Ascension Centre for Research and Analytics
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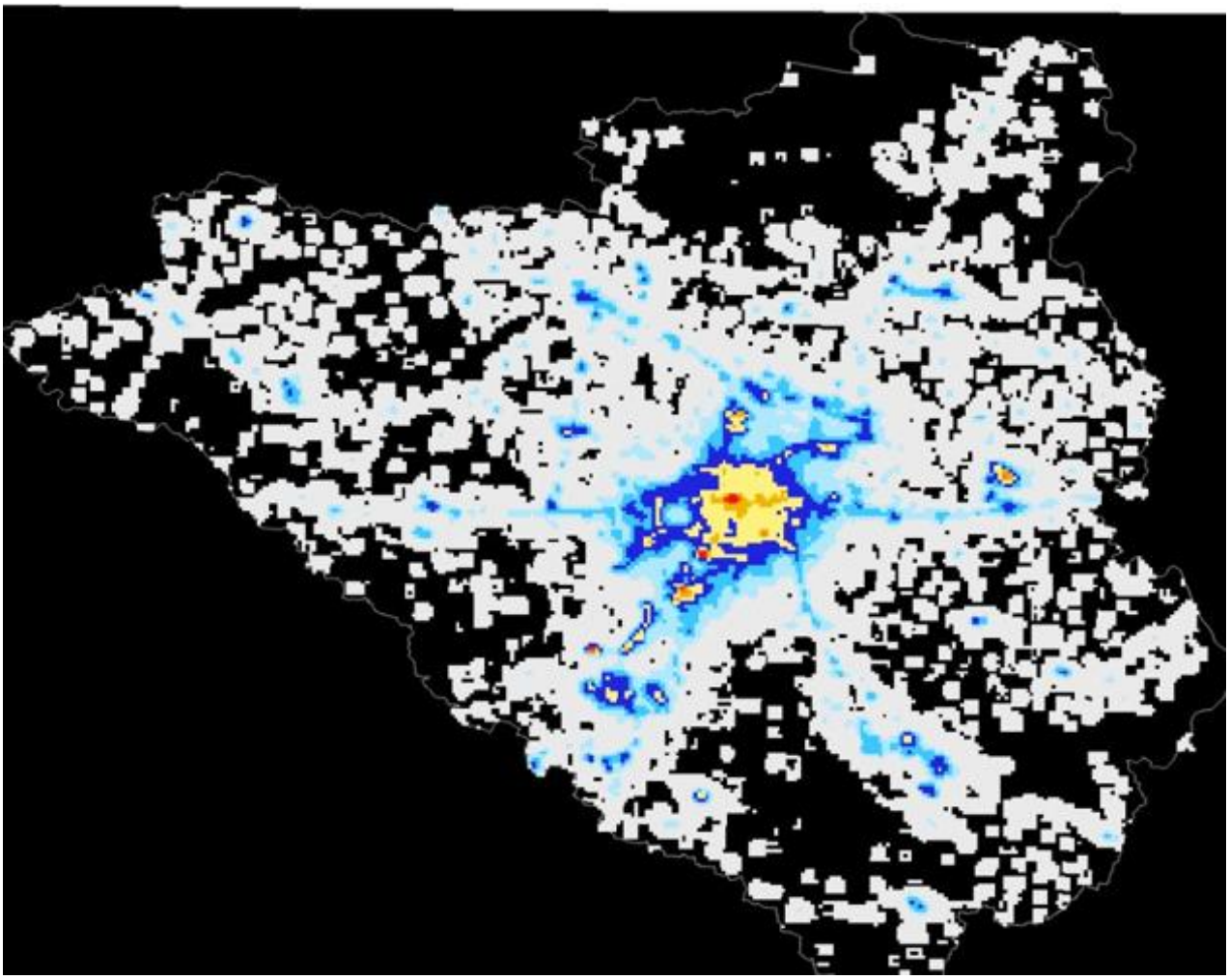
EXPLORING CHANGES IN NIGHTTIME LIGHTS IN ODISHA DURING 2018 to 2023



By Swarnim Kumar Gautam

June 2024

Ascension Centre for Research and Analytics (ACRA)

EXPLORING CHANGES IN NIGHTTIME LIGHTS IN ODISHA DURING YEARS 2018-2023

By Swarnim Kumar Gautam[1]

For sustainable future, monitoring and analyzing human activities on Earth is a very crucial factor to be done periodically. Night Time Lights (NTL) acquired by satellites is now-a-days becoming one of the indicators to analyze wide-range of human activities correlating the NTL with Land Use Land Cover (LULC), Socio-Economic parameters such as GDP, poverty, population, electricality consumption, and the similar ones.

This article focuses on measuring changes in nighttime light radiance at the district level in Orissa, a state of Eastern India. The data was obtained using satellite imageries from the Visible Infrared Imaging Radiometer Suite (VIIRS). This analysis is particularly valuable for understanding economic activities, urbanization, and infrastructural development.

The primary objectives of this study are:

1. To quantify the changes in nighttime light radiance (nW/cm²/sr) at the district level in Orissa between 2018 and 2023
2. Mapping the spatial distribution of nighttime light intensity, and
3. To identify areas of significant changes.

Data for this study comes from the Visible Infrared Imaging Radiometer Suite (VIIRS), specifically the annual VNL V2 average-masked dataset, which has a resolution of 15 arc seconds, approximately 500 meters at the Equator. The dataset for the years 2018 and 2023 is used for this analysis.

The methodology involves several steps. Initially, the VIIRS data for 2018 and 2023 is acquired and pre-processed to mask non-light sources such as fires and aurora. The data is then converted into a common coordinate system suitable for the study area and clipped to the boundary of Orissa. Using spatial analysis techniques, the radiance values range corresponding to areas are aggregated at the district level. The percentage change radiance is determined by subtracting the 2018 values from the 2023 values and normalizing these values to account for variations in data collection and processing methods.

Geographic Information System (GIS) tools are utilized to map the nighttime light radiance for 2018 and 2023, and districts with significant increases or decreases in radiance are identified.

The expected outcomes of this study include a comprehensive map (Figure: 3 – Figure 62) showing changes in nighttime light radiance at the district level, detailed statistics on the increase

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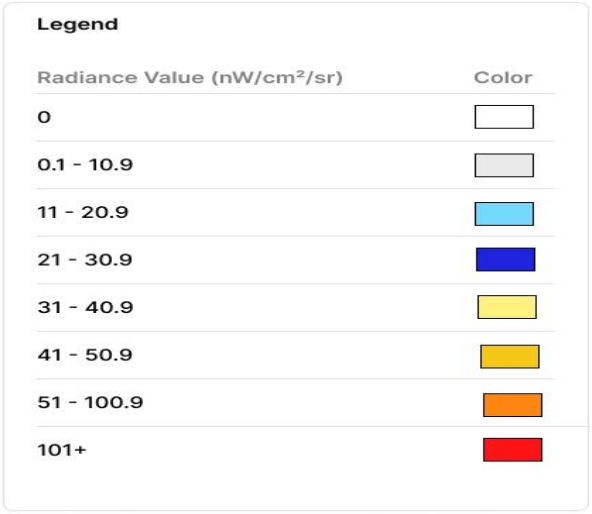
or decrease in radiance values, and insights into the relationship between nighttime light changes and socio-economic factors. These findings have significant implications for regional planning and development policies, offering a valuable tool for monitoring urbanization, infrastructure development, and disaster impact assessment.

Fig 1: India

Fig 2: Odisha

The annual average radiance values are divided into 8 categories with a unique color representing each range. This colour codes have been used in the maps presented in this paper in the later section.

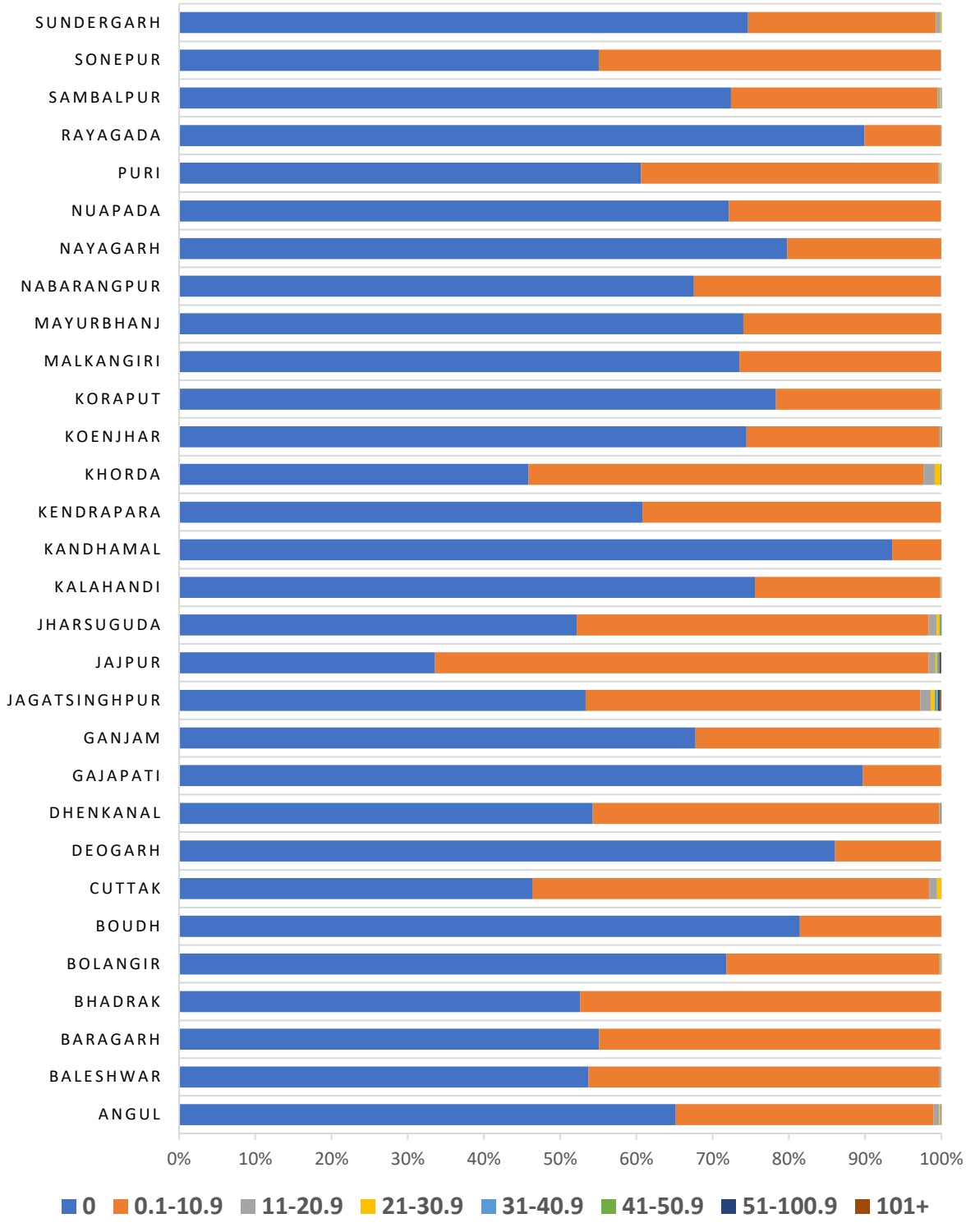


The statistical outcomes of area wise radiance range are shown in Table 1, Table 2 and Table 3 with Chart 1, Chart 2 and Chart 3.

