81°00'35"	21°10'52"	Rajnandgaon	1985	Mahanadi	Local	19.5	137.0	13.7	34.3	68.5	1.4	3.4
40	Singhore Tank	82°27'30"	23°41'00"	Koriya	1985	Mahanadi	Local Nalla	15.1	240.0	24.0	60.0	120.0	2.4	5.9
41	Bhulsi Tank	83°45'30"	23°20'30"	Balrampur	1986	Ganga	Local Nalla	18.1	297.0	29.7	74.3	148.5	2.9	7.3
42	Chamat Tank	82°02'30"	23°25'45"	Manen-dragarh-chjmiri-Bharatpu	1986	Mahanadi	Local Nalla	18.6	182.0	18.2	45.5	91.0	1.8	4.5
43	Charpara Tank	82°37'02"	23°12'54"	Koriya	1986	Mahanadi	Local Nalla	19.2	656.0	65.6	164.0	328.0	6.5	16.2
44	Ghunghutta Tank A	83°12'00"	23°02'10"	Surguja	1986	Mahanadi	Local Nalla	20.4	1,070.0	107.0	267.5	535.0	10.6	26.4
45	Kusmaha Tank	82°30'30"	23°12'15"	Koriya	1986	Mahanadi	Local Nalla	15.3	427.0	42.7	106.8	213.5	4.2	10.6
46	Palgi Tank	83°21'46"	23°49'47"	Balrampur	1986	Ganga	Local Nalla	15.0	319.0	31.9	79.8	159.5	3.2	7.9
47	Rajoli Tank	82°26'54"	23°29'36"	Koriya	1986	Mahanadi	Local Nalla	18.8	193.0	19.3	48.3	96.5	1.9	4.8
48	Silphoda Tank	82°36'36"	23°16'21"	Koriya	1986	Mahanadi	Local Nalla	15.5	300.0	30.0	75.0	150.0	3.0	7.4
49	Sonhat Tank	82°30'00"	23°28'12"	Koriya	1986	Mahanadi	Local Nalla	15.6	125.0	12.5	31.3	62.5	1.2	3.1
50	Badesathi Tank	82°32'30"	23°29'00"	Koriya	1987	Mahanadi	Local Nalla	17.0	2,900.0	290.0	725.0	1,450.0	28.7	71.7

