

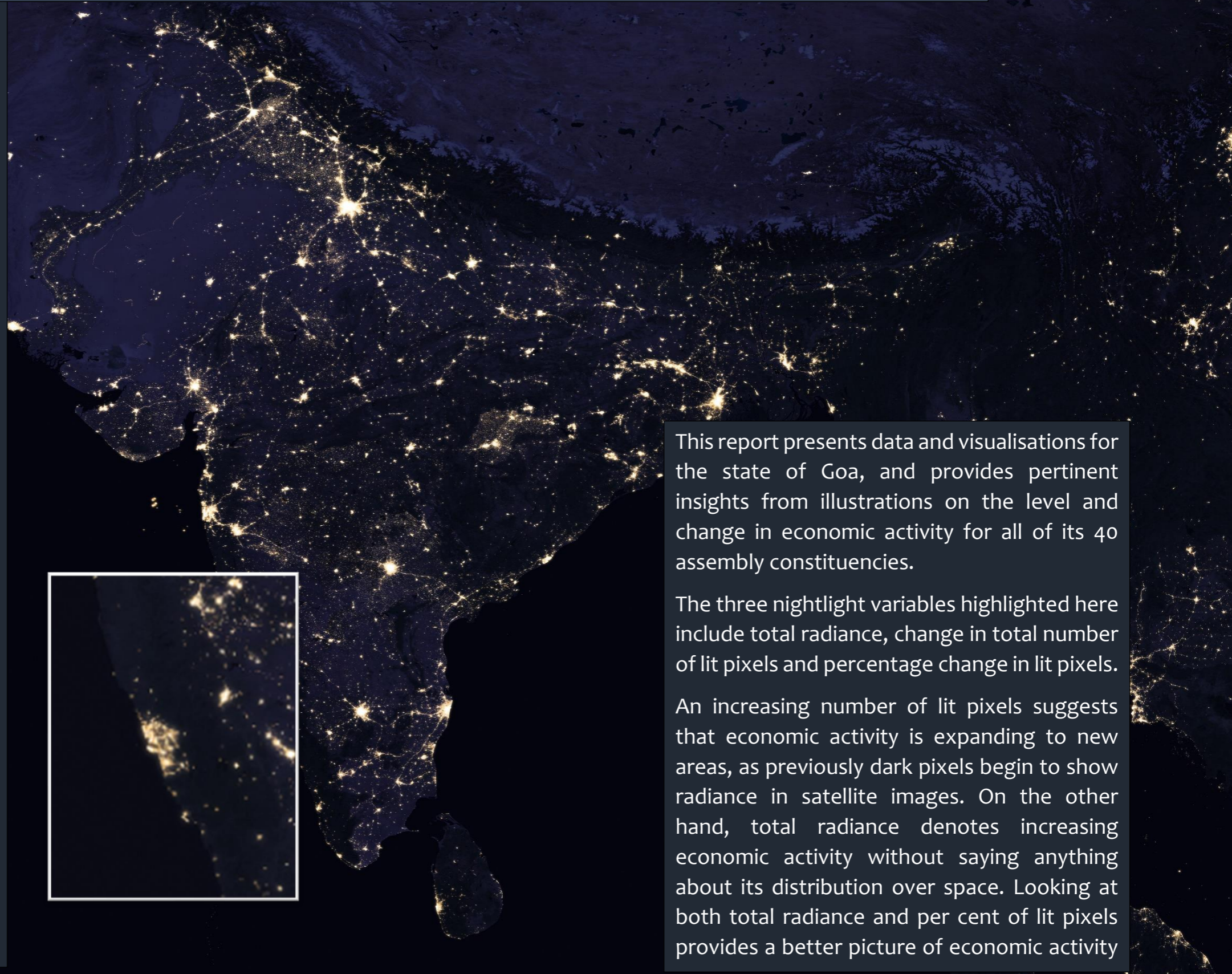
Nightlights as the Indicator of Growth in Economic Activity in Goa

Gross Domestic Product (GDP), historically has been a standard measure of economic activity. It records the value of all final goods and services produced within the country during a given period, net of the value of inputs. GDP data requires estimations and extrapolations because not all economic activities can be completely captured.

In recent time, night-time radiance, traced from outer space through satellites, has increasingly emerged as a pertinent measure for changes in economic activities irrespective of their sources (formal or informal sectors). It is also a more significant representation of economic activities in manufacturing and services, than agriculture. Farmers have lower access to electricity, and primarily use it for pumping water that doesn't generate nightlights. Ideally, an increase in luminosity eyes the essence of a country's developmental and its macro-economic indicators, for example - access to electricity, reliable power supply, increased electricity consumption, increased income level, industrial production, money and credit growth.

Nightlights has become a reasonable indicator for GDP at the national and sub-national levels, with a very high level of spatial granularity. It does not suffer from questions around data quality or manipulation, and its errors are considered to be free of political bias.

Ahead of assembly elections in Goa, we present nightlights data to enable a constituency-level comparison for the economic activities over six years, covering 2015 to 2020.



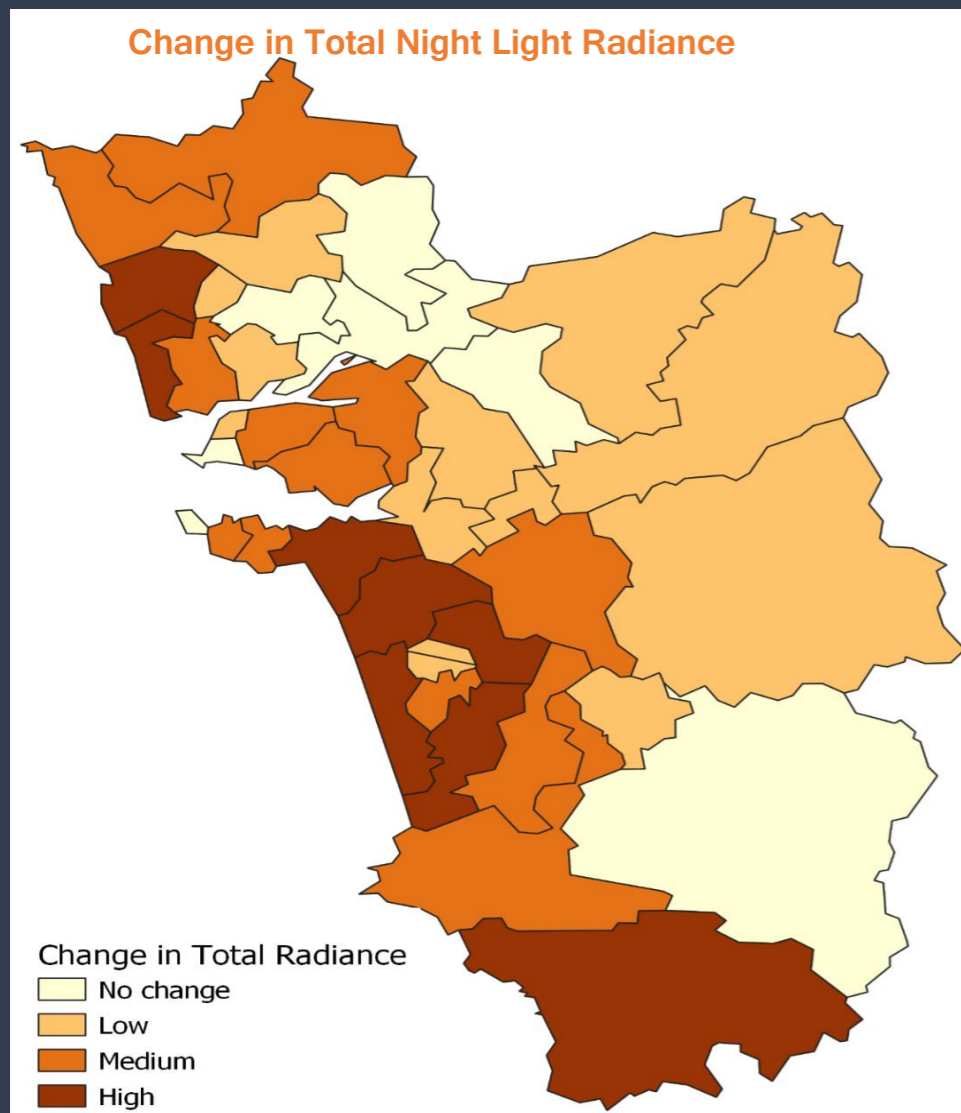
This report presents data and visualisations for the state of Goa, and provides pertinent insights from illustrations on the level and change in economic activity for all of its 40 assembly constituencies.