Table 1: Odisha's Night Time Lights - 2018

osr	2018 DATA		AREA(km²)								Percentage of Area							
S NO	DISTRICT	Total Area	0	0.1-10.9	11-20.9	21-30.9	31-40.9	41-50.9	51-100.9	101+	0	0.1-10.9	11-20.9	21-30.9	31-40.9	41-50.9	51-100.9	101+
1	ANGUL	6376.69	4154.76	2157.59	45.94	9.89	4.56	1.67	2.13	0.15	65.16%	33.84%	0.72%	0.16%	0.07%	0.03%	0.03%	0.00%
2	BALESHWAR	3702.45	1989.07	1701.67	10.50	1.06	0.15	0.00	0.00	0.00	53.72%	45.96%	0.28%	0.03%	0.00%	0.00%	0.00%	0.00%
3	BARAGARH	5809.89	3200.04	2598.90	8.82	2.13	0.00	0.00	0.00	0.00	55.08%	44.73%	0.15%	0.04%	0.00%	0.00%	0.00%	0.00%
4	BHADRAK	2451.07	1289.75	1158.28	2.89	0.15	0.00	0.00	0.00	0.00	52.62%	47.26%	0.12%	0.01%	0.00%	0.00%	0.00%	0.00%
5	BOLANGIR	6580.35	4726.08	1838.91	9.58	4.56	1.06	0.15	0.00	0.00	71.82%	27.95%	0.15%	0.07%	0.02%	0.00%	0.00%	0.00%
6	BOUDH	3129.91	2548.94	580.66	0.30	0.00	0.00	0.00	0.00	0.00	81.44%	18.55%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
7	CUTTAK	3943.16	1826.79	2054.14	40.47	21.30	0.46	0.00	0.00	0.00	46.33%	52.09%	1.03%	0.54%	0.01%	0.00%	0.00%	0.00%
8	DEOGARH	2815.47	2422.84	391.72	0.91	0.00	0.00	0.00	0.00	0.00	86.05%	13.91%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
9	DHENKANAL	4502.32	2443.15	2046.54	8.06	1.37	0.91	0.15	1.22	0.91	54.26%	45.46%	0.18%	0.03%	0.02%	0.00%	0.03%	0.02%
10	GAJAPATI	4075.85	3656.44	418.65	0.76	0.00	0.00	0.00	0.00	0.00	89.71%	10.27%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
11	GANJAM	8386.37	5682.50	2683.49	13.39	5.93	1.06	0.00	0.00	0.00	67.76%	32.00%	0.16%	0.07%	0.01%	0.00%	0.00%	0.00%
12	JAGATSINGHPUR	1669.91	890.57	732.94	22.97	8.98	4.56	2.13	4.72	3.04	53.33%	43.89%	1.38%	0.54%	0.27%	0.13%	0.28%	0.18%
13	JAJPUR	2901.94	974.21	1879.35	26.01	6.69	6.39	2.43	4.11	2.74	33.57%	64.76%	0.90%	0.23%	0.22%	0.08%	0.14%	0.09%
14	JHARSUGUDA	2123.39	1107.50	980.45	23.12	8.06	2.28	1.52	0.46	0.00	52.16%	46.17%	1.09%	0.38%	0.11%	0.07%	0.02%	0.00%
15	KALAHANDI	7918.98	5983.19	1925.60	6.85	2.74	0.30	0.30	0.00	0.00	75.56%	24.32%	0.09%	0.03%	0.00%	0.00%	0.00%	0.00%
16	KANDHAMAL	8078.98	7556.43	521.79	0.76	0.00	0.00	0.00	0.00	0.00	93.53%	6.46%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
17	KENDRAPARA	2480.75	1508.22	971.47	1.06	0.00	0.00	0.00	0.00	0.00	60.80%	39.16%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
18	KHORDA	2755.87	1263.21	1428.00	40.31	21.60	2.43	0.30	0.00	0.00	45.84%	51.82%	1.46%	0.78%	0.09%	0.01%	0.00%	0.00%
19	KOENJHAR	8320.93	6194.98	2101.00	19.17	4.11	1.06	0.15	0.30	0.15	74.45%	25.25%	0.23%	0.05%	0.01%	0.00%	0.00%	0.00%
20	KORAPUT	8582.66	6719.13	1846.49	11.71	3.96	0.61	0.00	0.76	0.00	78.29%	21.51%	0.14%	0.05%	0.01%	0.00%	0.01%	0.00%
21	MALKANGIRI	3582.16	2633.66	948.50	0.00	0.00	0.00	0.00	0.00	0.00	73.52%	26.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
22	MAYURBHANJ	10523.88	7789.73	2731.71	2.43	0.00	0.00	0.00	0.00	0.00	74.02%	25.96%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
23	NABARANGPUR	5306.57	3583.75	1721.14	1.67	0.00	0.00	0.00	0.00	0.00	67.53%	32.43%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
24	NAYAGARH	3900.56	3111.64	788.92	0.00	0.00	0.00	0.00	0.00	0.00	79.77%	20.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
25	NUAPADA	3870.33	2792.07	1076.89	1.37	0.00	0.00	0.00	0.00	0.00	72.14%	27.82%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
26	PURI	3501.14	2121.97	1366.39	6.85	3.35	2.43	0.15	0.00	0.00	60.61%	39.03%	0.20%	0.10%	0.07%	0.00%	0.00%	0.00%
27	RAYAGADA	7388.78	6643.22	738.26	5.93	0.76	0.61	0.00	0.00	0.00	89.91%	9.99%	0.08%	0.01%	0.01%	0.00%	0.00%	0.00%
28	SAMBALPUR	6757.98	4892.32	1832.80	22.06	7.61	1.98	0.91	0.30	0.00	72.39%	27.12%	0.33%	0.11%	0.03%	0.01%	0.00%	0.00%
29	SONEPUR	2364.82	1302.07	1060.77	1.98	0.00	0.00	0.00	0.00	0.00	55.06%	44.86%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%
30	SUNDERGARH	9731.75	7262.77	2399.62	48.98	12.32	3.80	2.28	1.98	0.00	74.63%	24.66%	0.50%	0.13%	0.04%	0.02%	0.02%	0.00%

FIG 3: DISTRIBUTION OF RADIANCE CATEGORIES 2018



1. **Analysis of 2018 data**
    1.1. **General Observations**:
    1.2. The majority of districts show a significant portion of radiance values in the 0 and 0.1-10.9 ranges, indicating low radiance levels in these areas.
    1.3. Some districts exhibit higher radiance values in the 11-20.9 and 21-30.9 ranges, indicating areas with moderate to high human activity and development.
2. **High Radiance Districts**:
    2.1. **Khorda**: This district shows a substantial portion of its area in the higher radiance categories (11-20.9, 21-30.9), suggesting significant urbanization and infrastructure.
    2.2. **Cuttack**: Similar to Khorda, Cuttack also displays higher radiance values in the 11-20.9 and 21-30.9 ranges.
    2.3. **Ganjam**: This district shows notable portions in the higher radiance categories, indicating moderate to high levels of development.
3. **Moderate Radiance Districts**:
    3.1. **Sambalpur**, **Puri**, **Nayagarh**, **Jharsuguda**, and **Balasore** show moderate levels of radiance in the 11-20.9 and 21-30.9 ranges, suggesting ongoing development and urbanization.
4. **Low Radiance Districts**:
    4.1. **Sundergarh**, **Rayagada**, **Nabarangpur**, **Malkangiri**, **Koraput**, **Nuapada**, and several others exhibit radiance primarily in the 0 and 0.1-10.9 ranges. This indicates low levels of nighttime activity, possibly due to rural settings or less development.

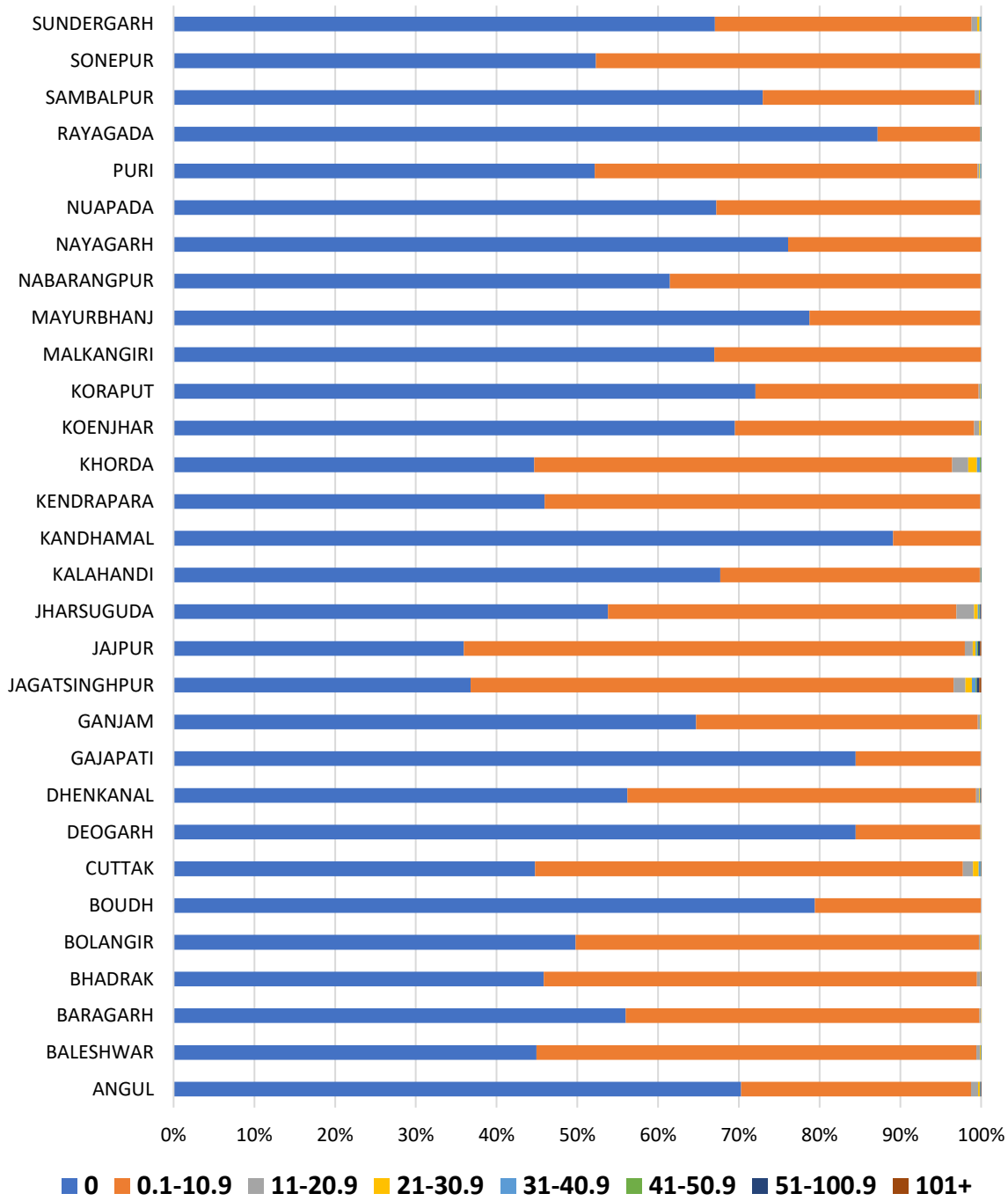
Implications

1. **Urbanization and Development**: Districts like Khorda and Cuttack with higher radiance values are likely to be more urbanized and developed, with significant infrastructure and economic activities.
2. **Rural Areas**: Districts with predominantly low radiance values may represent rural areas with less infrastructure and economic activity.
3. **Targeted Development**: The data can help in identifying districts that may benefit from targeted development initiatives to improve infrastructure and economic activities.

Table 2: Odisha's Night Time Lights- 2023

osr	2023 DATA		AREA(km²)								Percentage of Area							
S NO	DISTRICT	Total Area	0	0.1-10.9	11-20.9	21-30.9	31-40.9	41-50.9	51-100.9	101+	0	0.1-10.9	11-20.9	21-30.9	31-40.9	41-50.9	51-100.9	101+
1	ANGUL	6376.69	4480.61	1817.29	54.92	12.78	3.80	1.98	5.02	0.30	70.27%	28.50%	0.86%	0.20%	0.06%	0.03%	0.08%	0.00%
2	BALESHWAR	3702.45	1663.52	2017.33	17.04	3.96	0.30	0.15	0.15	0.00	44.93%	54.49%	0.46%	0.11%	0.01%	0.00%	0.00%	0.00%
3	BARAGARH	5809.89	3252.82	2546.27	9.28	1.52	0.00	0.00	0.00	0.00	55.99%	43.83%	0.16%	0.03%	0.00%	0.00%	0.00%	0.00%
4	BHADRAK	2451.07	1123.32	1315.42	10.19	0.91	0.15	0.30	0.30	0.46	45.83%	53.67%	0.42%	0.04%	0.01%	0.01%	0.01%	0.02%
5	BOLANGIR	6580.35	3275.29	3287.12	11.56	5.17	1.06	0.15	0.00	0.00	49.77%	49.95%	0.18%	0.08%	0.02%	0.00%	0.00%	0.00%
6	BOUDH	3129.91	2485.51	643.49	0.91	0.00	0.00	0.00	0.00	0.00	79.41%	20.56%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
7	CUTTAK	3943.16	1765.03	2089.44	48.83	27.69	9.28	1.52	1.22	0.15	44.76%	52.99%	1.24%	0.70%	0.24%	0.04%	0.03%	0.00%
8	DEOGARH	2815.47	2378.26	434.77	2.28	0.15	0.00	0.00	0.00	0.00	84.47%	15.44%	0.08%	0.01%	0.00%	0.00%	0.00%	0.00%
9	DHENKANAL	4502.32	2530.32	1944.16	16.73	4.56	1.98	0.76	1.98	1.83	56.20%	43.18%	0.37%	0.10%	0.04%	0.02%	0.04%	0.04%
10	GAJAPATI	4075.85	3442.70	630.86	2.28	0.00	0.00	0.00	0.00	0.00	84.47%	15.48%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%
11	GANJAM	8386.37	5425.11	2926.43	24.04	9.13	1.52	0.15	0.00	0.00	64.69%	34.90%	0.29%	0.11%	0.02%	0.00%	0.00%	0.00%
12	JAGATSINGHPUR	1669.91	614.46	998.40	24.80	13.08	7.45	2.59	5.48	3.65	36.80%	59.79%	1.48%	0.78%	0.45%	0.15%	0.33%	0.22%
13	JAJPUR	2901.94	1042.97	1800.40	28.75	9.58	4.87	4.41	7.45	3.50	35.94%	62.04%	0.99%	0.33%	0.17%	0.15%	0.26%	0.12%
14	JHARSUGUDA	2123.39	1142.03	916.71	46.40	9.43	3.80	2.13	2.13	0.76	53.78%	43.17%	2.19%	0.44%	0.18%	0.10%	0.10%	0.04%
15	KALAHANDI	7918.98	5361.15	2543.99	9.43	2.89	0.15	0.61	0.76	0.00	67.70%	32.13%	0.12%	0.04%	0.00%	0.01%	0.01%	0.00%
16	KANDHAMAL	8078.98	7198.94	876.39	3.65	0.00	0.00	0.00	0.00	0.00	89.11%	10.85%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%
17	KENDRAPARA	2480.75	1139.47	1339.31	1.98	0.00	0.00	0.00	0.00	0.00	45.93%	53.99%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%
18	KHORDA	2755.87	1230.81	1426.63	54.92	28.90	10.50	3.19	0.91	0.00	44.66%	51.77%	1.99%	1.05%	0.38%	0.12%	0.03%	0.00%
19	KOENJHAR	8320.93	5782.87	2465.49	53.09	14.00	3.96	1.37	0.15	0.00	69.50%	29.63%	0.64%	0.17%	0.05%	0.02%	0.00%	0.00%
20	KORAPUT	8582.66	6182.89	2374.82	17.95	5.32	1.06	0.46	0.15	0.00	72.04%	27.67%	0.21%	0.06%	0.01%	0.01%	0.00%	0.00%
21	MALKANGIRI	3582.16	2398.78	1182.16	1.22	0.00	0.00	0.00	0.00	0.00	66.96%	33.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
22	MAYURBHANJ	10523.88	8287.33	2228.02	8.52	0.00	0.00	0.00	0.00	0.00	78.75%	21.17%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%
23	NABARANGPUR	5306.57	3261.55	2041.21	3.80	0.00	0.00	0.00	0.00	0.00	61.46%	38.47%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
24	NAYAGARH	3900.56	2968.65	931.01	0.91	0.00	0.00	0.00	0.00	0.00	76.11%	23.87%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
25	NUAPADA	3870.33	2600.85	1265.83	3.65	0.00	0.00	0.00	0.00	0.00	67.20%	32.71%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%
26	PURI	3501.14	1825.94	1659.08	7.61	3.96	2.74	1.22	0.61	0.00	52.15%	47.39%	0.22%	0.11%	0.08%	0.03%	0.02%	0.00%
27	RAYAGADA	7388.78	6442.11	936.48	7.91	1.52	0.30	0.15	0.30	0.00	87.19%	12.67%	0.11%	0.02%	0.00%	0.00%	0.00%	0.00%
28	SAMBALPUR	6757.98	4930.35	1774.99	35.45	9.58	2.13	1.98	2.74	0.76	72.96%	26.27%	0.52%	0.14%	0.03%	0.03%	0.04%	0.01%
29	SONEPUR	2364.82	1236.50	1125.12	2.59	0.61	0.00	0.00	0.00	0.00	52.29%	47.58%	0.11%	0.03%	0.00%	0.00%	0.00%	0.00%
30	SUNDERGARH	9731.75	6522.53	3094.07	69.52	27.69	10.50	4.72	2.74	0.00	67.02%	31.79%	0.71%	0.28%	0.11%	0.05%	0.03%	0.00%