Annexure A1 continued

Sl. No	Name of the dam	Longitude of dam	Latitude of dam	District	Year of completion	River basin	Height above lowest foundation (m)	Reservoir area (1,000 sq m)	Effective PV area for low scenario (1,000 sq m)	Effective PV area for mid scenario (1,000 sq m)	Effective PV area for high scenario (1,000 sq m)	PV potential low scenario (MWp)	PV potential mid scenario (MWp)	PV potential high scenario (MWp)
51	Charcha Tank	82°33’21	23°20’04”	Koriya	1987	Mahanadi	Local Nalla	17.6	931.0	93.1	232.8	465.5	9.2	23.0
52	Chiniya Tank	83°36’20’’	23°50’30’’	Balrampur	1987	Ganpa	Local Nalla	15.2	141.0	14.1	35.3	70.5	1.4	3.5
53	Doura Tank	83°26’55”	23°30’45”	Balrampur	1987	Mahanadi	Local Nalla	25.1	227.0	22.7	56.8	113.5	2.2	5.6
54	Morga Tank Wors	80°40’00”	20°45’00”	Mohla-manpur	1987	Mahanadi	Local Nalla	21.0	274.0	27.4	68.5	137.0	2.7	6.8
55	Badra Tank Badra	82°28’00”	23°29’00”	Koriya	1988	Mahanadi	Local Nalla	20.6	125.0	12.5	31.3	62.5	1.2	3.1
56	Pathargawan	82°36’00”	23°26’00”	Koriya	1988	Mahanadi	Local Nalla	15.3	230.0	23.0	57.5	115.0	2.3	5.7
57	Tanjara Tank Tanjara 1	82°31’48”	23°27’00”	Koriya	1988	Mahanadi	Local Nalla	18.3	218.0	21.8	54.5	109.0	2.2	5.4
58	Tartora Tank	81°51’43”	23°40’48”	Manen-dragarh-chjmiri-Bharatpu	1988	Mahanadi	Local Nalla	16.1	360.0	36.0	90.0	180.0	3.6	8.9
59	Ajabnagar Tank	83°06’00”	23°09’00”	Surajpur	1989	Ganga	Local Nalla	16.7	1,018.0	101.8	254.5	509.0	10.1	25.2
60	Sondur Sondur	82°06’00”	20°14’00”	Dhamtari	1989	Mahanadi	Local	38.2	24,160.0	2,416.0	6,040.0	12,080.0	238.8	597.0
61	Styanagar Tank	82°48’36”	23°16’48”	Surajpur	1989	Ganga	Local Nella	15.0	195.0	19.5	48.8	97.5	1.9	4.8
62	Badauli Tank	83°14’00”	23°16’30”	Balrampur	1991	Ganga	Local Nalla	18.6	688.0	68.8	172.0	344.0	6.8	17.0
63	Ghoghra Tank	83°26’00”	23°30’00”	Balrampur	1991	Mahanadi	Local Nalla	21.0	336.0	33.6	84.0	168.0	3.3	8.3
64	Khamharpa-kut T.	83°26’00”	22°26’00”	Raigarh	1991	Mahanadi	Kharun	21.9	3,558.0	355.8	889.5	1,779.0	35.2	87.9
65	Kumharta Tank	83°59’30”	22°42’15”	Jashpur	1991	Mahanadi	Local	16.4	2,100.0	210.0	525.0	1,050.0	20.8	51.9
66	Tumdih	83°10’20”	22°55’25”	Surguja	1991	Mahanadi	Local	19.0	611.0	61.1	152.8	305.5	6.0	15.1
67	Uliya Tank	83°32’12”	23°24’39”	Balrampur	1991	Ganga	Local Nalla	24.6	350.0	35.0	87.5	175.0	3.5	8.7
68	Murwadand Tank	82°22’06”	22°49’00”	Korba	1992	Mahanadi	Local	15.9	124.0	12.4	31.0	62.0	1.2	3.1
69	Dandgaon Tank	82°52’30”	22°53’30”	Surguja	1994	Ganga	Local Nalla	17.1	716.0	71.6	179.0	358.0	7.1	17.7
70	Narkola Tank	83°08’00”	22°58’00”	Surguja	1994	Ganga	Local Nalla	17.8	465.0	46.5	116.3	232.5	4.6	11.5
71	Deokatta	80°46’12”	21°12’36”	Rajnandgaon	1996	Mahanadi	Local	18.4	559.0	55.9	139.8	279.5	5.5	13.8
72	Barkela Tank	82°20’10”	23°17’56”	Manen-dragarh-chjmiri-Bharatpu	1999	Mahanadi	Local Nalla	17.6	276.0	27.6	69.0	138.0	2.7	6.8
73	Pandridand Tank	82°49’12”	22°47’24”	Surguja	1999	Ganga	Local Nalla	16.2	221.0	22.1	55.3	110.5	2.2	5.5
74	Turga Tank	83°12’36”	22°59’24”	Surguja	1999	Ganga	Local Nalla	16.7	251.0	25.1	62.8	125.5	2.5	6.2
75	Chhota Palgi T.	82°34’00”	23°40’00”	Koriya	2000	Ganga	Local Nalla	17.0	64.0	6.4	16.0	32.0	0.6	1.6
76	Ghunghutta Tank	82°29’15”	23°29’00”	Koriya	2000	Ganga	Ghun-ghutta	31.5	12,657.0	1,265.7	3,164.3	6,328.5	125.1	312.8