The three nightlight variables highlighted here include total radiance, change in total number of lit pixels and percentage change in lit pixels.

An increasing number of lit pixels suggests that economic activity is expanding to new areas, as previously dark pixels begin to show radiance in satellite images. On the other hand, total radiance denotes increasing economic activity without saying anything about its distribution over space. Looking at both total radiance and per cent of lit pixels provides a better picture of economic activity

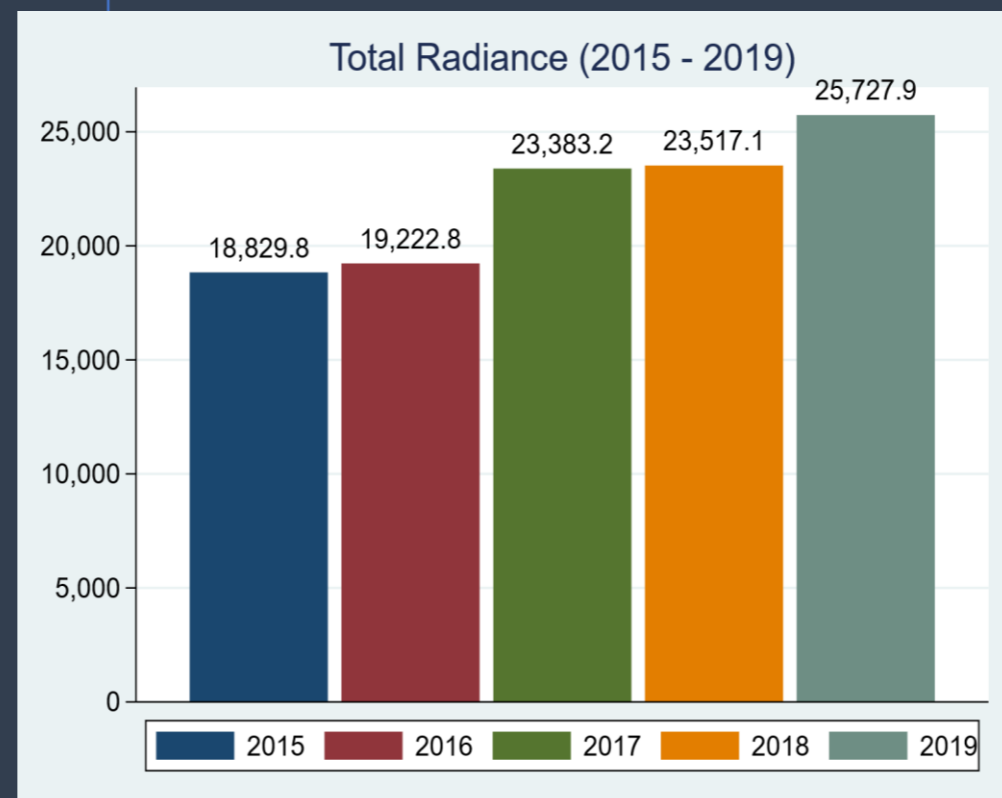
Image Source : NASA, Retrieved from <https://www.nasa.gov/sites/default/files/thumbnails/image/india-2016.jpg>

1. Growth Pattern of Total Radiance across constituencies from 2015 to 2019



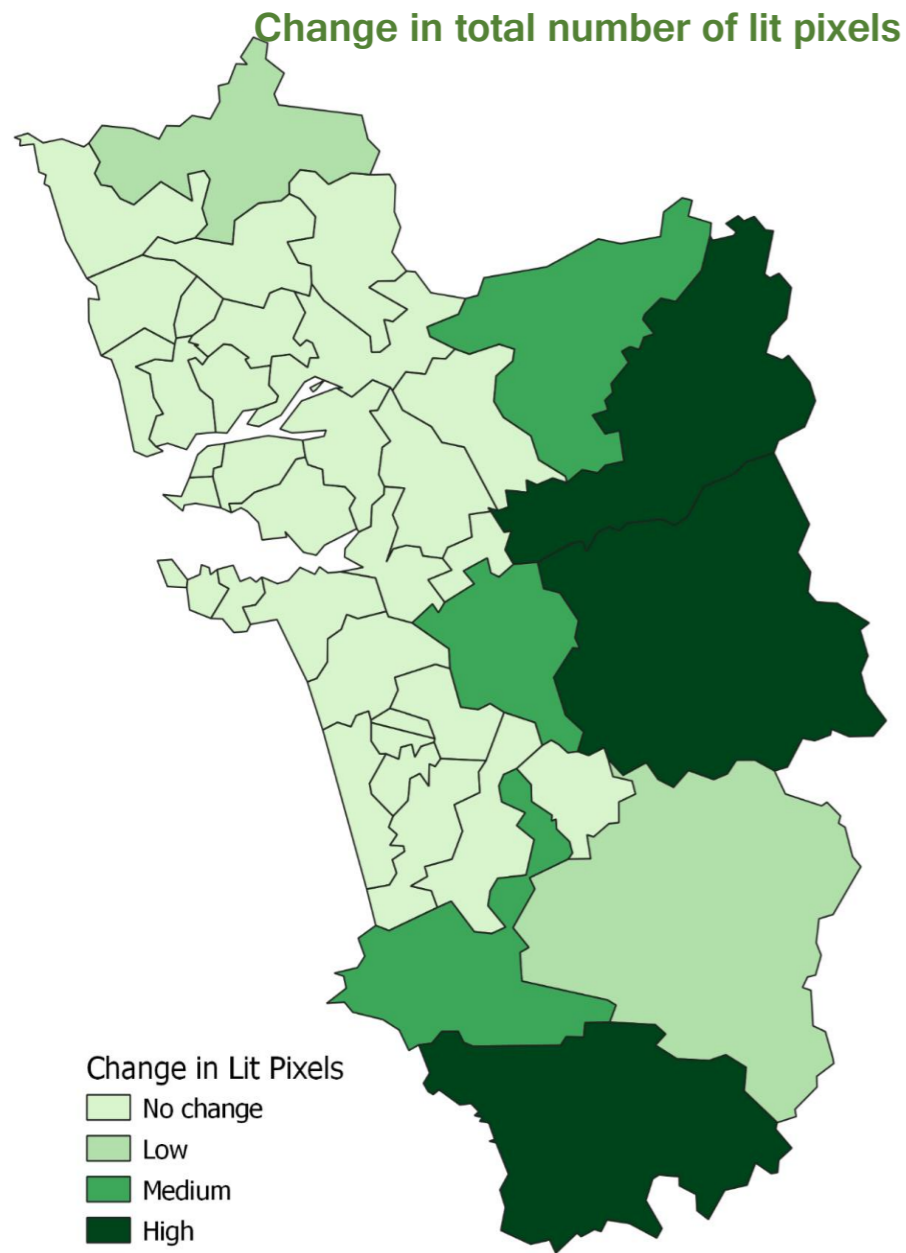
The visual on right describes constituency wise change in total radiance from 2015 to 2019. It is evident that that three constituencies, Benaulim, Cortalim and Calangute have shown the highest change, nearing 400 pixels. Nuvem, Siolim, Velim, Canacona and Curtorim have also shown a significant change of greater than 300 pixels. Constituencies of Bicholim, Taleigao and Sanquelim have a negative (subzero) change in total radiance.

The bar graph represented here signifies the total radiance from 2015 to 2019. There is a perceptible rise of total radiance from 18,829 in 2015 to 25,727 in 2019. A gradual year on year increase in total radiance is observed during the time period, denoting steadily increasing economic activity in the state.