FIG 4: DISTRIBUTION OF RADIANCE CATEGORIES 2023



Analysis of 2023 Data

1. **General Observations**:
    1.1. Similar to 2018, the majority of districts still show a significant portion of radiance values in the 0 and 0.1-10.9 ranges.
    1.2. Compared to 2018, several districts exhibit an increase in higher radiance values (11-20.9 and above), indicating growth in human activity and development.
2. **High Radiance Districts**:
    2.1. **Khorda**: This district continues to show a substantial portion of its area in the higher radiance categories, even more prominently than in 2018, suggesting ongoing urbanization and infrastructure development.
    2.2. **Cuttack**: Maintains a significant portion of high radiance values, indicating sustained development.
    2.3. **Ganjam**: Also shows a notable portion in the higher radiance categories, similar to 2018, indicating continuous development.
3. **Districts Showing Increased Radiance**:
    3.1. **Sonepur**: Shows a noticeable increase in radiance values in the 11-20.9 and higher ranges compared to 2018.
    3.2. **Jharsuguda**: Displays an increase in the higher radiance values, indicating development activities.
    3.3. **Jagatsinghpur**: Shows more distribution in the higher radiance ranges than in 2018.
4. **Low Radiance Districts**:
    4.1. **Sundergarh**, **Rayagada**, **Nabarangpur**, **Malkangiri**, **Koraput**, and **Nuapada** still exhibit radiance primarily in the 0 and 0.1-10.9 ranges. These districts remain largely rural with less nighttime activity and development.

Implications

1. **Urbanization and Development**: The increase in higher radiance values in several districts points to ongoing urbanization and infrastructural development. This can be linked to increased economic activities and improvements in living standards.
2. **Policy and Planning**: The data can inform government and policymakers about areas that have seen significant development and those that have not, allowing for targeted interventions and resource allocation.
3. **Sustainability and Growth**: Understanding the distribution and changes in nighttime light radiance can help in planning for sustainable growth, ensuring that infrastructural development is balanced with environmental considerations.

Comparative Analysis: 2018 vs 2023

1. **General Trend**: There is an overall increase in the distribution of higher radiance values across several districts from 2018 to 2023, indicating a trend of increasing development and urbanization.
2. **Urban Centers**: Districts like Khorda and Cuttack continue to dominate in higher radiance values, reinforcing their status as key urban centers.

3. **Emerging Areas**: Districts such as Sonepur, Jharsuguda, and Jagatsinghpur show significant changes, suggesting emerging development activities.
4. **Persistent Rural Areas**: Some districts remain largely unchanged in their low radiance values, indicating persistent rural characteristics and possibly a lack of significant development.

Table 3: Change in % Area Between 2018 and 2023

		Change in Percentage of Area							
DISTRICT	Total Area	0	0.1-10.9	11-20.9	21-30.9	31-40.9	41-50.9	51-100.9	101+
ANGUL	6376.6949	5.11%	-5.34%	0.14%	0.05%	-0.01%	0.00%	0.05%	0.00%
BALESHWAR	3702.4538	-8.79%	8.53%	0.18%	0.08%	0.00%	0.00%	0.00%	0.00%
BARAGARH	5809.8924	0.91%	-0.91%	0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%
BHADRAK	2451.0694	-6.79%	6.41%	0.30%	0.03%	0.01%	0.01%	0.01%	0.02%
BOLANGIR	6580.3534	-22.05%	22.01%	0.03%	0.01%	0.00%	0.00%	0.00%	0.00%
BOUDH	3129.9103	-2.03%	2.01%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
CUTTAK	3943.1552	-1.57%	0.90%	0.21%	0.16%	0.22%	0.04%	0.03%	0.00%
DEOGARH	2815.4717	-1.58%	1.53%	0.05%	0.01%	0.00%	0.00%	0.00%	0.00%
DHENKANAL	4502.3174	1.94%	-2.27%	0.19%	0.07%	0.02%	0.01%	0.02%	0.02%
GAJAPATI	4075.8484	-5.24%	5.21%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
GANJAM	8386.3716	-3.07%	2.90%	0.13%	0.04%	0.01%	0.00%	0.00%	0.00%
JAGATSINGHPUR	1669.9074	-16.53%	15.90%	0.11%	0.25%	0.17%	0.03%	0.05%	0.04%
JAJPUR	2901.9406	2.37%	-2.72%	0.09%	0.10%	-0.05%	0.07%	0.12%	0.03%
JHARSUGUDA	2123.3891	1.63%	-3.00%	1.10%	0.06%	0.07%	0.03%	0.08%	0.04%
KALAHANDI	7918.9772	-7.86%	7.81%	0.03%	0.00%	0.00%	0.00%	0.01%	0.00%
KANDHAMAL	8078.9799	-4.42%	4.39%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
KENDRAPARA	2480.7535	-14.86%	14.83%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
KHORDA	2755.8653	-1.18%	-0.05%	0.53%	0.26%	0.29%	0.10%	0.03%	0.00%
KOENJHAR	8320.927	-4.95%	4.38%	0.41%	0.12%	0.03%	0.01%	0.00%	0.00%
KORAPUT	8582.6602	-6.25%	6.16%	0.07%	0.02%	0.01%	0.01%	-0.01%	0.00%
MALKANGIRI	3582.164194	-6.56%	6.52%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%
MAYURBHANJ	10523.8758	4.73%	-4.79%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%
NABARANGPUR	5306.5704	-6.07%	6.03%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
NAYAGARH	3900.5633	-3.67%	3.64%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
NUAPADA	3870.3284	-4.94%	4.88%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%
PURI	3501.1365	-8.46%	8.36%	0.02%	0.02%	0.01%	0.03%	0.02%	0.00%
RAYAGADA	7388.7801	-2.72%	2.68%	0.03%	0.01%	0.00%	0.00%	0.00%	0.00%
SAMBALPUR	6757.9844	0.56%	-0.86%	0.20%	0.03%	0.00%	0.02%	0.04%	0.01%
SONEPUR	2364.8159	-2.77%	2.72%	0.03%	0.03%	0.00%	0.00%	0.00%	0.00%
SUNDERGARH	9731.75429	-7.61%	7.14%	0.21%	0.16%	0.07%	0.03%	0.01%	0.00%

`

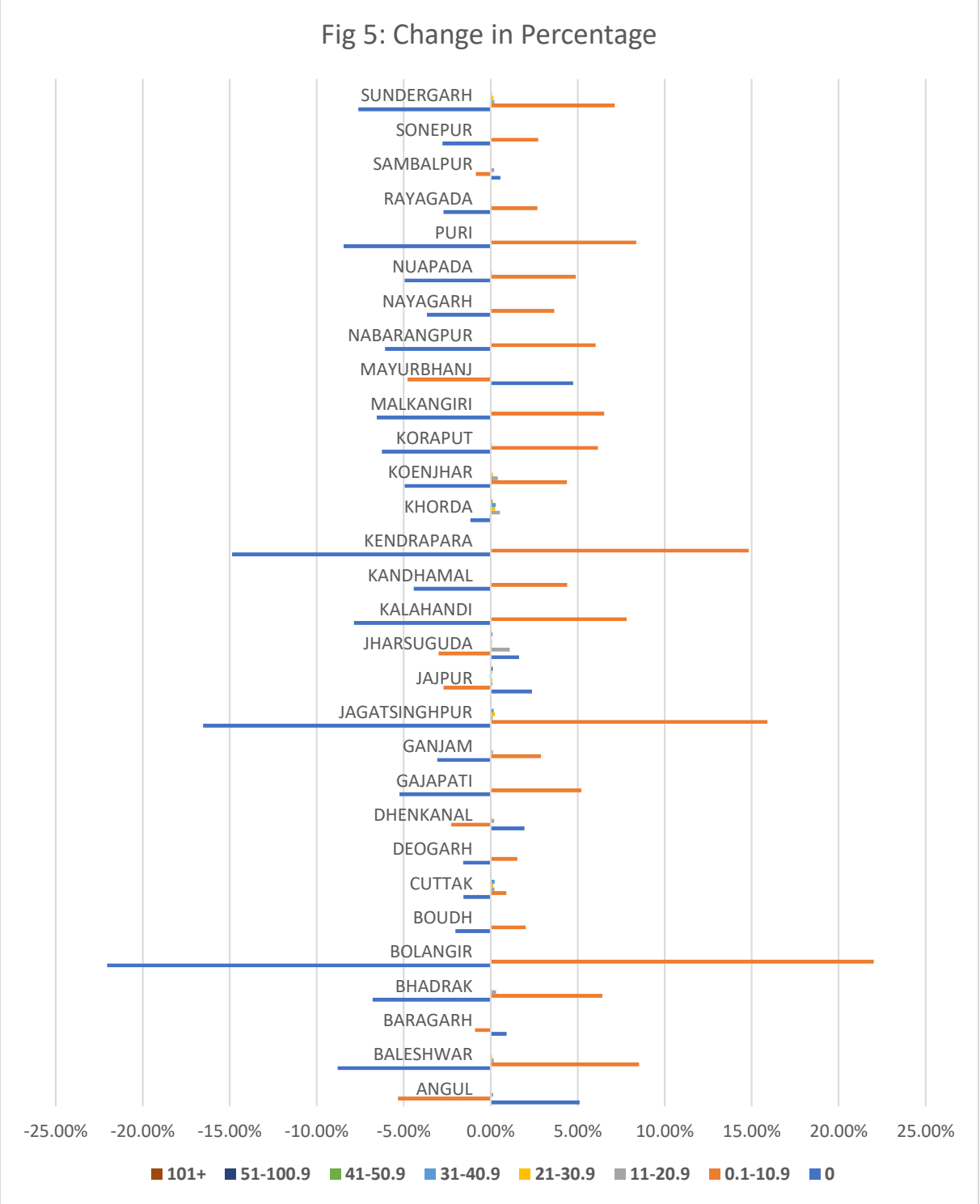


Fig 5: Change in Percentage
SUNDERGARH
SONEPUR
SAMBALPUR
RAYAGADA
PURI
NUAPADA
NAYAGARH
NABARANGPUR
MAYURBHANJ
MALKANGIRI
KORAPUT
KOENJHAR
KHORDA
KENDRAPARA
KANDHAMAL
KALAHANDI
JHARSUGUDA
JAJPUR
JAGATSINGHPUR
GANJAM
GAJAPATI
DHENKANAL
DEOGARH
CUTTAK
BOUDH
BOLANGIR
BHADRAK
BARAGARH
BALESHWAR
ANGUL
-25.00%
-20.00%
-15.00%
-10.00%
-5.00%
0.00%
5.00%
10.00%
15.00%
20.00%
25.00%
101+
51-100.9
41-50.9
31-40.9
21-30.9
11-20.9
0.1-10.9
0