Annexure A1 continued

Sl. No	Name of the dam	Longitude of dam	Latitude of dam	District	Year of completion	River basin	Height above lowest foundation (m)	Reservoir area (1,000 sq m)	Effective PV area for low scenario (1,000 sq m)	Effective PV area for mid scenario (1,000 sq m)	Effective PV area for high scenario (1,000 sq m)	PV potential low scenario (MWp)	PV potential mid scenario (MWp)	PV potential high scenario (MWp)
77	Batra Tank	82°59'00"	23°17'55"	Surajpur	2002	Ganga	Local Nalla	15.9	1,700.0	170.0	425.0	850.0	16.8	42.0
78	Gej Reservior	82°34'00"	23°18'00"	Koriya	2002	Mahanadi	Local Nalla	27.5	4,133.0	413.3	1,033.3	2,066.5	40.9	102.1
79	Malhaniya Tank	82°53'00"	22°43'00"	Korba	2002	Ganga	Malhaniya	21.8	1,836.0	183.6	459.0	918.0	18.2	45.4
80	Champi Tank	82°13'00"	22°23'00"	Korba	2003	Mahanadi	Champi	15.4	4,523.0	452.3	1,130.8	2,261.5	44.7	111.8
81	Ghongha Tank	81°58'00"	22°18'02"	Bilaspur	2003	Mahanadi	Ghonga	17.9	7,880.0	788.0	1,970.0	3,940.0	77.9	194.7
82	Bardar Tank	82°22'20"	23°04'30"	Manen-dragarh-chjmiri-Bharatpu	2004	Mahanadi	Local Nalla	18.3	903.0	90.3	225.8	451.5	8.9	22.3
83	Jagatpur Tank	82°25'12"	23°17'28"	Manen-dragarh-chjmiri-Bharatpu	2004	Mahanadi	Local Nalla	18.9	592.0	59.2	148.0	296.0	5.9	14.6
84	Kachhod Tank	82°09'24"	23°27'10"	Manen-dragarh-chjmiri-Bharatpu	1994	Mahanadi	Local Nalla	16.9	72.0	7.2	18.0	36.0	0.7	1.8
85	Kadna Tank	82°36'00"	23°45'00"	Surajpur	2004	Mahanadi	Local Nalla	21.6	230.0	23.0	57.5	115.0	2.3	5.7
86	Lai Tank	82°20'10"	23°17'35"	Manen-dragarh-chjmiri-Bharatpu	2004	Mahanadi	Local Nalla	16.5	126.0	12.6	31.5	63.0	1.3	3.1
87	Saliyadih Tank	83°23'24"	23°12'00"	Surguja	2004	Ganga	Local Nalla	15.9	159.0	15.9	39.8	79.5	1.6	3.9
88	Ayabhandha	80°50'45"	20°51'30"	Rajnandgaon	2005	Mahanadi	Local	16.2	436.0	43.6	109.0	218.0	4.3	10.8
89	Chandra Nagar T.	83°40'42"	23°38'05"	Balrampur	2005	Ganga	Local Nalla	20.9	593.0	59.3	148.3	296.5	5.9	14.7
90	Rajpuri Tank	82°27'42"	23°30'48"	Koriya	2005	Ganga	Local Nalla	15.6	378.0	37.8	94.5	189.0	3.7	9.3
91	Parasrampur T.	83°21'36"	23°08'59"	Surguja	2006	Ganga	Garasili	20.7	164.0	16.4	41.0	82.0	1.6	4.1
92	Gangpur Tank	81°51'09"	22°48'00"	Gaurela-pendra-marwahi	2007	Mahanadi	Khudan	16.4	566.0	56.6	141.5	283.0	5.6	14.0
93	Sardih Tank	83°19'00"	23°06'44"	Surguja	2007	Mahanadi	Local	19.0	435.0	43.5	108.8	217.5	4.3	10.8
94	Ghumarapa-dar T.	82°30'48"	19°54'01"	Gariaband	2012	Mahanadi	Local Nalla	20.8	1,197.0	119.7	299.3	598.5	11.8	29.6
95	Kosarteda	81°52'30"	19°27'00"	Bastar	2013	Godavari	Kosarteda	25.6	15,870.0	1,587.0	3,967.5	7,935.0	156.9	392.2
Total												**4,792.0**	**11,980.1**	**23,488.7**

Source: iFOREST assessment

A2: Site-wise details of wind energy potential in Chhattisgarh at 100m AGL for wind speed greater than 6 m/s.