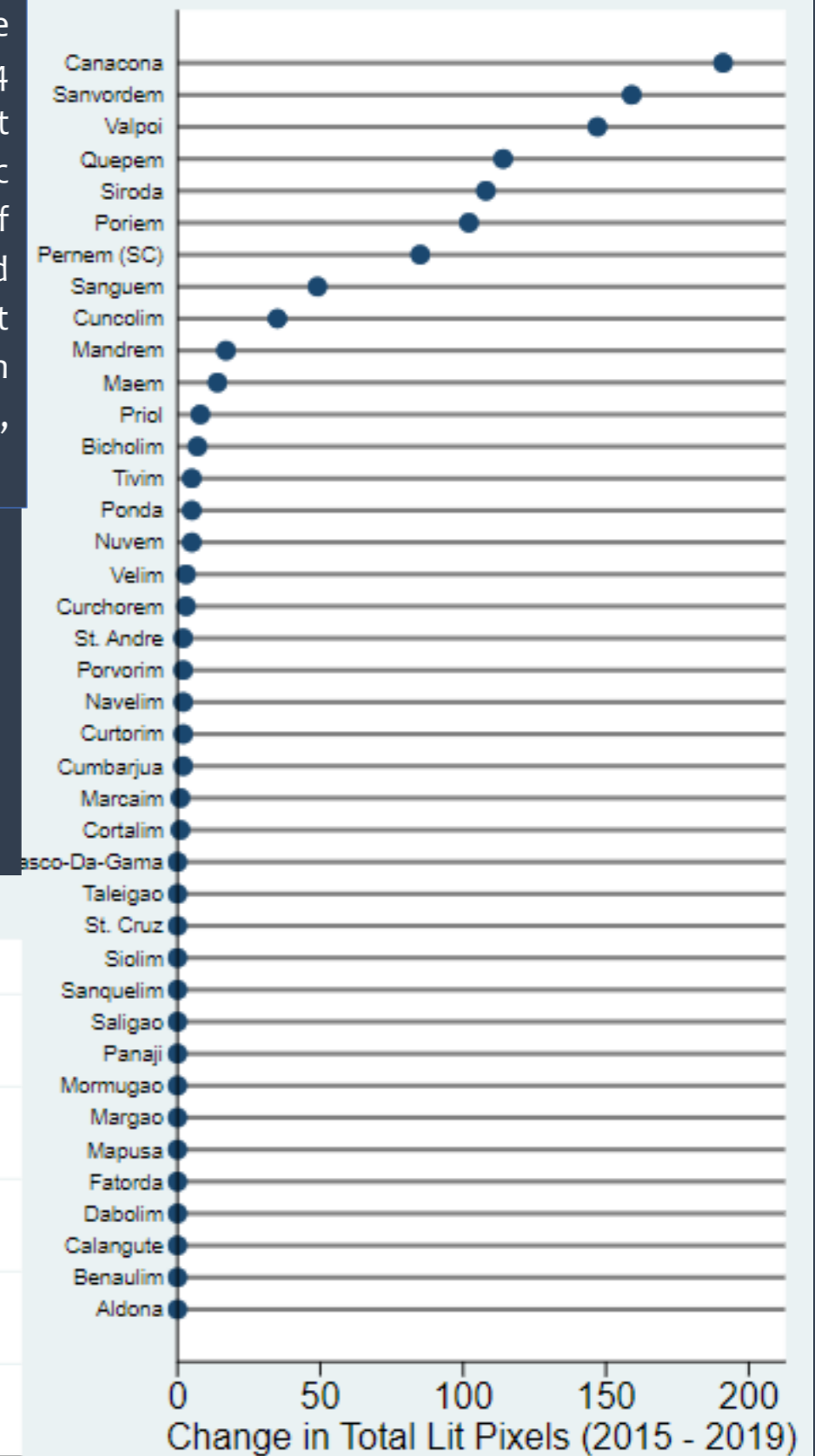
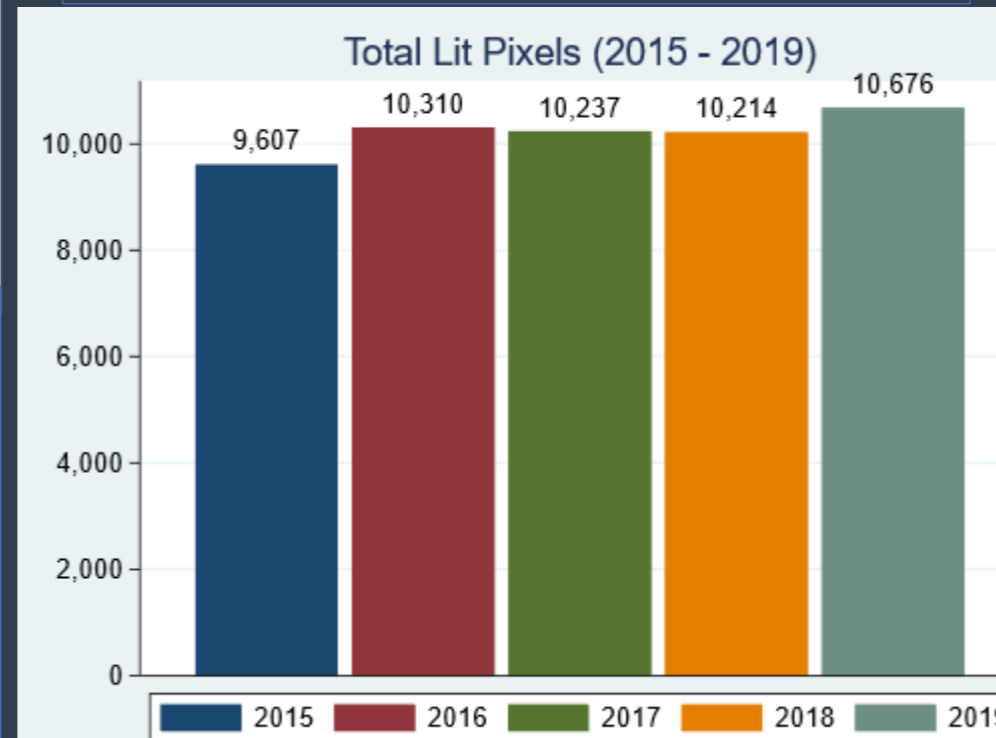
Through this visual, we show a five-year growth trajectory from 2015 to 2019, essentially the pre-pandemic years. The data suggests that the change in total nightlight was highest in eight constituencies in Goa - Siolim (6), Calangute (8), Cortalim (27), Nuvem (28), Benaulim (32), Velim (35), Curtorim (29) and Canacona (40); most of these constituencies lie in the district of South Goa. Medium change in Total Radiance was observed in constituencies of Mandrem (1), Pernem (2), Saligao (7), Santa Cruz (13), St Andre (14), Cumbarjua (15), Siroda (22), Cuncolim (34), Quepem (36), Vasco Da Gama (25), Dabolim (26), and Navelim (33). It signifies that 50% of the constituencies of Goa fall in the high and medium category for change in total radiance; while 30% of Goa falls in the category of low change in total radiance.