Analysis of Percentage Change

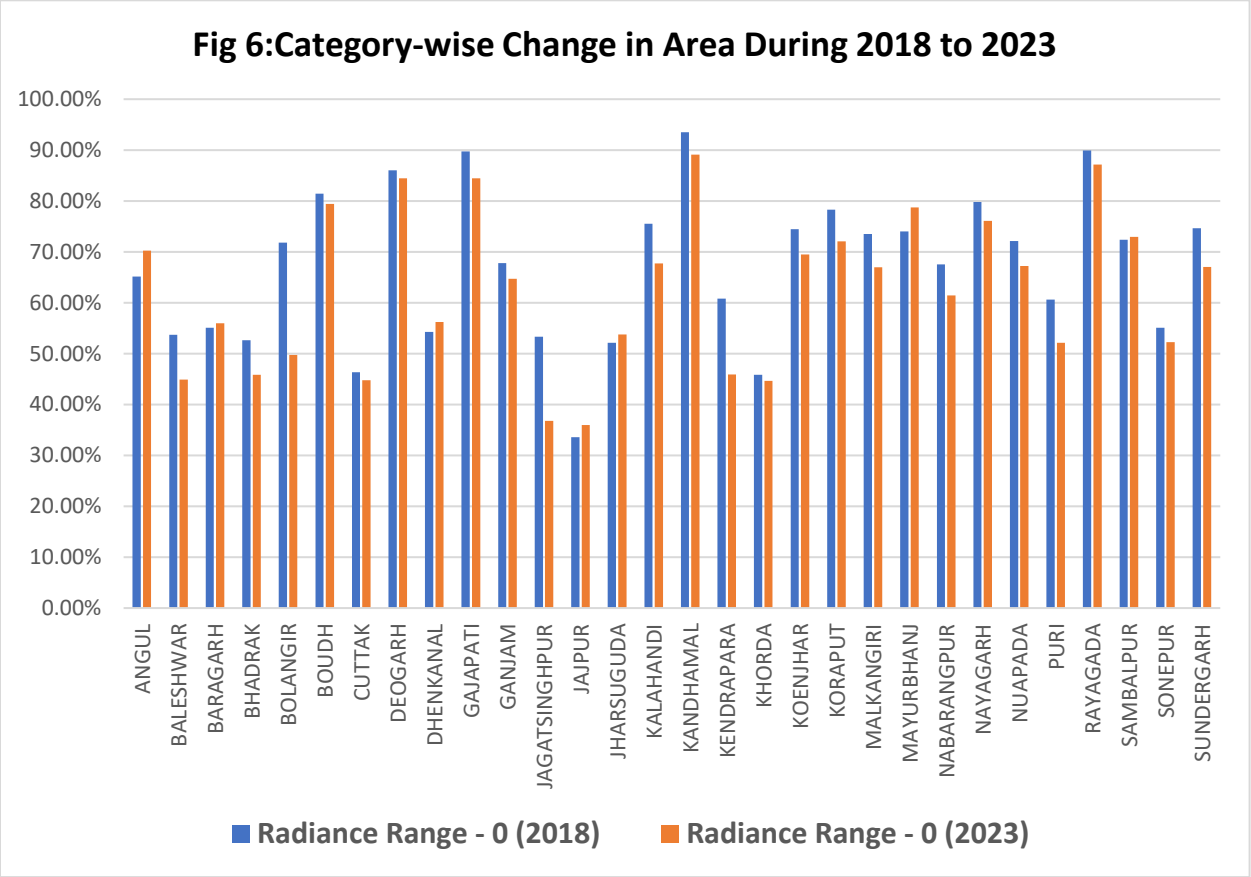
1. **Significant Increases**:
    1.1. **Sundergarh**: Shows a notable increase in the 11-20.9 range, suggesting development activities leading to higher radiance.
    1.2. **Puri**: Significant increase in the 11-20.9 range, indicating growth in human activity and infrastructure.
    1.3. **Nuapada**: Also exhibits a considerable increase in the 11-20.9 range.
    1.4. **Kendrapara**: Displays a significant rise in the 11-20.9 range.
    1.5. **Ganjam**: Shows an increase in the 11-20.9 range, similar to the trends observed in other districts.
2. **Decreases or Minimal Changes**:
    2.1. **Khorda**: A notable decrease in the 0.1-10.9 range, indicating a reduction in lower radiance values, possibly due to improved lighting infrastructure and urbanization.
    2.2. **Jagatsinghpur**: Shows a significant drop in the 0.1-10.9 range, suggesting changes in light distribution or increased efficiency.
    2.3. **Bhadrak**: Shows a notable reduction in the 11-20.9 range, indicating a shift in radiance levels.
    2.4. **Balasore**: A significant drop in the 0.1-10.9 range.
3. **Stable Districts**:
    3.1. **Sonepur**, **Sambalpur**, **Rayagada**, **Nayagarh**, **Mayurbhanj**, **Malkangiri**, **Koraput**, **Kandhamal**, **Kalahandi**, **Jharsuguda**, **Jajpur**, **Dhenkanal**, **Deogarh**, **Boudh**, **Bargarh**, and **Angul** show minimal changes across most radiance categories.
4. **Mixed Changes**:
    4.1. **Khorda** and **Cuttack** exhibit both increases and decreases across different ranges, reflecting complex development dynamics.

Implications

1. **Urbanization and Infrastructure Development**: Districts with significant increases in higher radiance values, such as Puri, Nuapada, and Kendrapara, suggest ongoing urbanization and infrastructure improvements.
2. **Economic Activities**: The increases in districts like Sundergarh and Ganjam highlight regions experiencing economic growth.
3. **Efficiency and Lighting Improvements**: Reductions in lower radiance ranges, particularly in Khorda and Jagatsinghpur, may indicate improvements in lighting infrastructure or more efficient use of nighttime lighting.

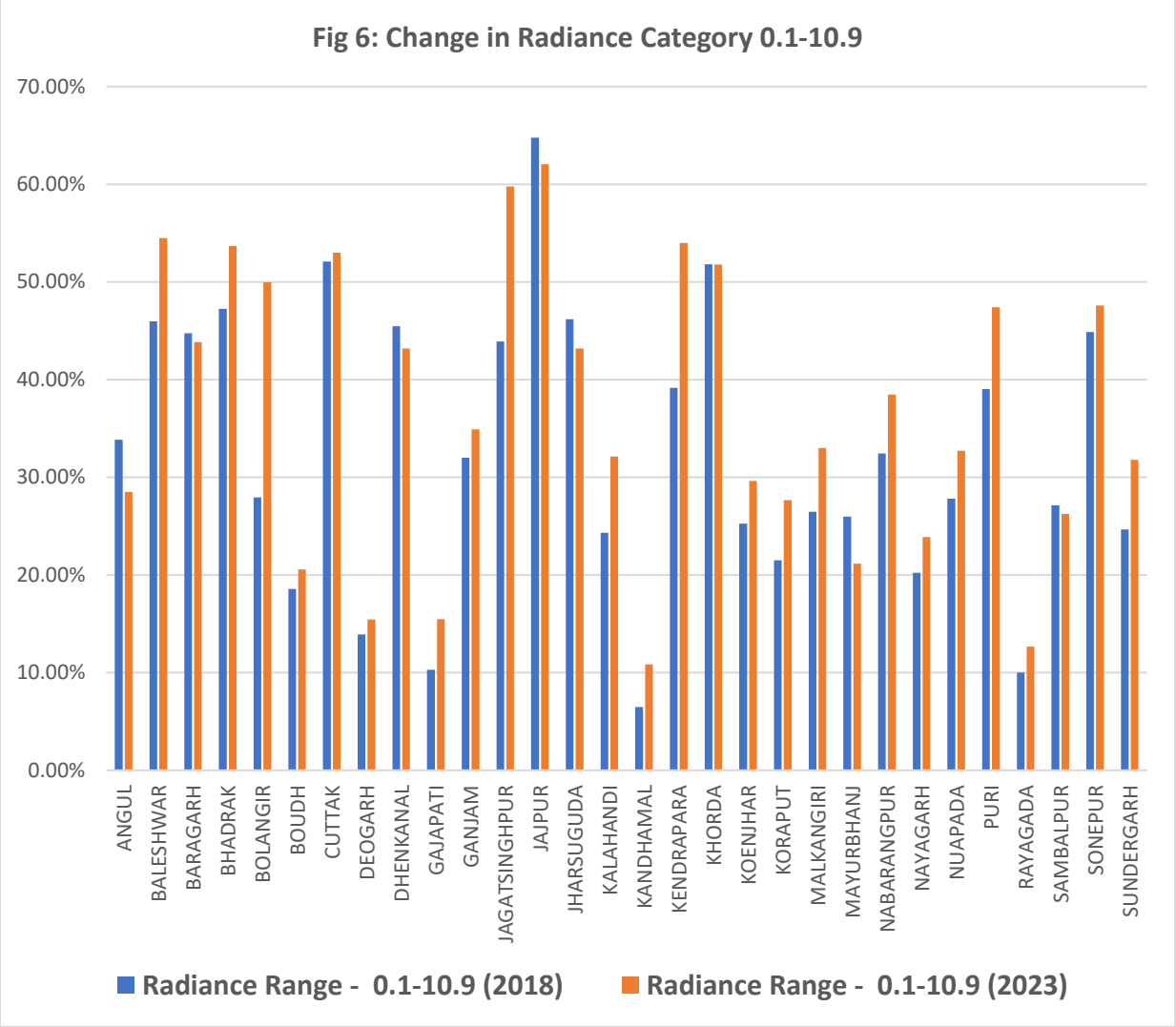
Radiance Category-wise Changes during 2018 to 2023

Radiance category - 0



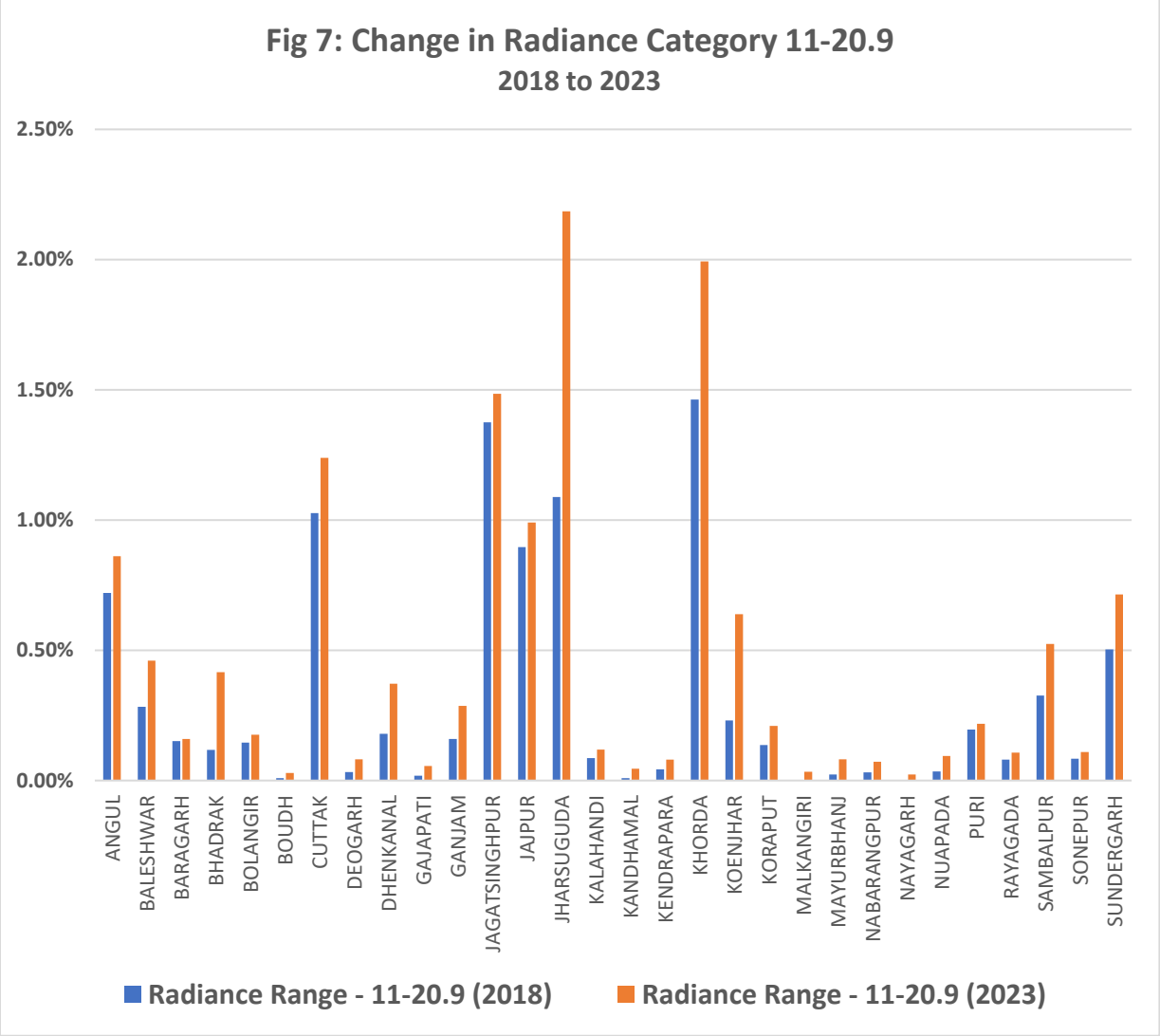
1. **Observation**: The proportion of areas with zero radiance has decreased in most districts, indicating a general increase in nighttime light due to development.
2. **Significant Changes**:
    - 2.1. **Kendrapara**: Shows the largest decrease in zero radiance, suggesting significant lighting and infrastructure developments.
    - 2.2. **Bolangir**: A notable decrease, indicating substantial improvements in basic infrastructure.
    - 2.3. **Khorda** and **Baleshwar**: Also show decreases, reflecting urbanization and infrastructural expansion.