S. No.	District	Wind speed (m/s)	Area (sq. m)	Potential (MW)	Annual generation (MWh)	CUF (%)
1	Kondagaon	6	4190166	41.6	87.39	23.98
2	Kondagaon	6.1	3379005	32	70.64	25.2
3	Dantewada	6.7	1529281	16	46.8	33.39
4	Kanker	6.4	1166582	12.8	32.63	29.1
5	Kondagaon	6.1	1156345	12.8	28.26	25.2
6	Bastar	6	1282186	12.8	26.89	23.98
7	Bastar	6.1	1009939	9.6	21.19	25.2
8	Kondagaon	6	887285	9.6	20.17	23.98
9	Kanker	6.4	559418	6.4	16.32	29.1
10	Dantewada	6.2	661314	6.4	14.83	26.46
11	Kanker	6.2	612020	6.4	14.83	26.46
12	Kondagaon	6	625962	6.4	13.44	23.98
13	Dantewada	6.9	239521	3.2	10.22	36.47
14	Dantewada	6.7	307619	3.2	9.36	33.39
15	Kondagaon	6.5	457145	3.2	8.55	30.49
16	Kondagaon	6.4	203783	3.2	8.16	29.1
17	Dantewada	6.3	320979	3.2	7.78	27.76
18	Dantewada	6.3	303661	3.2	7.78	27.76
19	Kanker	6.3	301288	3.2	7.78	27.76
20	Gaurela-pendra-marwahi	6.3	215972	3.2	7.78	27.76
21	Kanker	6.1	292274	3.2	7.06	25.2
22	Narayanpur	6.1	278151	3.2	7.06	25.2
23	Kanker	6	299422	3.2	6.72	23.98

Source: iFOREST Assessment

A3: Top 15 site-wise details of wind energy potential in Chhattisgarh at 150 m AGL for wind speed greater than 6 m/s.

S. No.	District	Wind speed (m/s)	Area (sq. m)	Potential (MW)	Annual generation (MWh)	CUF (%)
1	DANTEWADA	7.2	239521	3.2	11.62	41.44
2	DANTEWADA	7	307618	3.2	10.67	38.08
3	KONDAGAON	7	457145	3.2	10.67	38.08
4	KANKER	7	559418	6.4	21.35	38.08
5	KANKER	6.9	1166582	12.8	40.89	36.47
6	DANTEWADA	6.9	1529281	16	51.12	36.47
7	KANKER	6.8	301288	3.2	9.79	34.91
8	KANKER	6.7	612022	6.4	18.72	33.39
9	KONDAGAON	6.7	203783	3.2	9.36	33.39
10	KANKER	6.6	292274	3.2	8.95	31.92
11	NARAYANPUR	6.6	3268448	32	89.47	31.92
12	NARAYANPUR	6.6	278151	3.2	8.95	31.92
13	DANTEWADA	6.6	320979	3.2	8.95	31.92
14	KANKER	6.6	299423	3.2	8.95	31.92
15	NARAYANPUR	6.5	333720	3.2	8.55	30.49