2. Growth Pattern of Change in total number of lit pixels across constituencies from 2015 to 2019 - Indicates the distribution of night lights in the assembly constituency area



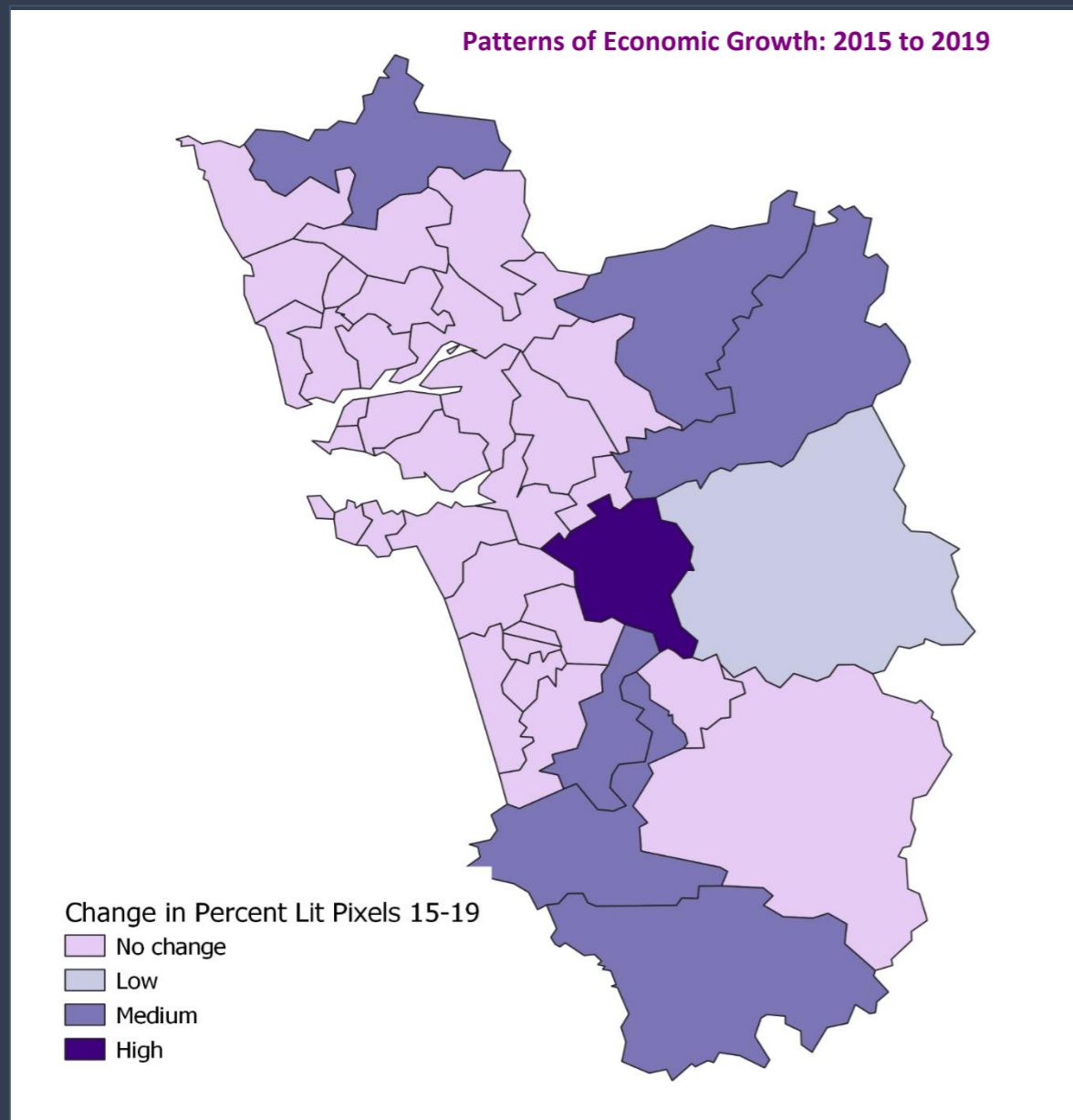
The visual on right indicates the constituency-wise change in total lit pixels from 2015 to 2019. 24 constituencies have shown a zero-point change in lit pixels from 2015 to 2019, signifying that economic activity is not expanding to newer areas in most of Goa. This also highlights the already developed status of the state. Canacona has shown an almost 200-point increase in the time period. Sanvordem and Valpoi have also shown significant change, greater than 150, in lit pixels.

The bar graph below represents change in total lit pixels from 2015 to 2019. The trend indicates a slow and gradual upward trend in lit pixels over time. There has been a 1069-point increase in lit pixels from 2015 to 2019.



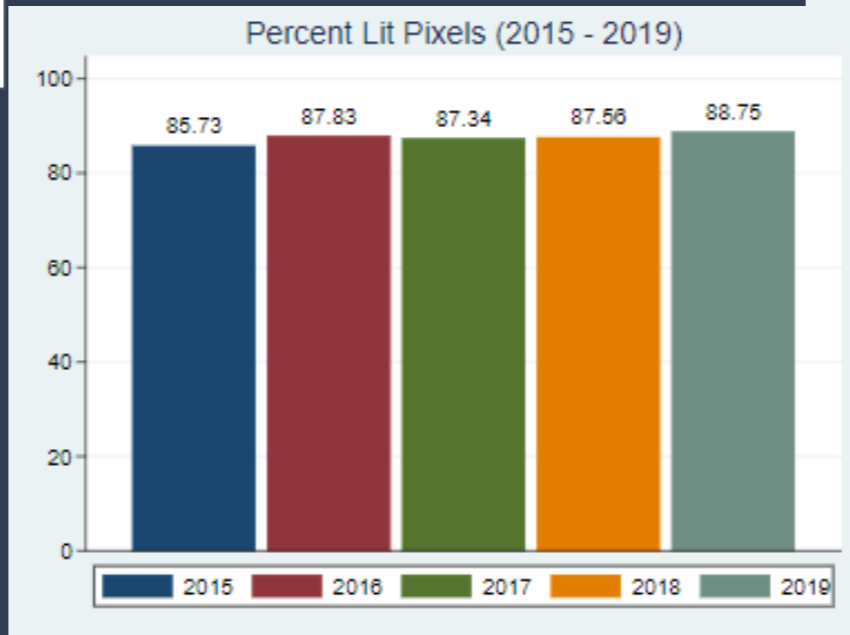
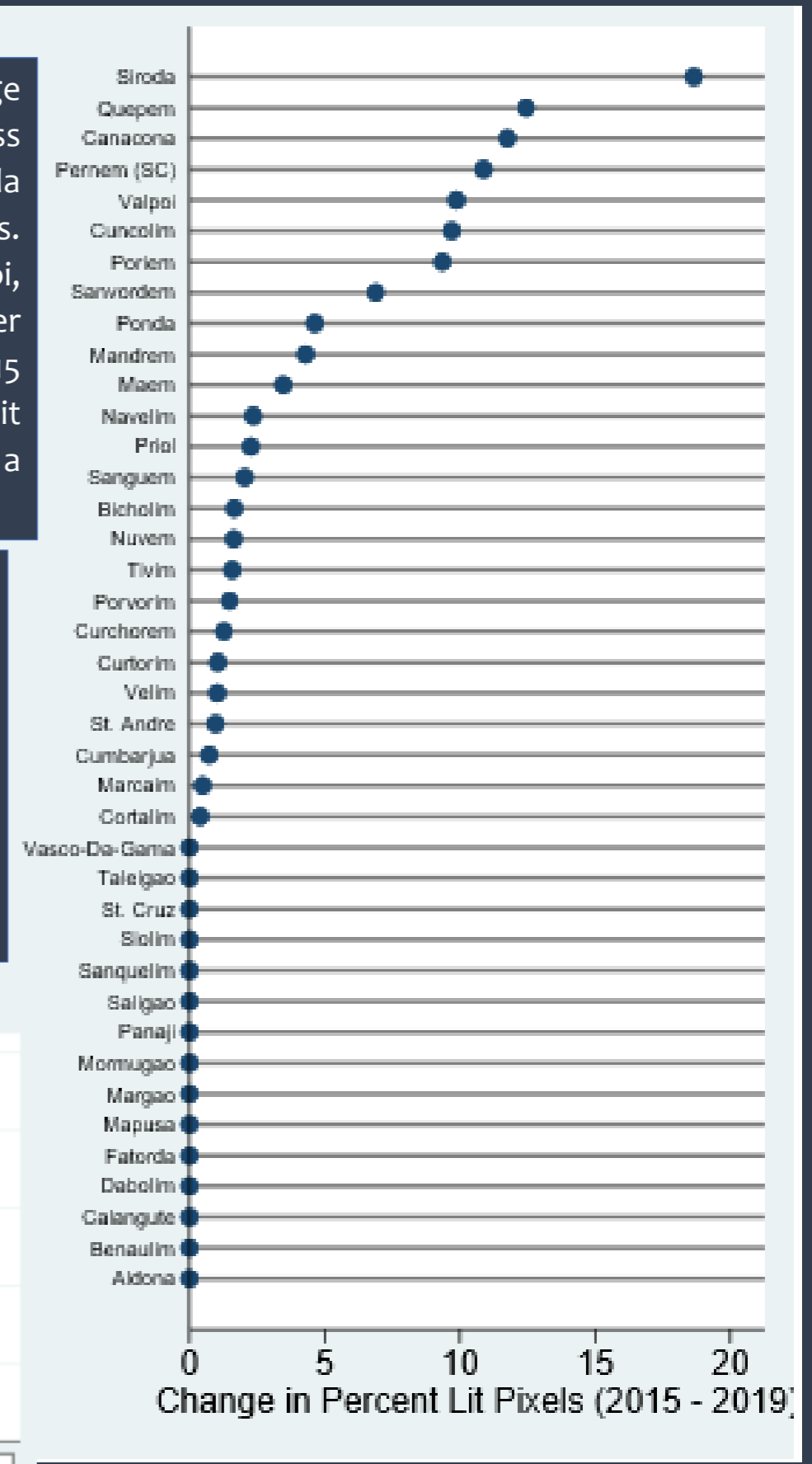
The visual suggests that the change in lit pixels from 2015 to 2019 and represents economic activity in more detail than the total radiance. It is high in only three constituencies of Valpoi (19), Sanvordem (38) and Canacona (40). Constituencies of Poriem(18), Siroda (22), Quepem (36) stay in the medium change in lit pixels category. 32 constituencies in Goa out of 40, i.e., around 80% do not show any changes in the lit pixels, suggesting non-expansion of economic activity to newer areas.