Radiance Category: 0.1-10.9 (nW/cm²/sr)



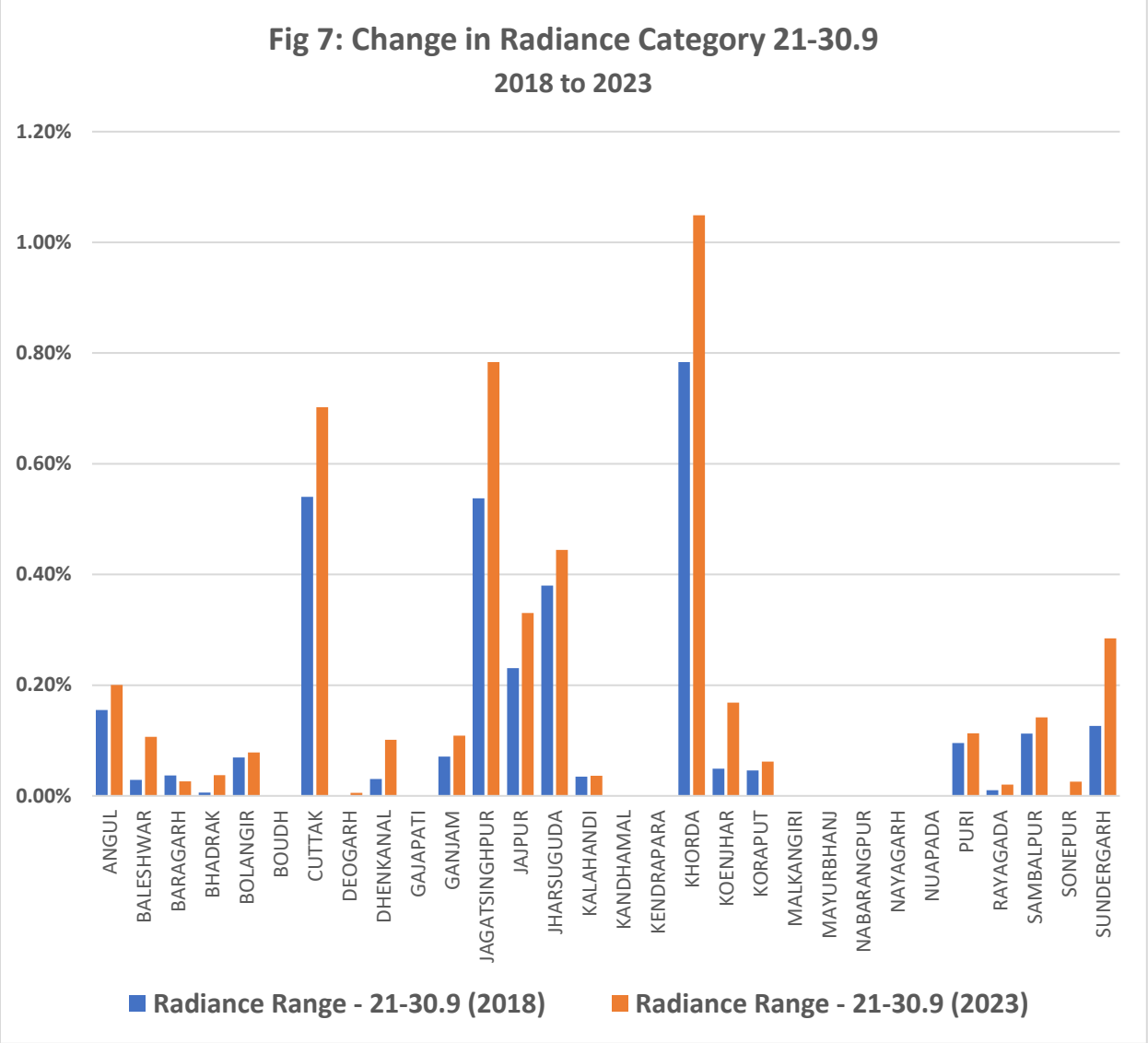
1. **Observation**: Changes in this low radiance range indicate minor infrastructural developments or enhanced lighting in rural areas.
2. **Significant Changes**:
    - 2.1. **Kendrapara**: Shows a notable increase, likely due to new developments and infrastructural projects.
    - 2.2. **Jagatsinghpur**: Exhibits an increase, suggesting improved rural lighting.
    - 2.3. **Khorda** and **Angul**: Both show decreases, which might indicate a transition of these areas to higher radiance categories due to development.

Radiance Range: 11-20.9 (nW/cm²/sr)



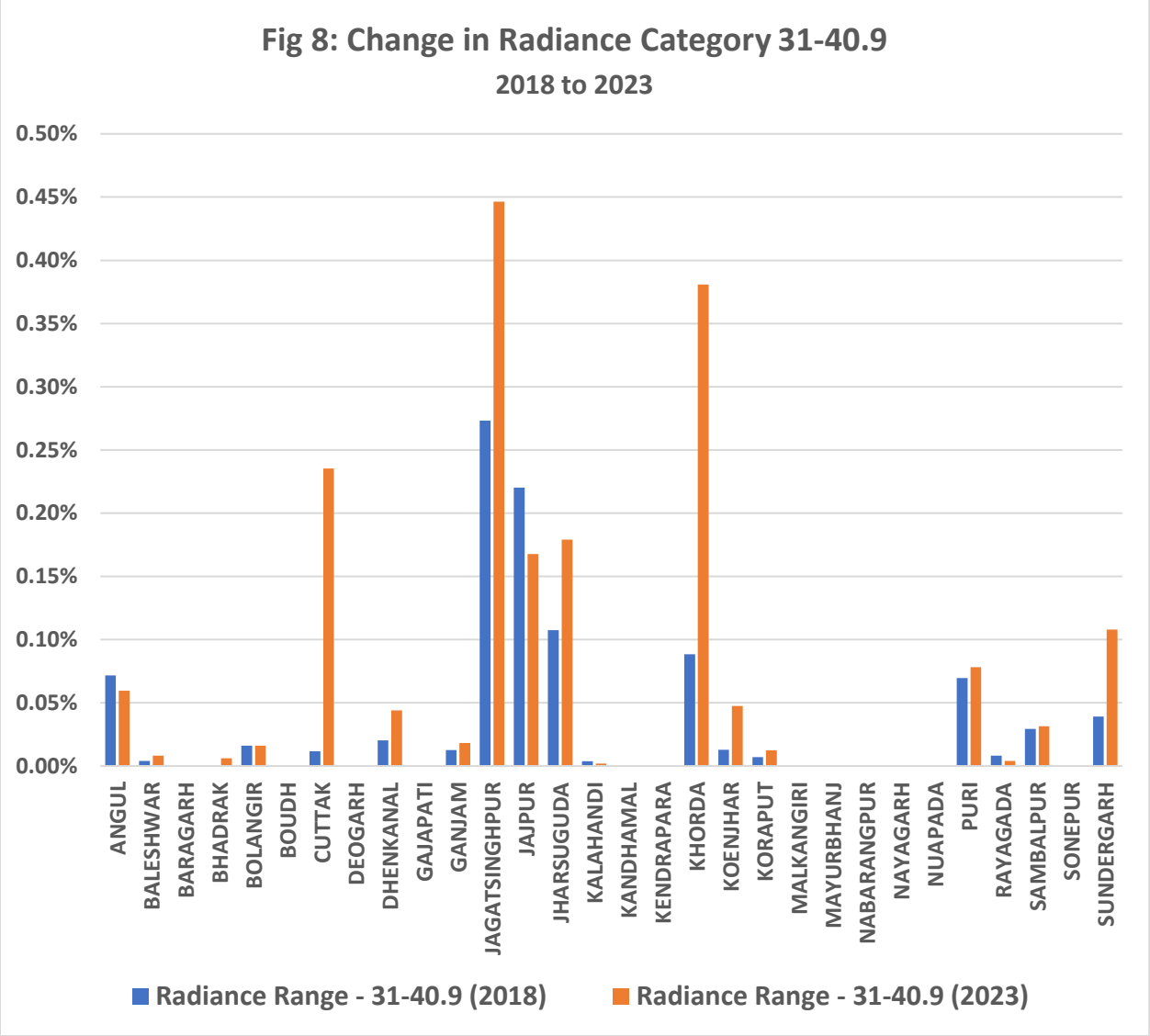
1. **Observation**: This range shows minor changes across districts, reflecting moderate development.
2. **Significant Changes**:
    2.1. **Malkangiri** and **Mayurbhanj**: Slight increases suggest minor urban or infrastructural improvements.
    2.2. **Deogarh**: Shows some increase, reflecting ongoing development activities.

Radiance Range: 21-30.9 (nW/cm²/sr)



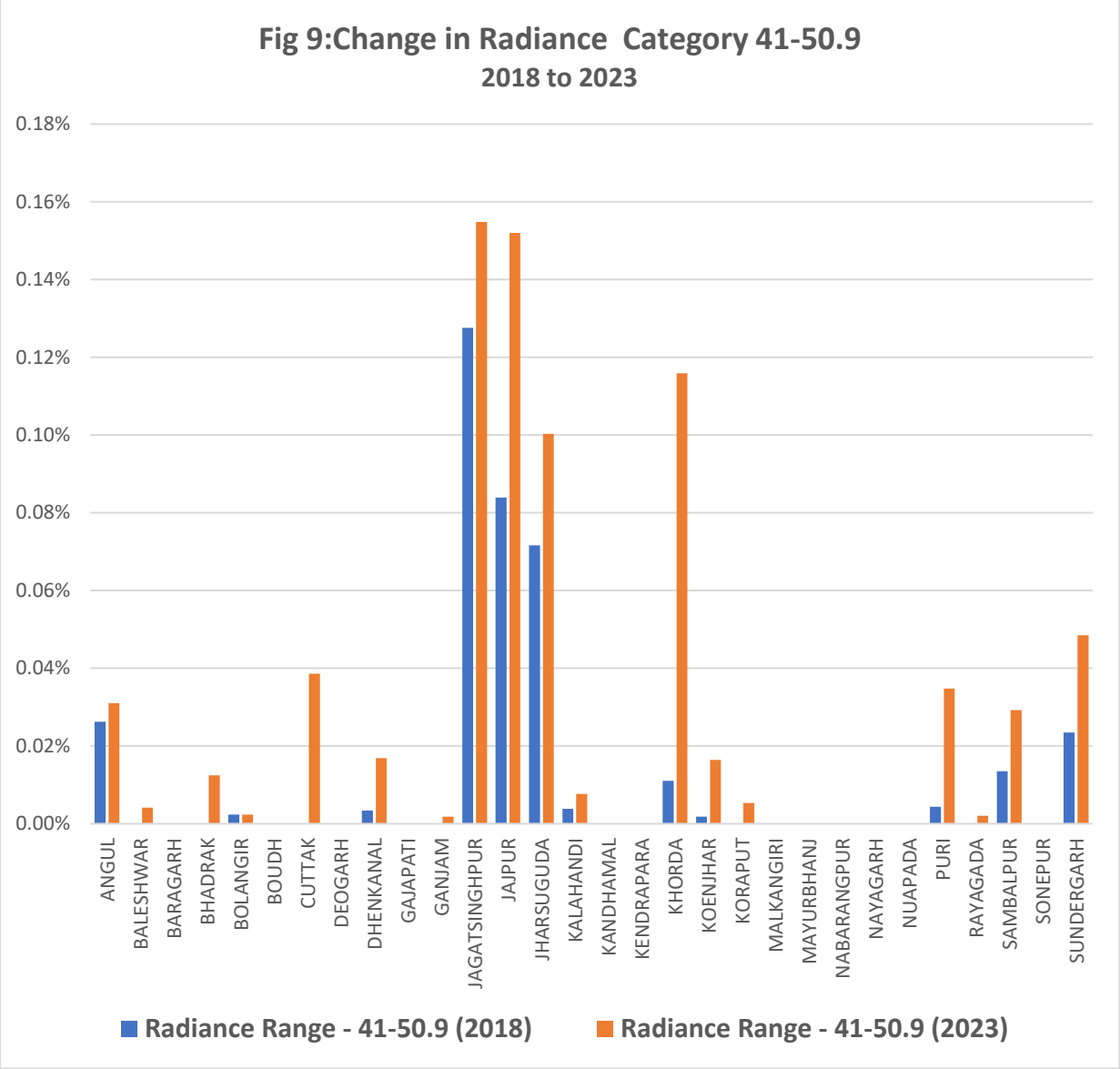
1. **Observation**: Moderate changes in this range indicate areas transitioning from rural to more urbanized statuses.
2. **Significant Changes**:
    - 2.1. **Malkangiri**: A significant increase, indicating considerable development in previously less developed areas.
    - 2.2. **Nabarangpur**: Also shows an increase, reflecting developmental activities.
    - 2.3. **Deogarh** and **Rayagada**: Slight increases indicate moderate urbanization and development.

Radiance Range: 31-40.9 (nW/cm²/sr)



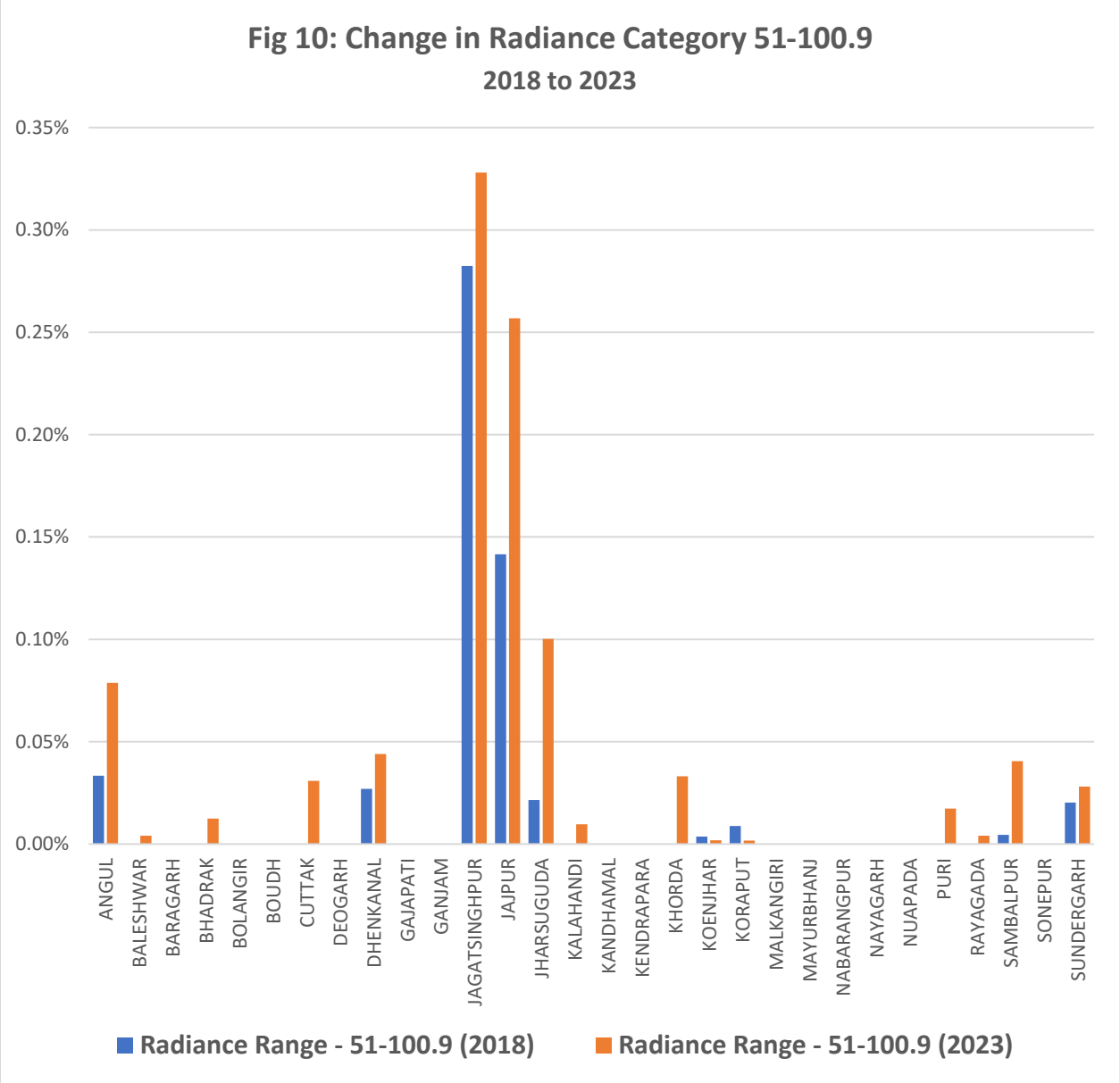
1. **Observation**: Substantial increases in this range reflect robust development and urbanization.
2. **Significant Changes**:
    2.1. **Khorda**: A notable increase suggests significant urban growth.
    2.2. **Malkangiri**: Further indicates substantial development activities.
    2.3. **Deogarh** and **Ganjam**: Show moderate increases, highlighting infrastructural growth.