Source: iFOREST Assessment

A4: District-wise re-assessed biomass potential in Chhattisgarh

District	Surplus biomass over fetch area (kt)					Total	Bioenergy potential over fetch area (Giga Joule)					Total (GJ/ sq. km)	Po- tential (MW)
	Kharif rice	Rabi rice	Wheat	Cotton	Sugar- cane		Kharif rice	Rabi rice	Wheat	Cotton	Sugar- cane		
Korba	8.22	-	-	-	-	8.22	127.38	-	-	-	-	127.38	36.08
Surajpur	10.55	-	-	-	-	10.55	163.54	-	-	-	-	163.54	32.4
Gaurela-Pendra-Marwahi	13.6	-	-	-	-	13.6	210.74	-	-	-	-	210.74	19.27
Mohla Manpur	15.01	-	-	-	-	15.01	232.65	-	-	-	-	232.65	19.78
Manendragarh-Chirmiri-Bharatpur	17.5	-	0.01	-	-	17.51	271.29	-	0.1	-	-	271.39	45.46
Narayanpur	18.02	-	-	-	-	18.02	279.32	-	-	-	-	279.32	76.64
Koriya	18.07	-	0.01	-	-	18.08	280.16	-	0.13	-	-	280.29	26.42
Sukma	18.25	-	-	0.43	-	18.68	282.92	-	-	7.53	-	290.46	66.4
Kondagaon	19.07	-	-	-	-	19.07	295.51	-	-	-	-	295.51	70.87
Khairagarh-Chhuikhadan-Gandai	19.57	-	-	-	-	19.57	303.38	-	-	-	-	303.38	18.69
Dantewada	19.96	-	-	-	-	19.96	309.42	-	-	-	-	309.42	41.83
Bijapur	20.84	-	-	0.04	-	20.88	323.03	-	-	0.73	-	323.77	84.1
Balrampur	21.41	-	-	-	-	21.41	331.9	-	-	-	-	331.9	79.15
Sarangarh-Bilaigarh	22.34	0.34	-	-	-	22.68	346.27	5.21	-	-	-	351.48	22.96
Surguja	25.17	-	-	-	-	25.17	390.19	-	-	-	-	390.19	77.64
Kanker	27.66	-	-	-	-	27.66	428.79	-	-	-	-	428.79	109.33
Bastar	34.52	-	-	-	-	34.52	535.12	0.02	-	-	-	535.13	139.93
Kabirdham	36.47	-	0.01	-	-	36.48	565.25	-	0.09	-	-	565.34	99.65
Mungeli	38.17	-	-	-	-	38.17	591.66	-	-	-	-	591.66	64.5
Bilaspur	41.06	-	-	-	-	41.06	636.48	-	-	-	-	636.48	88.58
Gariaband	42.67	0.22	-	-	-	42.89	661.38	3.47	-	-	-	664.85	154.29
Jashpur	46.59	-	-	-	-	46.59	722.11	-	-	-	-	722.11	184.83
Raipur	51.67	-	-	-	-	51.67	800.92	-	-	-	-	800.92	92.52
Balod	51.89	-	-	-	-	51.89	804.24	-	-	-	-	804.24	112.43
Raigarh	58.37	0.16	-	-	-	58.53	904.75	2.52	-	-	-	907.27	254.82
Sakti	59.06	-	-	-	-	59.06	915.36	-	-	-	-	915.36	58.08
Durg	63.31	-	-	-	-	63.31	981.37	-	-	-	-	981.37	90.24
Baloda Bazar	74.41	-	-	-	-	74.41	1,153.29	-	-	-	-	1,153.29	170.69
Dhamtari	77.78	-	-	-	-	77.78	1,205.62	-	-	-	-	1,205.62	195.07
Mahasamund	81.04	0.14	-	-	-	81.18	1,256.14	2.21	-	-	-	1,258.36	247.54
Bemetara	85.9	-	-	-	-	85.9	1,331.49	-	-	-	-	1,331.49	150.67
Janjgir–Champa	133.05	-	-	-	-	133.05	2,062.26	-	-	-	-	2,062.26	365.12
Rajnandgaon	196.76	-	0.01	-	-	196.77	3,049.78	-	0.22	-	-	3,050.00	975.61
Total	1,467.96	0.86	0.04	0.47	0	1,469.33	22,753.71	13.43	0.54	8.26	0	22,775.96	4,271.59

Source: iFOREST Assessment

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