3. Growth Pattern of Percentage change in lit pixels across constituencies from 2015 to 2019 - indicates the percentage of lit pixels with respect to total pixels



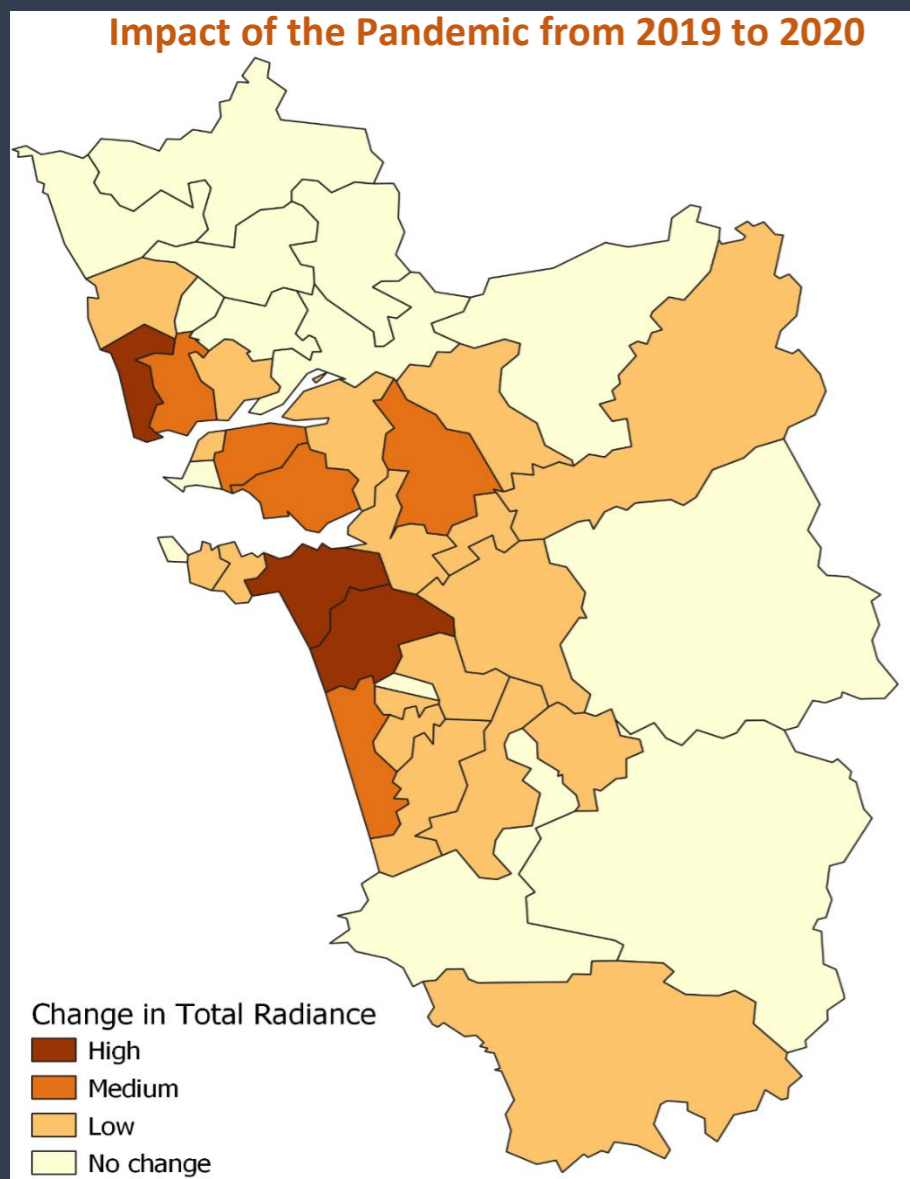
The visual on right represents percentage change in lit pixels from 2015 to 2019 across all 40 constituencies of Goa. Here, Siroda shows an almost 18% increase in lit pixels. Quepem, Canacna, Pernem, Valpoi, Cuncolim and Porlem have shown a greater than 10% increase in lit pixels. 15 constituencies have upto 5% increase in lit pixls, while 15 constituencies have shown a zero per cent change.

The data represented below describes the percent of lit pixels in Goa from 2015 to 2019. The visual suggests only marginal increase in per cent lit pixels from 2015 to 2019, the per cent of lit pixels have remained approximately the same from 2016 to 2018. Overall, a 3.02% increase in lit pixels is observed from 2015 to 2019.



The above visual signifies that from 2015 to 2019, only one constituency of Siroda (22) has a high percentage change in lit pixels. Constituencies of Pernem (2), Poriem (18), Valpoi (19), Cuncolim (34), Quepem (36) and Canacona (40) have shown a medium percentage change in lit pixels, while only one constituency of Sanvordem (38) falls under low change category. 32 constituencies out of 40 (i.e., 80%) witnessed no change in percentage lit pixels indicating possible saturation in economic growth.