Radiance Range: 41-50.9(nW/cm²/sr)



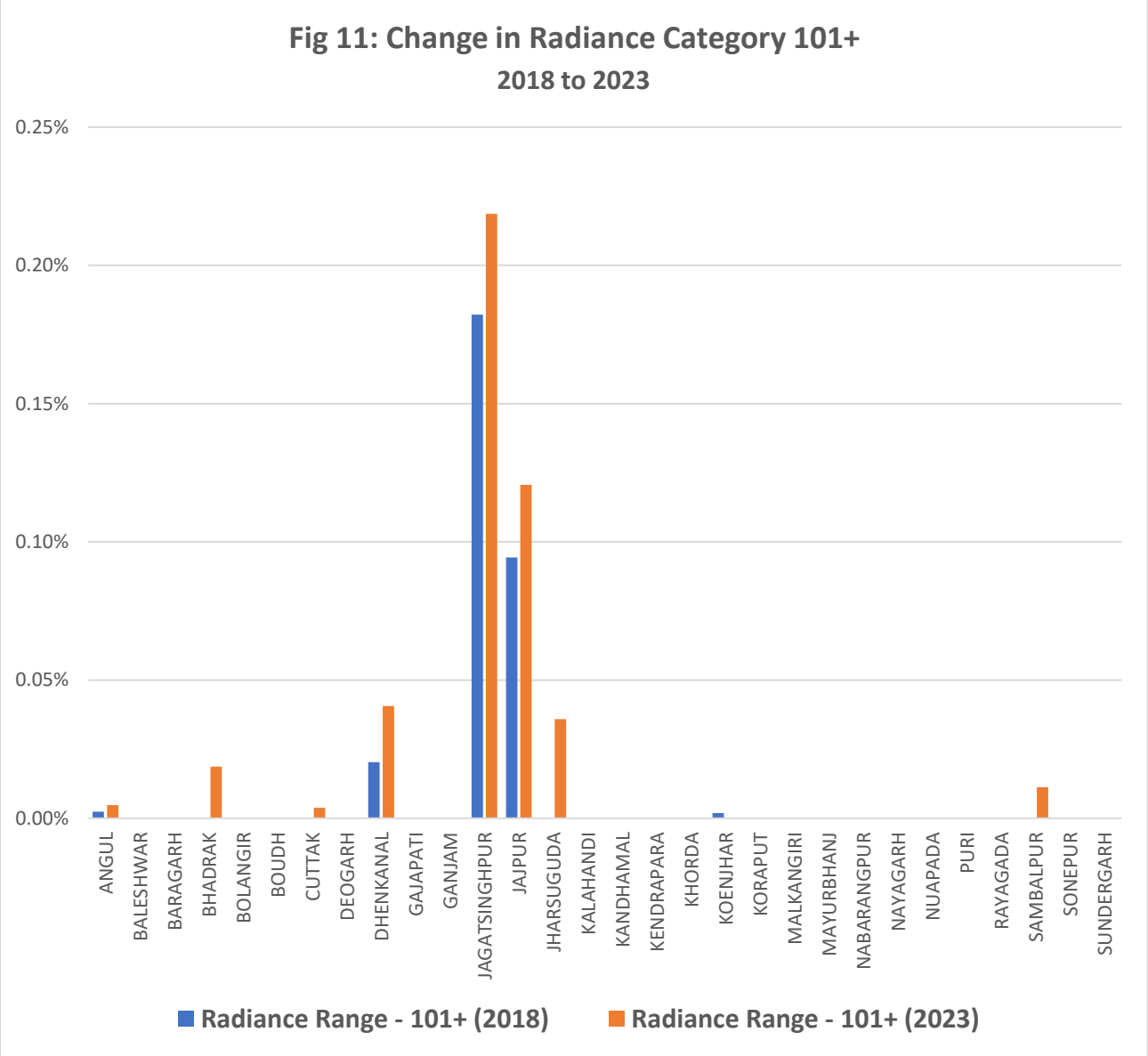
1. **Observation**: Changes in this range highlight areas with higher levels of development and urban growth.
2. **Significant Changes**:
    - 2.1. **Khorda**: Shows a substantial increase, reflecting strong economic and infrastructural development.
    - 2.2. **Jagatsinghpur**: An increase in this range indicates significant urbanization.
    - 2.3. **Kalahandi**: Shows a slight increase, suggesting moderate development activities.

Radiance Range: 51-100.9 (nW/cm²/sr)



1. **Observation**: Indicates high levels of urban and economic development.
2. **Significant Changes**:
    2.1. **Khorda**: Exhibits substantial increases, pointing to high-intensity development activities.
    2.2. **Malkangiri**: Also shows a notable increase, indicating significant urban growth.
    2.3. **Jajpur** and **Kalahandi**: Show moderate increases, suggesting steady development.

Radiance Range: 101+ (nW/cm²/sr)



1. **Observation**: The highest radiance range changes indicate areas with the most intense urbanization and economic development.
2. **Significant Changes**:
    - 2.1. **Khorda**: Substantial increases highlight significant urbanization and economic activity, making it one of the most developed districts in the analysis.
    - 2.2. **Jagatsinghpur**: Shows moderate increases, indicating ongoing urbanization.
    - 2.3. **Jajpur**: Also shows some increase, reflecting high-intensity development.

The visual representation for outcomes of radiance change are shown for each district below.

