

Advance GIS Analysis for Computing Strahler Stream (Narwa) Order in Chhattisgarh State

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ABSTRACT

Stream-order is a useful resource of every river network, having wide range of applications. A method for determining stream orders needs to address various network topologies and geographical conditions at quick and easy pace. This paper introduces a general stream-order framework for vector hydrography and a full Chhattisgarh state analysis. It also presents a linear stream order procedure for river networks. The river network identifies different situations of Narwa/streams. There are number of methodologies used for stream order, however, one of the most popular and acceptable analysis is Strahler Stream Order. In Watershed approach-based soil and moisture conservation treatment, require a wide use of structure identification by using this order. It may assume "right structure at right place".

Key Words - Strahler Stream, drainage orders, advance GIS technology,

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INTRODUCTION

In this study the Strahler drainage numbers and length of Chhattisgarh state was analyzed and detailed drainage orders along with drainage length of each stream has been calculated. The data set used in the study was prepared by NRSC Hyderabad, using Survey of India Topo sheet (1:50,000) manual digitization process. The error removal process is relatively tricky and hence because of use of advance GIS technology was used to remove the error. Streams with various orders do have their own hydraulic characteristics (Moges and Bhole 2015). These characteristics have an impact on the hydraulics of the channel with different order.

Study Area

The study area includes Chhattisgarh state has the geographical area is about 135,100 Sq. km (Anonymous, 2021). There are five major river basins

extant in the state. Mahanadi Basin drains out 75,858.45 Sq. km, Godavari Basin drains out 38,694.02 Sq. km, Ganga Basin drains out 18,406.65 Sq km, Brahmani Basin drains out 1,394.55 Sq. km and Narmada Basin drains out 743.88 Sq. km of catchment area in the state.

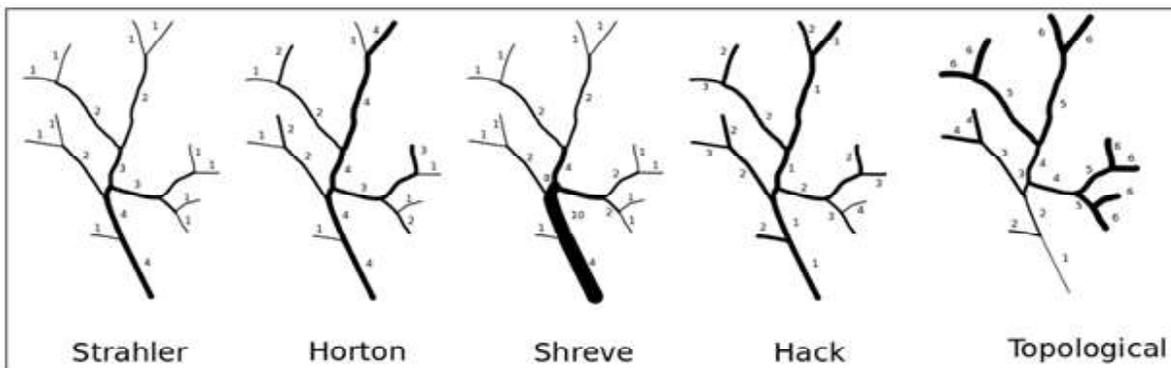
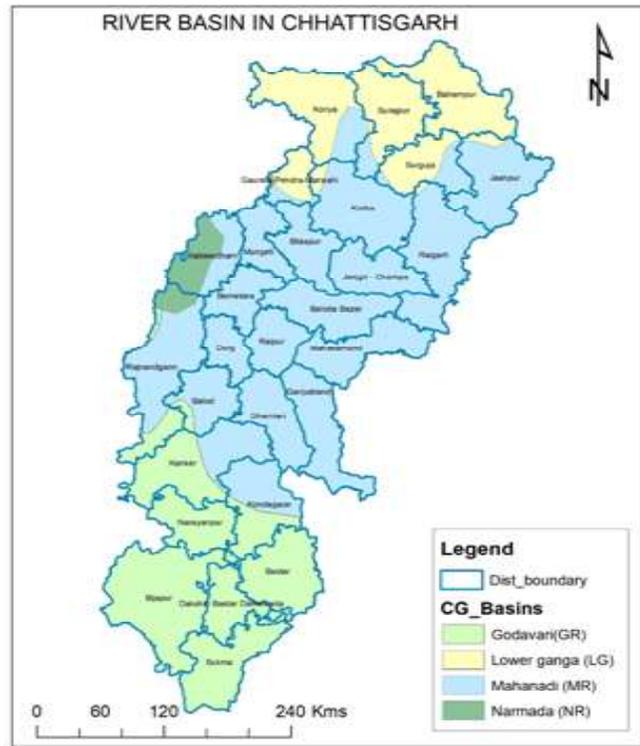
Objectives of the study:

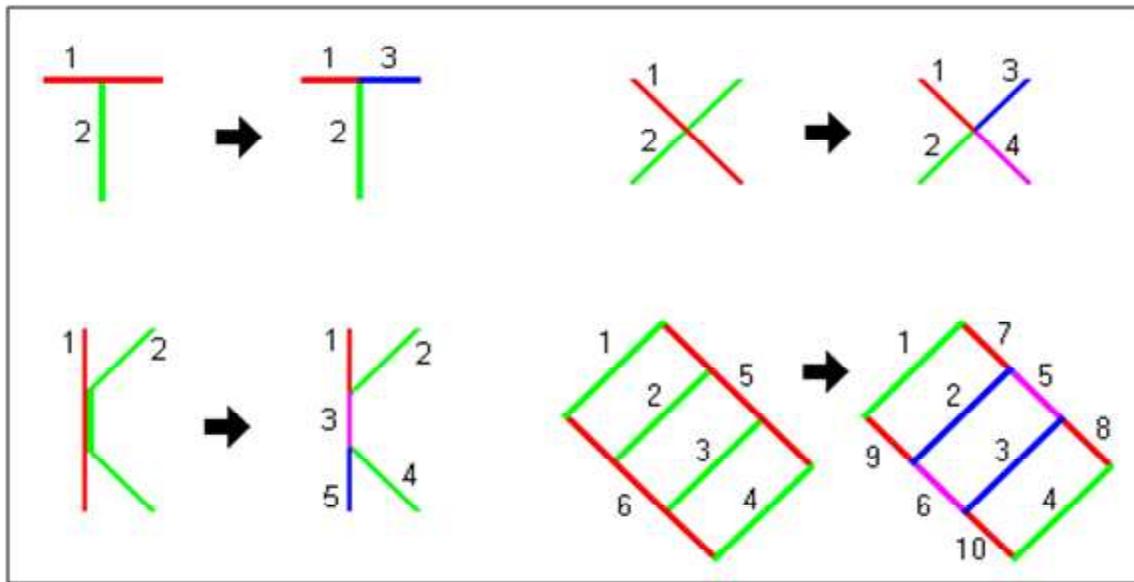
- i. To identify the actual number of stream order, it will help to guidance planning proper interventions.
- ii. To calculate the accurate drainage/Narwa length stream order wise.
- iii. To prepare Drainage Line Treatment (DLT) plan

MATERIALS AND METHODS

There are various types of methodology used for

determination of stream order i.e., Strahler, Shreve, Horton, Scheidegger, Woldenberg and Hack (Doornkamp and King, 1971; Gleyzer *et al.* 2004) however, under this study the Strahler Stream Order method (Strahler, 1957) assigns an order of $k = 1$ to the streams that have no tributaries. Thereafter, proceeding downstream, when two (or more) streams of the same order k meet, they form a stream with an order of $k + 1$. However, when a stream of order k is met by one of a lower order, no change occurs in the down-stream order. For this analysis using the NRSC data sets for which was procure by Rural Development in 2008-2009. The split selected lines where it intersects using Planarize Lines on the Advanced Editing toolbar was used for data correction. When Planarize is used on a multipart line feature, it is split at the point of intersection into a new feature.





Under the Edit tool of ArcGIS 10.3 the line feature was selected to split at intersections and Planarize Lines on the Advanced Editing toolbar was selected to get the results. The selected lines are split into new features where they intersect. Planarize also removes overlapping line segments—such as those created by constructing lines from polygons that have shared boundaries. (Source ArcGIS Desktop)

RESULTS

The result was very important to overcome the duplicate count errors. Stream Order is shown as the measure of the relative size of streams. There are only two 9th order streams naming i.e. Mahanadi and Indravati. There are 17623 micro watersheds. Drainage density is the length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. Most of the hilly and forested area under the districts, Balarampur, Bastar, Bijapur, Dantewada, Durg, Jashpur, Korba, Koriya, Narayanpur, Sarguja, Surajpur and Sukma having high drainage density area. The stream wise full details and length calculated this information support further planning process. The District-Block wise drainage count is given in appendices. Here in this analysis followed by the Strahler Method. This analysis support Narwa project for further detailing of Narwa treatment plan easily. The

drainage count will give the assumptions DLT structures require every Narwa. Output of final map will support the field person for planning the structures at right locations. Over structuring may be minimize and selection process quite easy. This analysis broadly supports “Ridge to Valley” treatment concept.