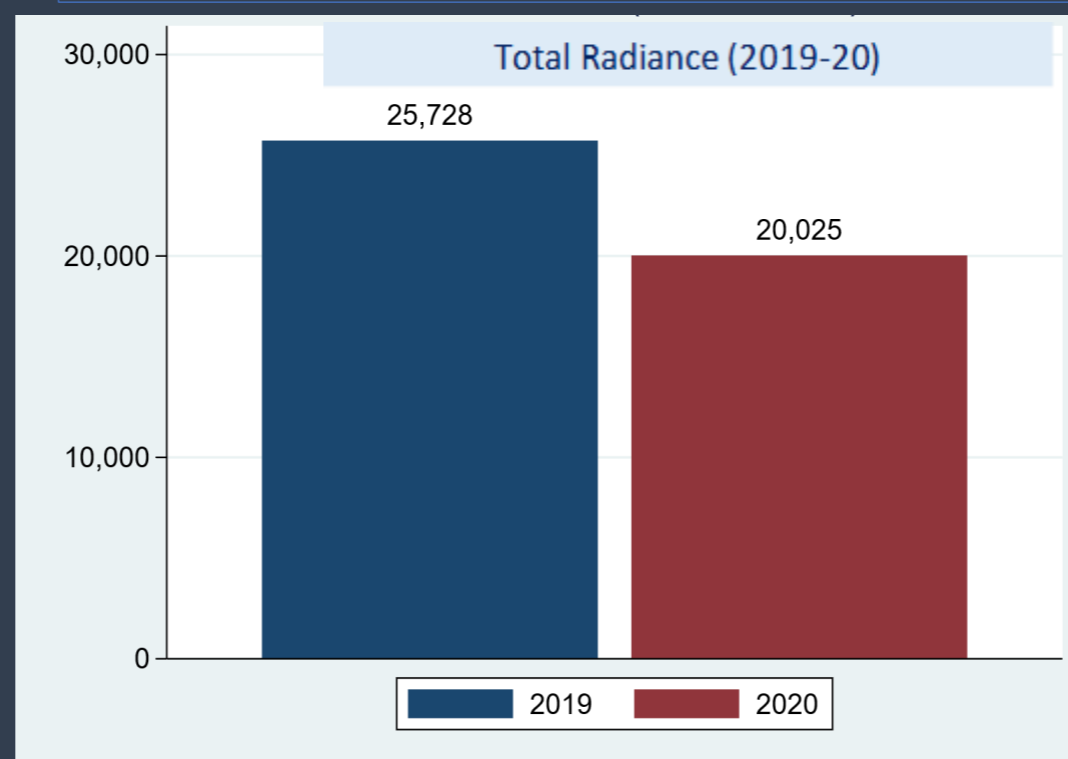
4. Pandemic Impact on Total Radiance across constituencies from 2019 to 2020



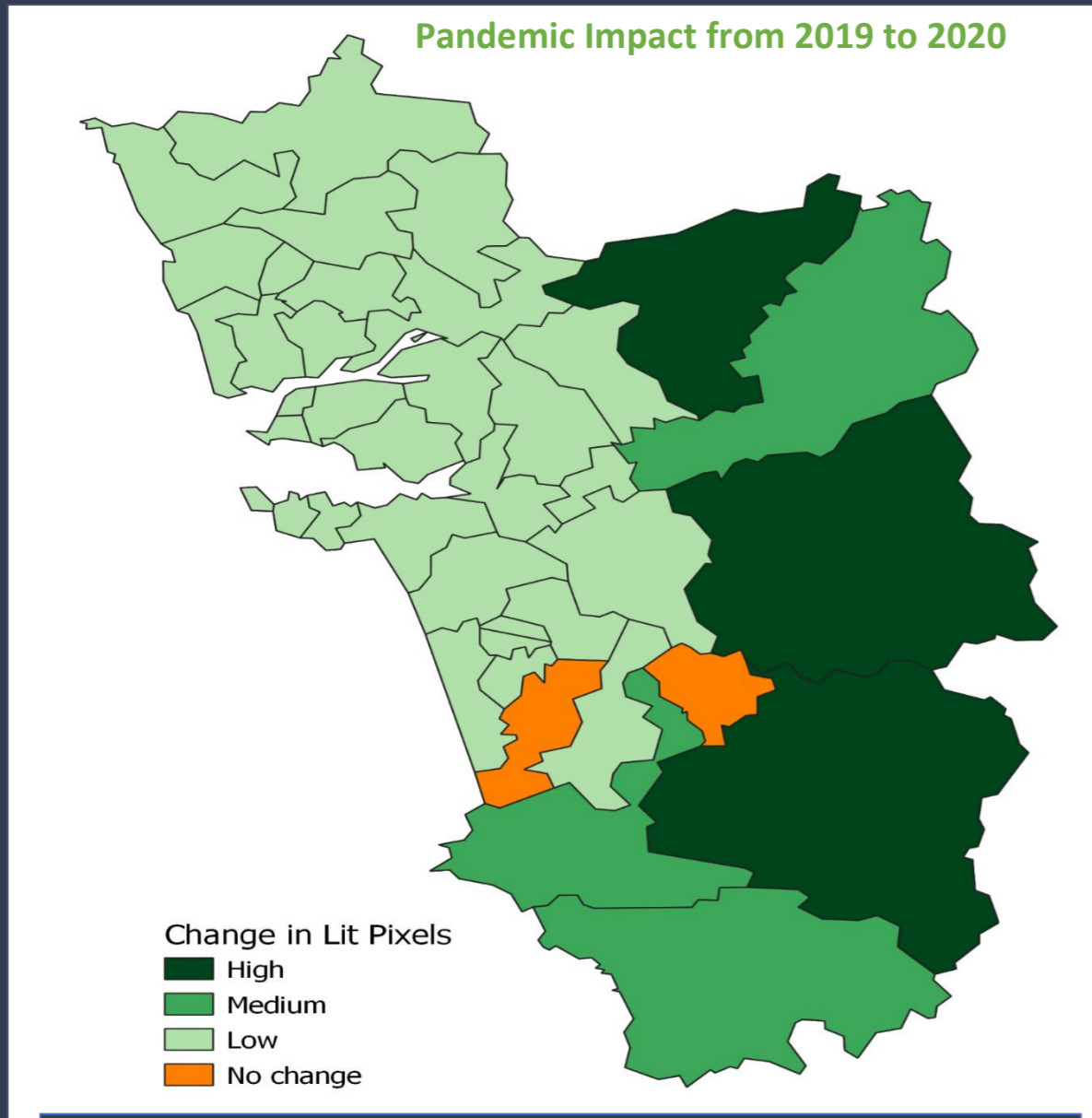
The visual describes change in total radiance in Goa from 2019 to 2020, constituency wise. It is noted that there has been a negative change in total radiance across all 40 constituencies. Highest negative change is noted in Cortalim, Nuvem, and Calangute, elucidating a 300-to-400-point decrease in total radiance. It is pertinent to note that Cortalim and Calangute had shown highest change in total radiance from 2015-2019, and the pandemic effect on these constituencies is highly evident. Pernem, Bicholim, Mormugao and Mandrem have shown the least change in total radiance from 2019-20, suggesting no impact of pandemic on total radiance.

The perceptible pandemic impact on economic activity, and hence total radiance is stark and evident. Total radiance in the state has declined from 25,728 to 20,025, suggesting the significant negative impact on the Goan economy.

This visual describes the pandemic effect on change in total radiance, by comparing year 2019 with 2020. Only 3 constituencies of Calangute (8), Cortalim (27), Nuvem (28) fall in the high change in total radiance category. Only 20% of constituencies exhibited high and medium change in nightlight radiance from 2019 to 2020, illustrating a significant pandemic impact. 14 constituencies have shown no change in total nightlight radiance, comprising of 35% of the total constituencies, impact of pandemic remained muted over here.

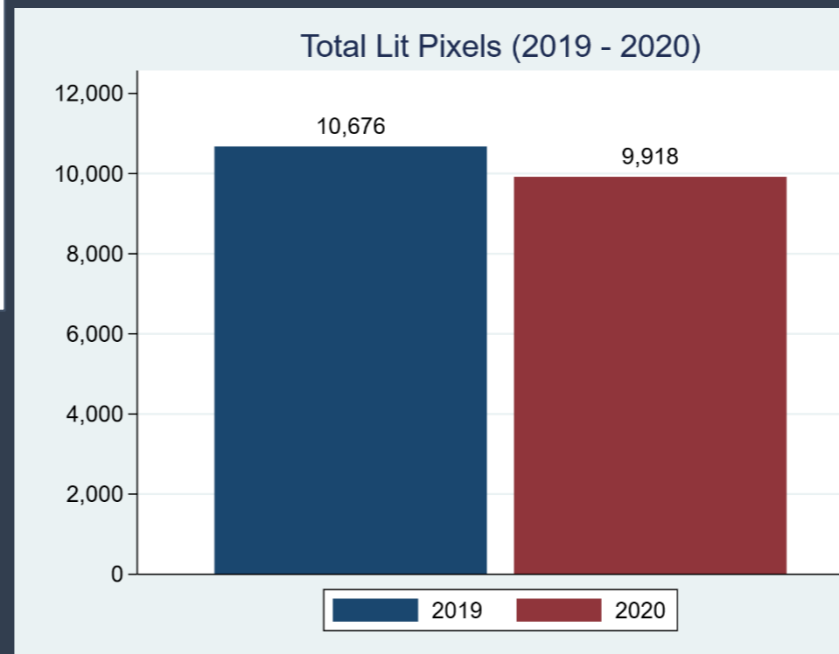


5. Pandemic Impact on Change in total number of lit pixels across constituencies from 2019 to 2020 - Indicates the distribution of night lights in the assembly constituency area



The present visual represents constituency-wise change in lit pixels from 2019 to 2020. As observed, 2 constituencies have shown zero change, 31 constituencies have shown little change in lit pixels from 2019 to 2020. Sanvordem, Poriem and Sanguem have shown the highest negative change in lit pixels, greater than 100 points. It is also noted that no constituency has shown a positive change in lit pixels from 2019 to 2020.