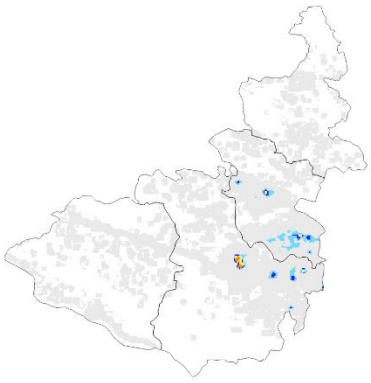


Figure 12: NTL_ANGUL_2018

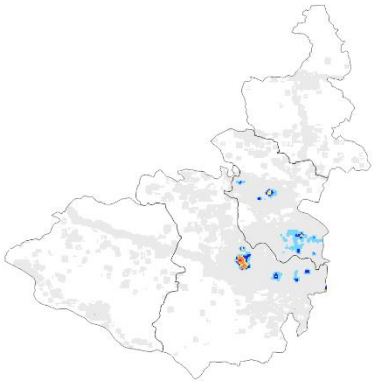


Figure 13: NTL_ANGUL_2023

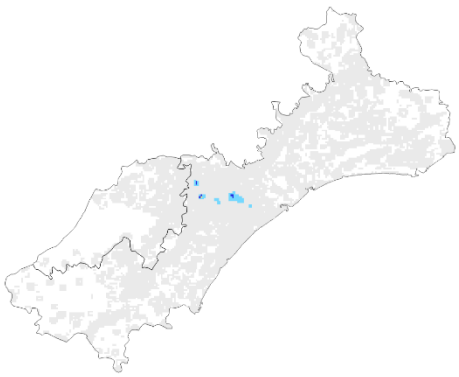


Figure 14: NTL_BALESHWAR_2018

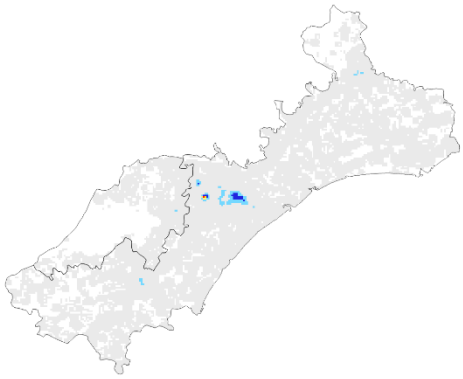


Figure 15: NTL_ BALESHWAR _2023

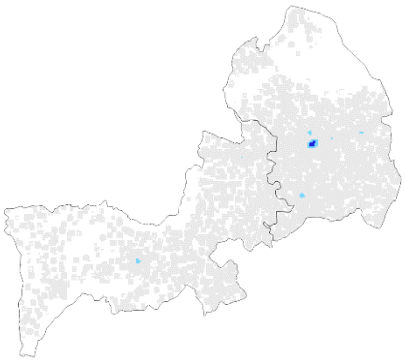


Figure 16: NTL_BARAGARH_2018

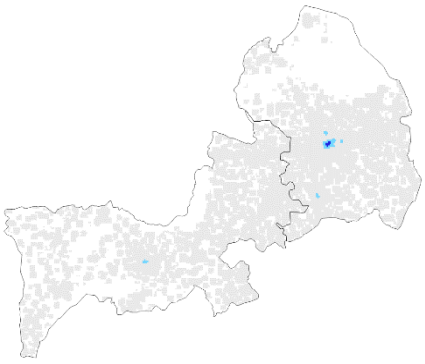


Figure 17: NTL_ BARAGARH _2023

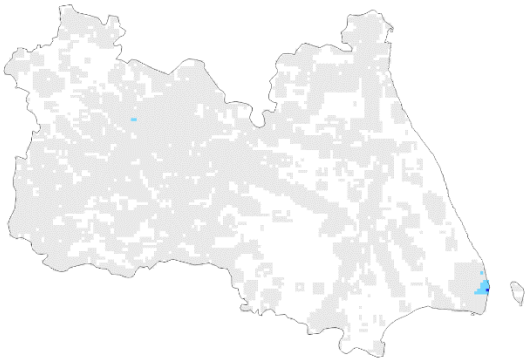


Figure 18: NTL_BHADRAK_2018

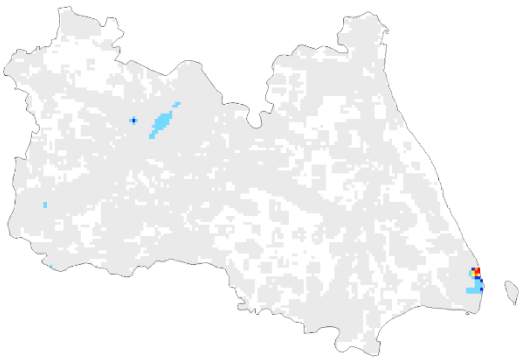


Figure 19: NTL BHADRAK _2023

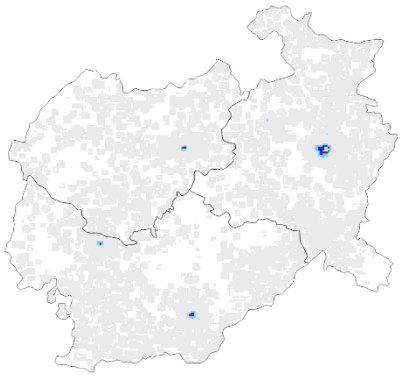


Figure 20: NTL_BOLANGIR_2018

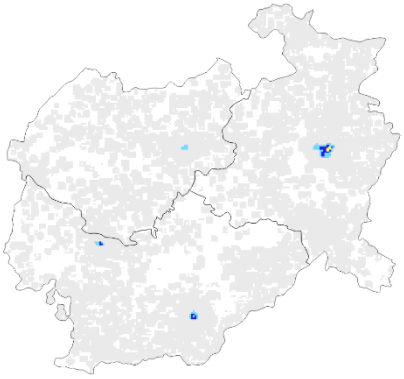


Figure 21: NTL_ BOLANGIR _2023

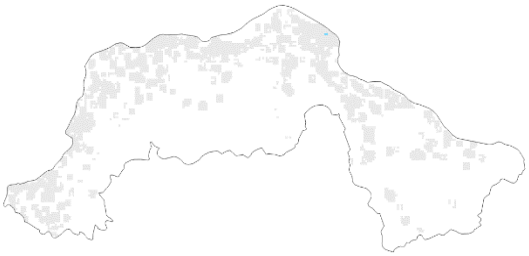


Figure 22: NTL_BOUDH_2018

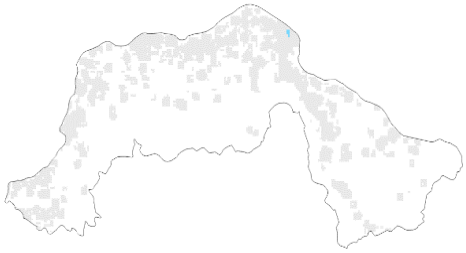


Figure 23: NTL_ BOUDH _2023

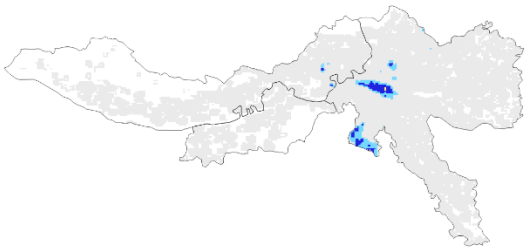


Figure 23: NTL_CUTTAK_2018

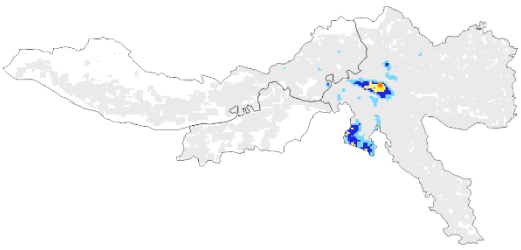


Figure 24: NTL_ CUTTAK _2023

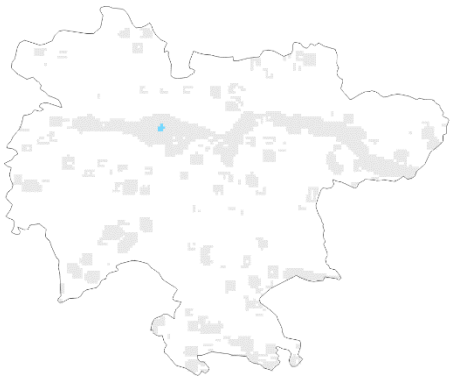


Figure 25: NTL_DEOGARH_2018

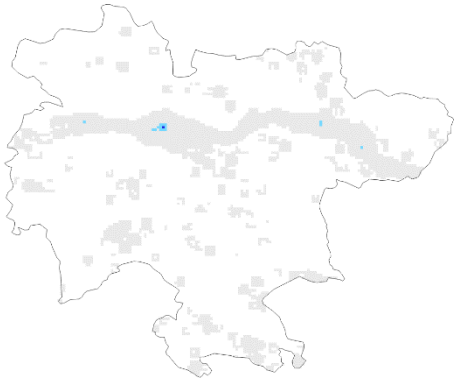


Figure 26: NTL_ DEOGARH _2023

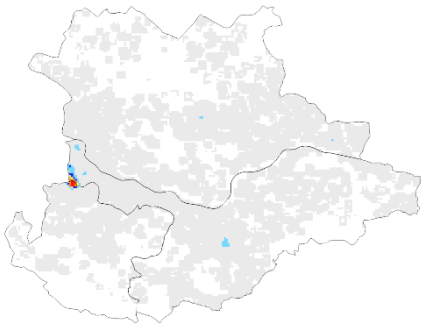


Figure 27: NTL_DHENKANAL_2018

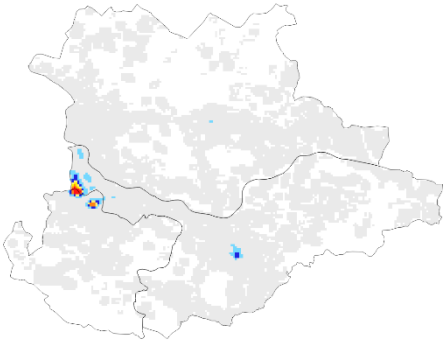


Figure 28: NTL_ DHENKANAL _2023

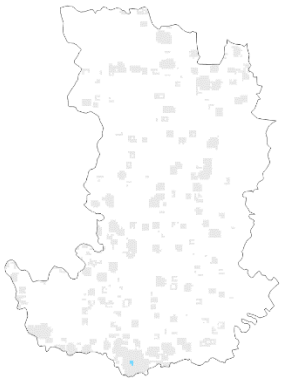


Figure 29: NTL_GAJAPATI_2018

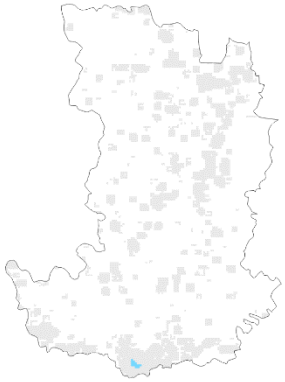


Figure 30: NTL_ GAJAPATI _2023

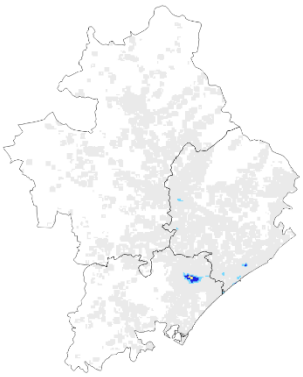


Figure 31: NTL_GANJAM_2018

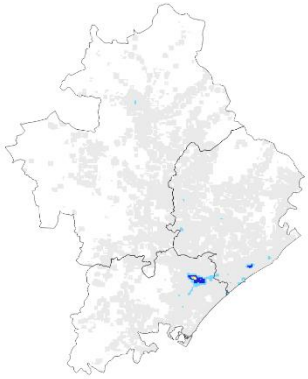


Figure 32: NTL_ GANJAM _2023

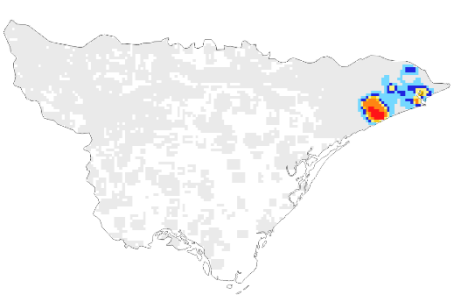


Figure 33: NTL_JAGATSINGHPUR_2018

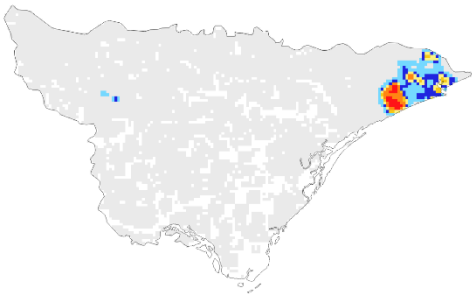


Figure 34: NTL_ JAGATSINGHPUR _2023

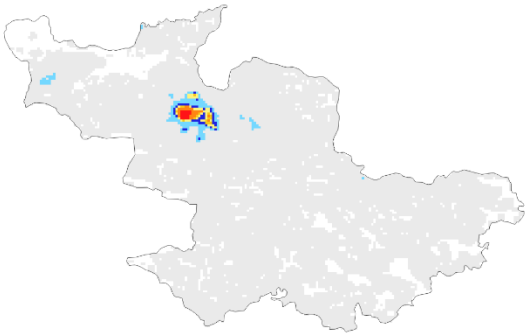


Figure 35: NTL_JAJPUR_2018

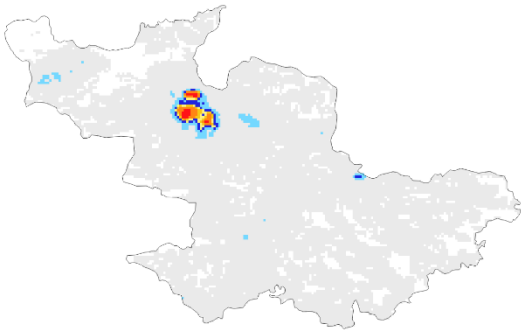


Figure 36: NTL_ JAJPUR _2023

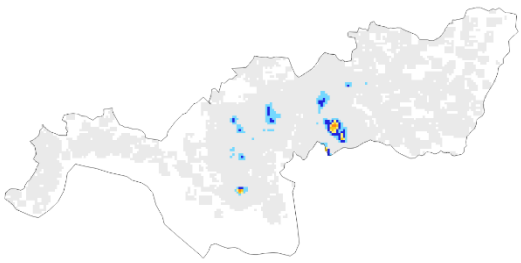


Figure 37: NTL_JHARSUGUDA_2018

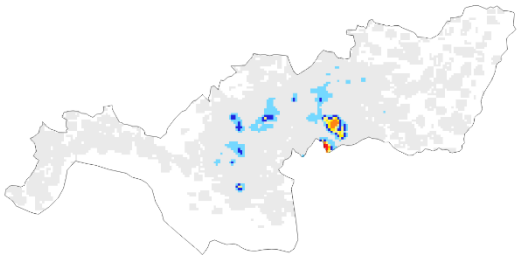


Figure 38: NTL_ JHARSUGUDA _2023

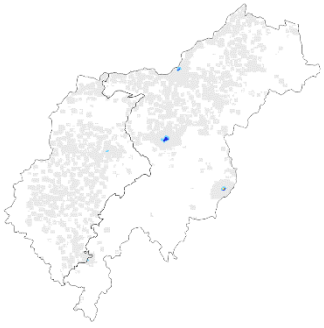


Figure 39: NTL_KALAHANDI_2018

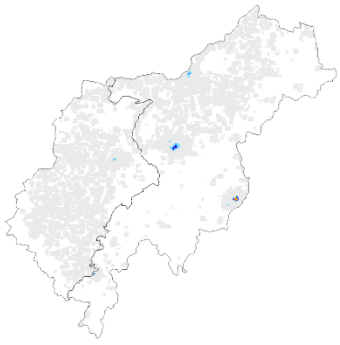


Figure 40: NTL_ KALAHANDI _2023

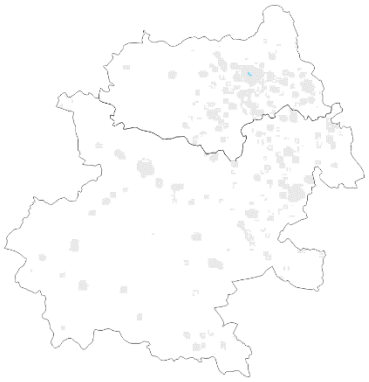


Figure 41: NTL_KANDHAMAL_2018

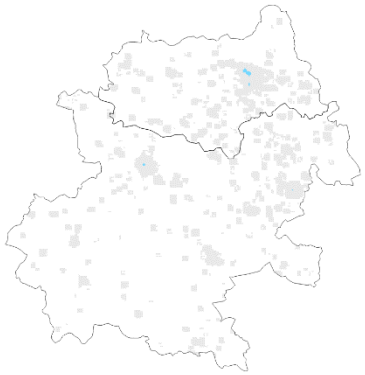


Figure 42: NTL_ KANDHAMAL _2023

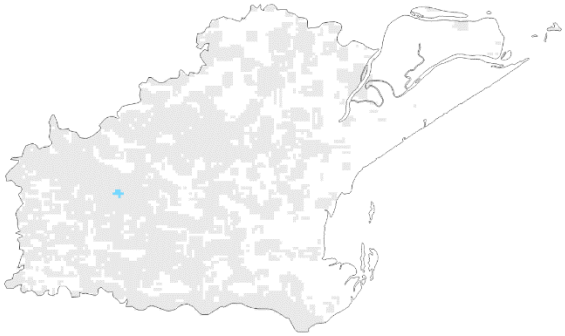


Figure 43:NTL_KENDRAPARA

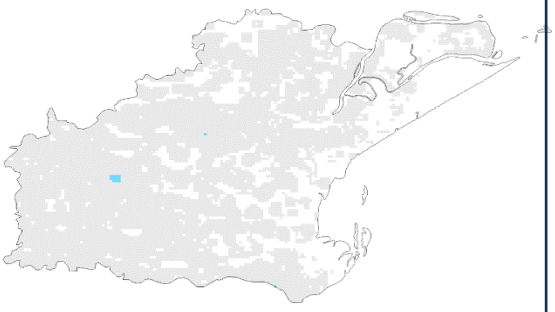


Figure 44: :NTL_KENDRAPARA10

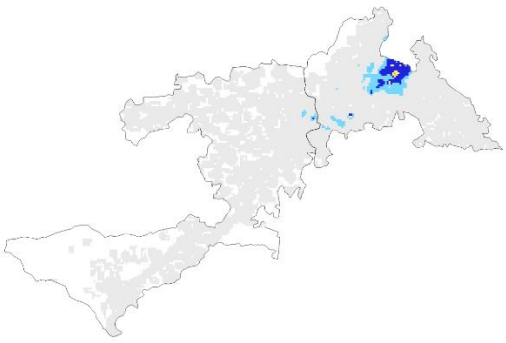


Figure 45: NTL_KHORDA_2018

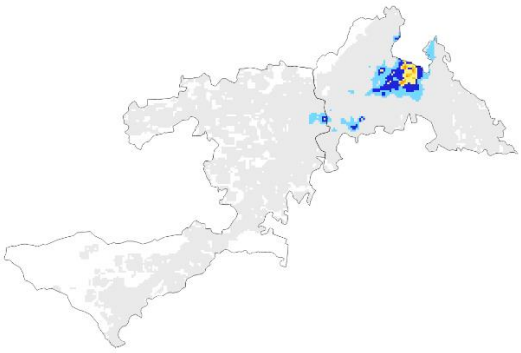


Figure 46: NTL_ KHORDA _2023

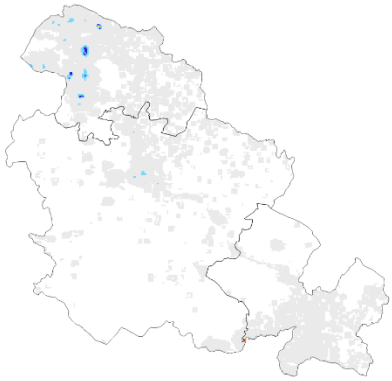


Figure 47: NTL_KOENJHAR_2018

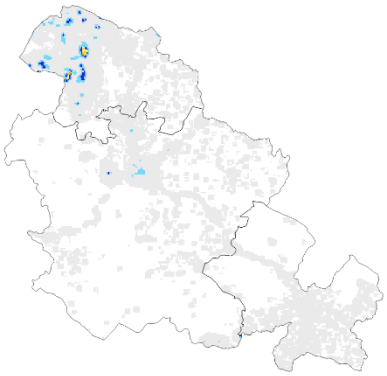


Figure 48: NTL_ KOENJHAR _2023

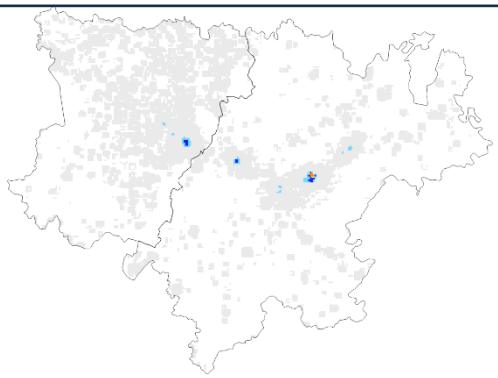


Figure 49: NTL_KORAPUT_2018

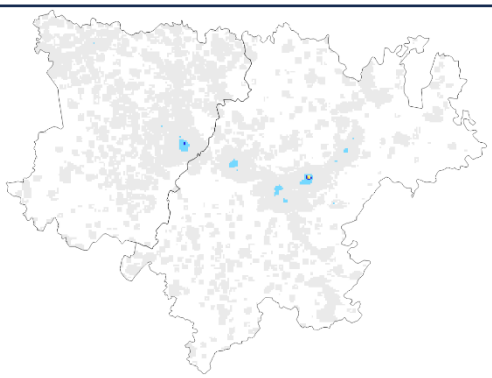


Figure 50: NTL_ KORAPUT _2023

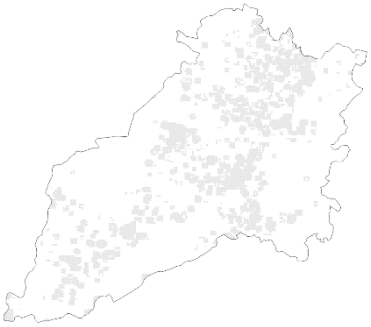


Figure 51: NTL_ MALKAGIRI _2018

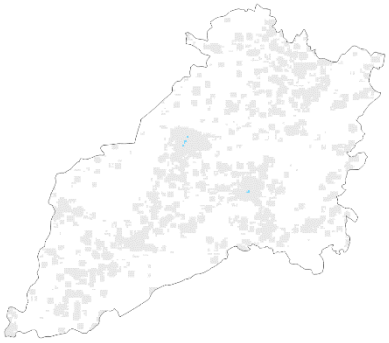


Figure 52: NTL_ MALKAGIRI _2023

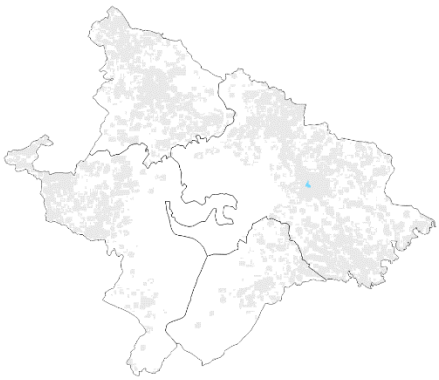


Figure 53: NTL_MAYURBHANJ_2018

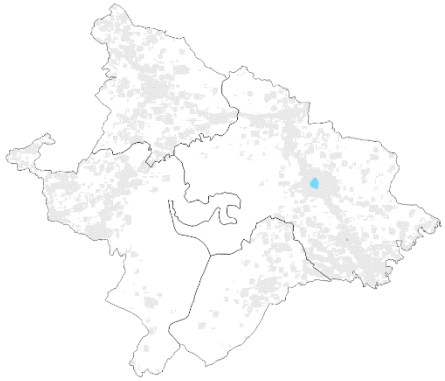


Figure 54: NTL_ MAYURBHANJ _2023

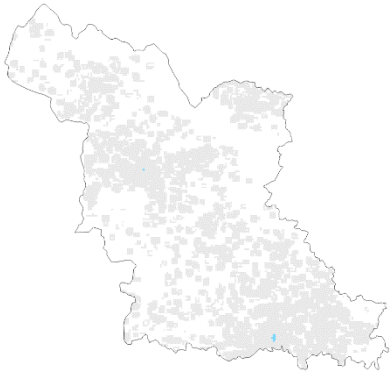


Figure 55: NTL_NABARANGPUR_2018

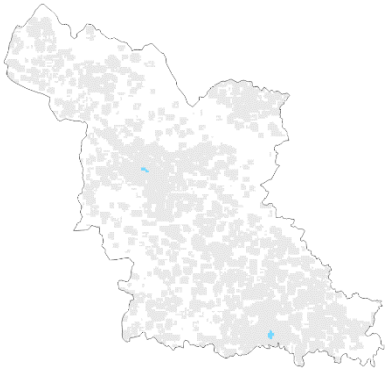


Figure 56: NTL_ NABARANGPUR _2023

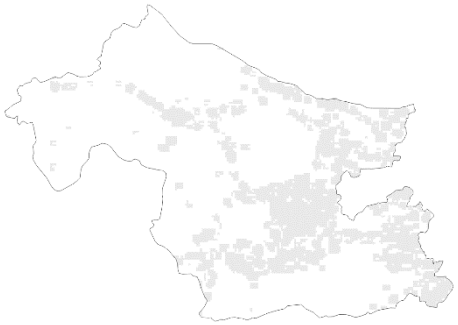


Figure 57: NTL_NAYAGARH_2018

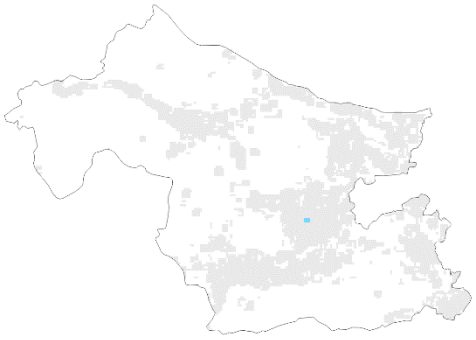


Figure 58: NTL_ NAYAGARH _2023

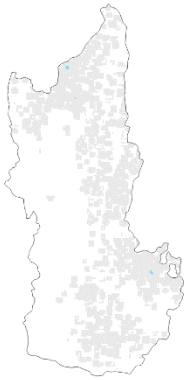


Figure 59: NTL_NUAPADA_2018

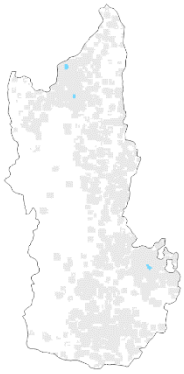


Figure 60: NTL_ NUAPADA _2023

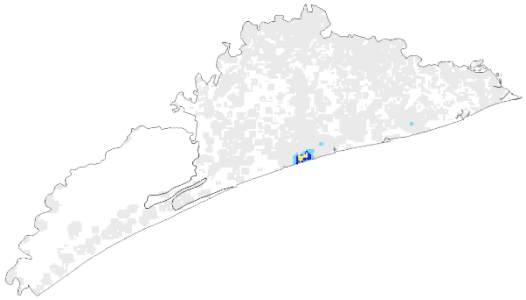


Figure 61: NTL_PURI_2018

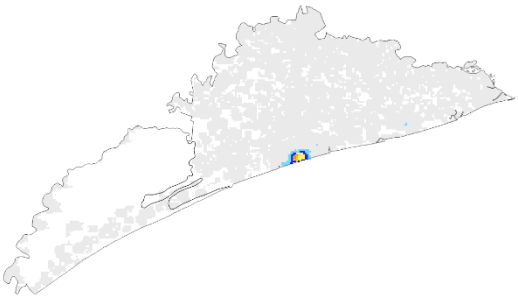


Figure 62: NTL_ PURI _2023

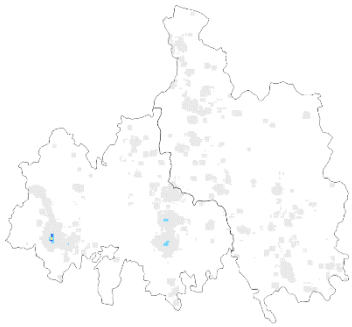


Figure 63: NTL_RAYAGADA_2018

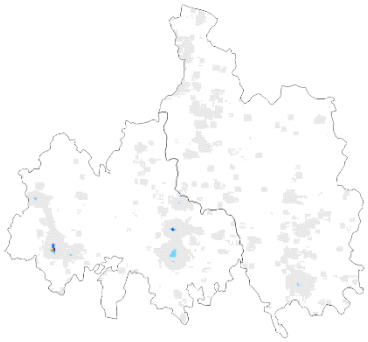


Figure 64: NTL_ RAYAGADA _2023

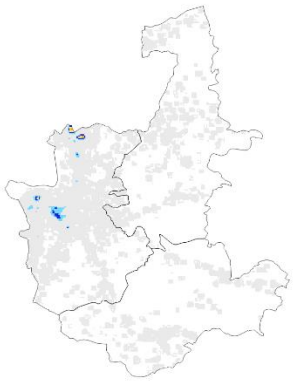


Figure 65: NTL_SAMBALPUR_2018

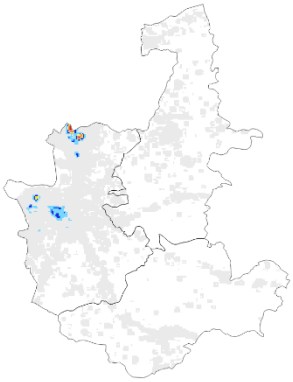


Figure 66: NTL_ SAMBALPUR _2023

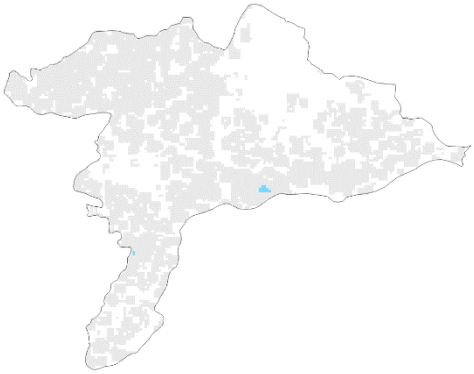


Figure 67: NTL_SONEPUR_2018

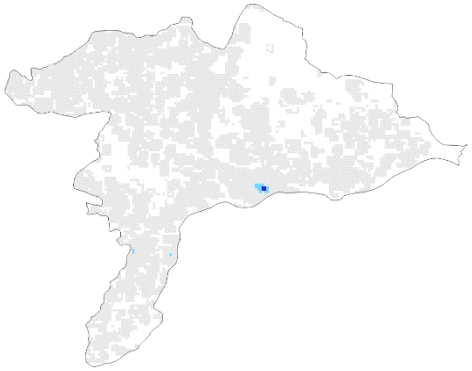


Figure 68: NTL_ SONEPUR _2023

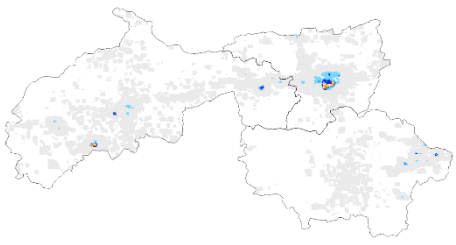


Figure 69: NTL_SUNDERGARH_2018

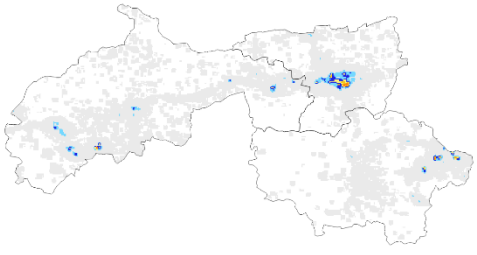


Figure 70: NTL_ SUNDERGARH _2023

Summing Up

The analysis of nighttime light radiance data from the Visible Infrared Imaging Radiometer Suite (VIIRS) for the years 2018 and 2023 provides valuable insights into the economic activities, urbanization, and infrastructural development across Orissa, India. By utilizing the annual VNL V2 average-masked dataset, we accurately quantified changes in radiance at the district level, mapped the spatial distribution of nighttime light intensity, and identified areas of significant changes.

The results indicate a general trend of increasing nighttime light radiance in several districts, suggesting ongoing urbanization and infrastructure development. Districts such as Khorda, Kendrapara, Ganjam, and Puri show notable increases in higher radiance values, reflecting significant growth in economic activities and improvements in living standards. Conversely, districts like Sundergarh, Rayagada, and Malkangiri, which still exhibit lower radiance values, highlight areas where development has been slower or where rural characteristics persist.

Our analysis also reveals districts with mixed changes in radiance, indicating complex development dynamics. For instance, while Khorda shows a decrease in lower radiance values, it simultaneously experiences growth in higher radiance categories, suggesting a shift towards more efficient lighting and urban concentration. Similarly, districts like Cuttack and Bolangir demonstrate both increases and decreases across different radiance ranges, reflecting varied development patterns within the districts.

In conclusion, the use of VIIRS nighttime light data has proven to be an effective tool for monitoring and analyzing regional development patterns in Orissa. The findings of this study not only highlight areas of significant growth but also identify regions where development efforts may need to be intensified. By providing a detailed spatial and temporal analysis of nighttime light radiance, this research contributes to a better understanding of the socio-economic landscape of Orissa and supports more informed policy formulation and regional planning. The methodology and insights gained from this study can serve as a model for similar analyses in other regions, facilitating a broader application of nighttime light data in monitoring and promoting sustainable development.