The visual below indicates total lit pixels in 2019 and 2020 and studies the pandemic impact. Decline of 758 total lit pixels (-7.1%) is observed from 2019 to 2020.

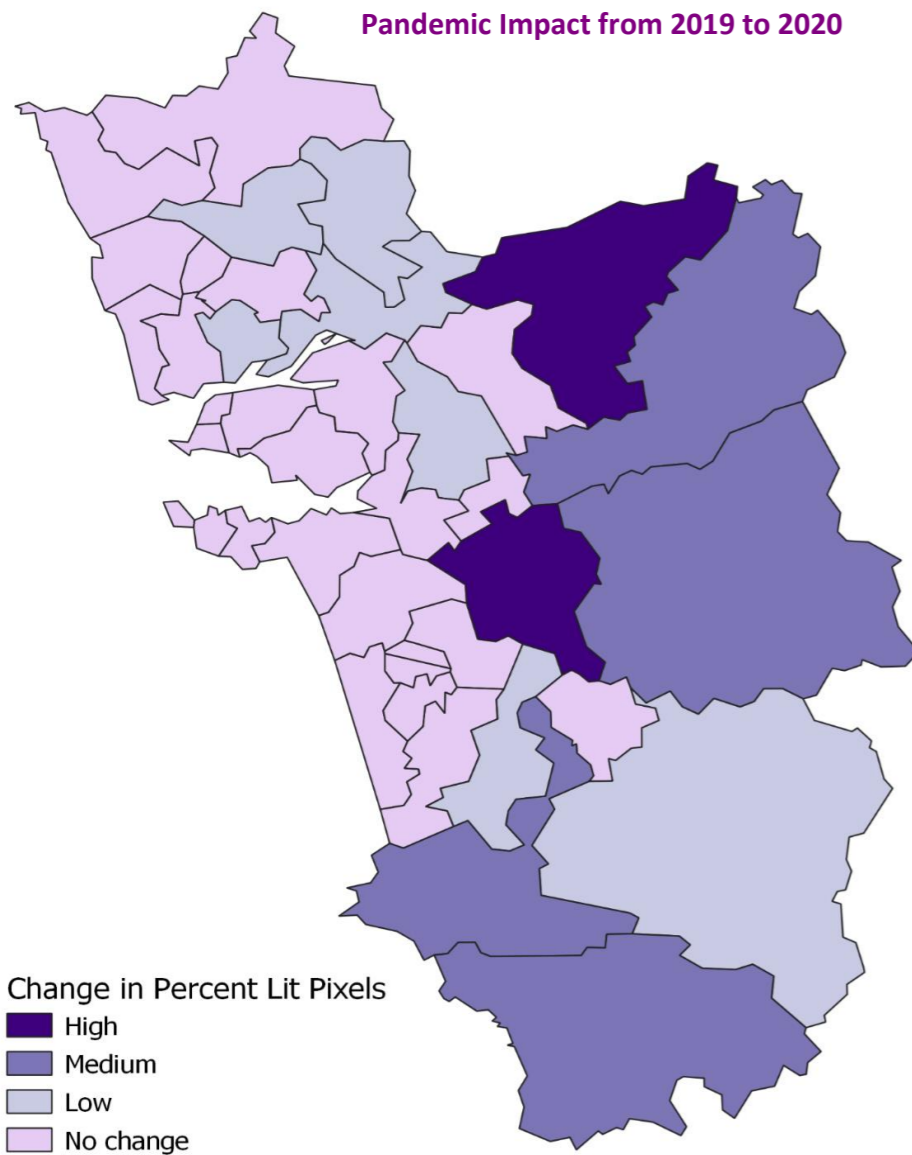


The data suggests marginal change in lit pixels in most constituencies from 2019 to 2020. Velim and Curchorem have shown absolutely no change in Lit Pixels, surpassing the pandemic impact. All other 38 constituencies had marginal to high negative impact. Siroda, Quepem, Canacona, Valpoi, Sanguem, Porlem and Sanvordem showed -50% to -150% change in lit pixels, representing significant pandemic impact.

It is also pertinent to note that lit pixel change are higher in constituencies having larger area.

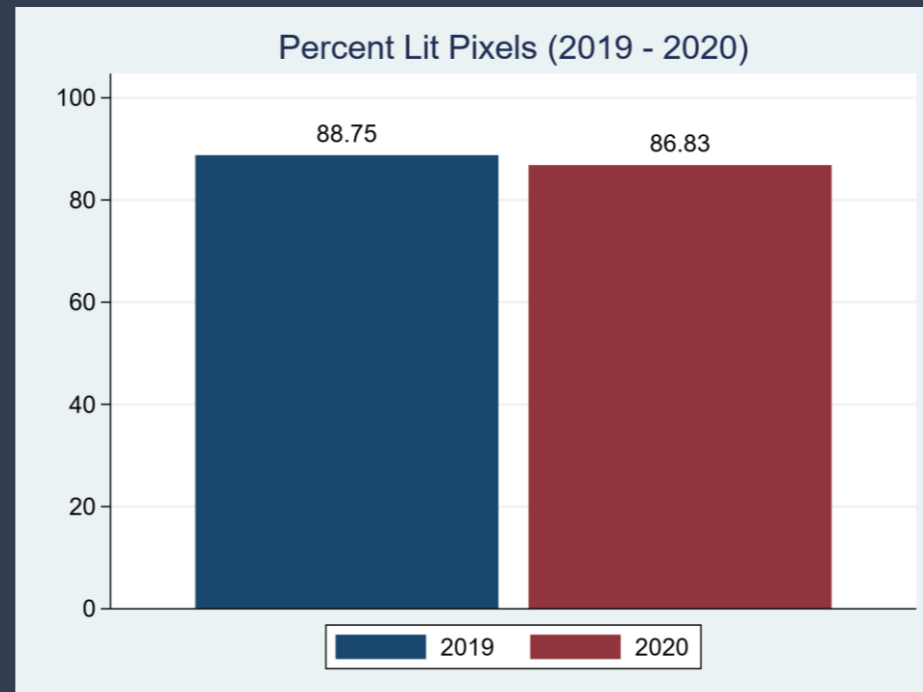


6. Pandemic impact on Percentage change in lit pixels across constituencies from 2019 to 2020 - indicates the percentage of lit pixels with respect to total pixels

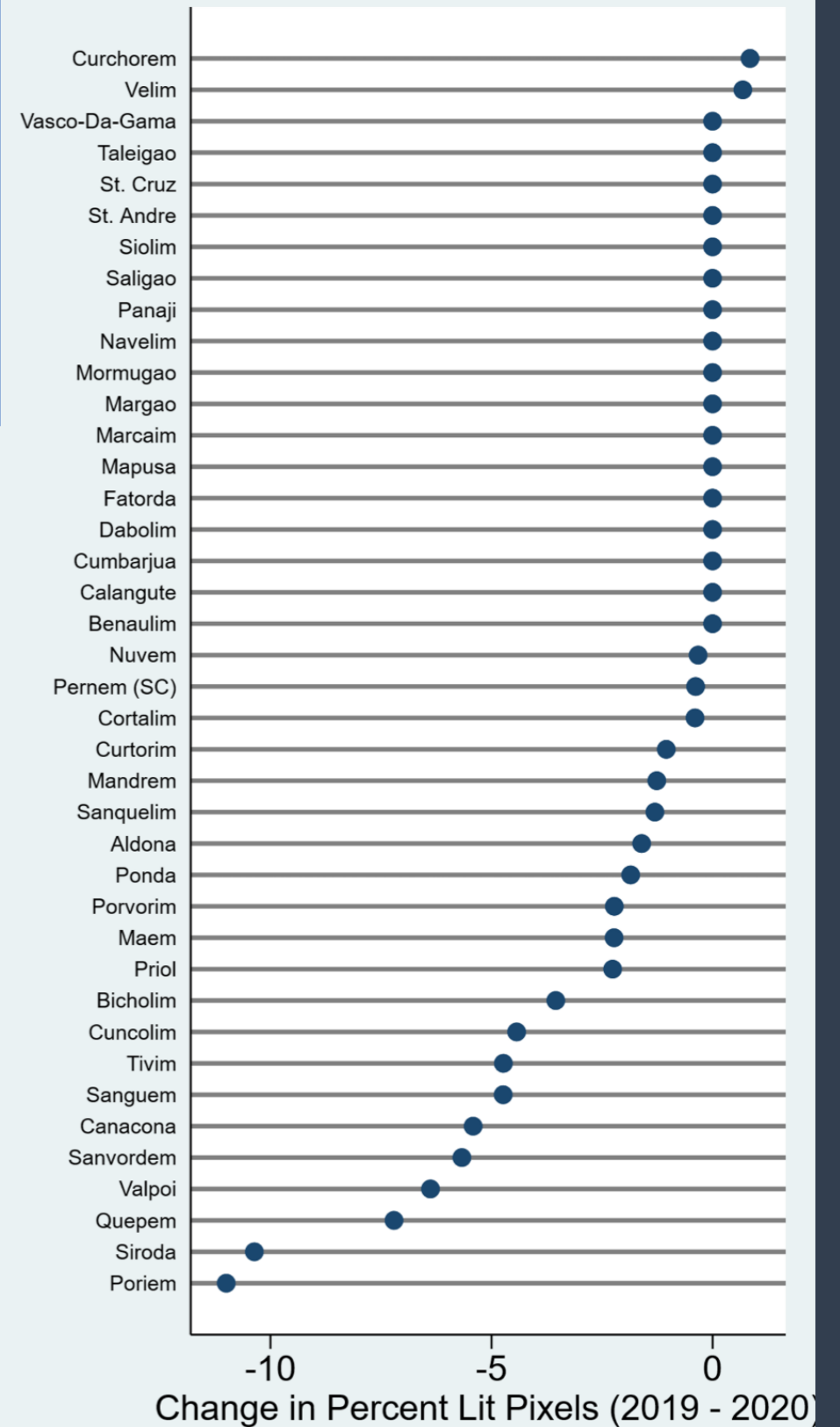


The visual on right is representative of the pandemic effect on percentage change in lit pixels. It is evident that only two constituencies of Curchorem and Vellem have shown a minute but positive % increase in lit pixels. 17 constituencies show a zero per cent change, and all other constituencies show a negative per cent change in lit pixels. Siroda and Poriem have a greater than 10% decline in lit pixels.

The visual below describes the pandemic effect, studied while comparing 2019 with 2020, on per cent of lit pixels. The pandemic impact on the states' percent lit pixels is noted, as a 1.92% drop in percent of lit pixels is observed from 2019 to 2020.



In this visual constituencies of Poriem (18) and Siroda (22) elucidate a high negative percentage change in lit pixels, representing high pandemic impact more than -10% change. Constituencies of Valpoi (19), Sanvordem (38), Quepem (36) and Canacona (40) denote a medium percent change in lit pixels. The number of constituencies having no change in percent lit pixels are 27 out of 40 (67.5%), representing no change from pre-to-post pandemic phase.



Appendix - Data table

No.	Name	Total Pixels	Lit Pixels 2015	Lit Pixels 2019	Lit Pixels 2020	Percent Lit Pixels 2015	Percent Lit Pixels 2019	Percent Lit Pixels 2020	Total Radiance 2015	Total Radiance 2019	Total Radiance 2020
1	Mandrem	396	375	392	387	94.70	98.99	97.73	346.87	550.47	510.31
2	Pernem	782	556	641	638	71.10	81.97	81.59	436.76	622.54	625.01
3	Bicholim	423	326	333	318	77.07	78.72	75.18	453.06	433.99	413.95
4	Tivim	317	295	300	285	93.06	94.64	89.91	574.30	652.34	576.37
5	Mapusa	57	57	57	57	100	100	100	285.06	455.69	360.20
6	Siolim	227	227	227	227	100	100	100	466.68	778.07	653.12
7	Saligao	159	159	159	159	100	100	100	612.31	846.50	621.97
8	Calangute	133	133	133	133	100	100	100	802.48	1171.30	820.13
9	Porvorim	135	133	135	132	98.52	100	97.78	479.53	587.34	473.69
10	Aldona	187	187	187	184	100	100	98.40	387.18	449.09	365.52
11	Panaji	24	24	24	24	100	100	100	367.27	436.87	309.27
12	Taleigao	33	33	33	33	100	100	100	362.93	331.58	263.95
13	St. Cruz	135	135	135	135	100	100	100	646.73	836.44	632.74
14	St. Andre	207	203	205	205	98.07	99.03	99.03	494.66	696.79	476.15
15	Cumbarjua	273	265	267	267	97.07	97.80	97.80	561.51	747.55	554.15
16	Maem	404	382	396	387	94.55	98.02	95.79	560.27	597.96	514.94
17	Sanquelim	383	379	379	374	98.96	98.96	97.65	1081.90	1045.65	870.21
18	Poriem	1091	563	665	545	51.60	60.95	49.95	456.60	557.68	469.06
19	Valpoi	1489	378	525	430	25.39	35.26	28.88	402.04	573.59	454.91
20	Priol	354	344	352	344	97.18	99.44	97.18	691.36	847.09	636.41
21	Ponda	108	102	107	105	94.44	99.07	97.22	284.48	422.67	296.55
22	Siroda	579	351	459	399	60.62	79.27	68.91	411.70	650.86	484.16
23	Marcaim	206	205	206	206	99.51	100	100	500.11	578.68	397.72
24	Mormugao	17	17	17	17	100	100	100	286.67	310.87	272.85
25	Vasco-Da-Gama	45	45	45	45	100	100	100	556.14	796.75	620.79
26	Dabolim	64	64	64	64	100	100	100	490.06	708.04	593.59
27	Cortalim	252	251	252	251	99.60	100	99.60	770.48	1140.56	738.39
28	Nuvem	306	301	306	305	98.37	100	99.67	915.97	1260.61	890.14
29	Curtorim	191	189	191	189	98.95	100	98.95	308.51	594.59	417.04
30	Fatorda	30	30	30	30	100	100	100	166.34	301.66	227.34
31	Margao	39	39	39	39	100	100	100	403.25	570.61	430.46
32	Benaulim	217	217	217	217	100	100	100	473.40	858.51	639.12
33	Navelim	85	83	85	85	97.65	100	100	353.39	569.30	467.63
34	Cuncoim	361	310	345	329	85.87	95.57	91.14	404.18	613.76	482.96
35	Velim	292	285	288	290	97.60	98.63	99.32	424.39	721.54	550.97
36	Quepem	916	290	404	338	31.66	44.10	36.90	216.93	419.57	326.77
37	Curcholem	236	230	233	235	97.46	98.73	99.58	388.64	523.63	407.50
38	Sanvordem	2310	549	708	577	23.77	30.65	24.98	386.66	498.34	434.23
39	Sanguem	2407	440	489	375	18.28	20.32	15.58	282.43	337.15	243.27
40	Canacona	1625	455	646	558	28.00	39.75	34.34	336.62	631.68	501.85