No. of Stream Details Analysis, Chhattisgarh		
Sl no	Stream order	No. of streams (Count)
1	1	375086
2	2	88229
3	3	20383
4	4	4737
5	5	1065
6	6	282
7	7	76
8	8	25
9	9	2
Grand total		489885
In words Four Lakhs, eighty-nine thousand, eight hundred eighty-five only		

Table 1. Stream order of Chhattisgarh (Strahler Method)

Dist. Name	Block Name	1st Order stream	Length in metre	2nd Order stream	Length in metre	3rd Order stream	Length in metre	4th Order stream	Length in metre	5th Order stream	Length in metre	6th Order stream	Length in metre	7th Order stream	Length in metre	8th Order stream	Length in metre	9th Order Stream	Length in metre	Grand Total count of drainage	Grand Total Length of Stream	
Balod	Balod	404	298249.23	97	8768.98	30	2103.53	7	5357.22	3	1873.06			1	1133.88					542	317485.89	
Balod	Dondi	1926	1117040.37	457	41313.65	110	7712.94	27	20663.55	6	3746.12	2	158.13								2528	1190634.77
Balod	Dondi Luhara	1168	792983.94	298	26939.75	84	5889.88	16	12245.07	4	2497.41	2	158.13								1572	840714.19
Balod	Gunderdehi	258	285177.62	63	5695.32	15	1051.76	3	2295.95												339	294220.66
Balod	Gurur	295	247380.09	63	5695.32	16	1121.88	7	5357.22	1	624.35										383	261312.74
Balod Total		4051	2740831.26	978	88413.02	255	17880.00	60	45919.01	14	8740.95	4	316.27	1	2267.75	1	1442.77	1	885.07	5364	2904368.25	
Baloda Bazar	Baloda Bazar	389	378555.49	98	8859.38	24	1682.82	5	3826.58	1	624.35	1	79.07								520	395955.54
Baloda Bazar	Bhatapara	282	287925.85	75	6780.14	21	1472.47	2	1530.63	2	1248.71										383	300400.57
Baloda Bazar	Bilagarh	605	513384.86	141	12746.66	38	2664.47	11	8418.48	3	1873.06	1	79.07								800	540609.37
Baloda Bazar	Kasdol	3495	2140448.10	851	76931.98	188	13182.12	45	34439.26	11	6867.89	3	237.20	1	1133.88						4594	2273240.42
Baloda Bazar	Palari	300	310408.28	50	4520.09	13	911.53	3	2295.95												366	318135.85
Baloda Bazar	Simga	339	355650.65	88	7955.36	19	1332.24	8	6122.59												456	373946.31
Baloda Bazar Total		5410	3986373.23	1303	117793.62	303	21245.64	74	56633.44	17	10614.01	5	395.33	1	1133.88	5	7213.84	1	885.07	7119	4202288.07	
Bairampur	Bairampur	5680	2651217.99	1307	118155.23	313	21946.82	72	55102.82	21	13111.43	4	316.27	2	2267.75						7399	2862118.29
Bairampur	Rajpur	2949	1182843.46	599	54150.71	129	9045.17	31	23724.82	4	2497.41	5	395.33	1	1133.88						3319	1275233.56
Bairampur	Ramanujani	8995	3721579.97	2021	182702.16	466	32674.82	107	81888.90	25	15608.84	5	395.33	2	2267.75	4	5771.07				11625	4042888.84
Bairampur	Sanni(Kusmi)	7256	3509953.89	1708	154406.38	377	26434.35	88	67347.88	24	14984.49	8	632.53	2	2267.75						9463	3776027.26
Bairampur	Shankargarh	3148	1329253.02	731	66083.76	174	12200.47	39	29847.36	10	6243.54	1	79.07								4103	1443707.21
Bairampur	Wadrafnagar	7036	3056530.39	1638	148078.25	389	27775.76	91	69643.83	17	10614.01	4	316.27	1	1133.88	2	2885.54				9178	3316477.92
Bairampur Total		34664	15451378.72	8004	723576.48	1848	129577.39	428	327955.60	101	63059.72	27	2134.80	8	9071.00	7	10099.38			45087	167616453.08	
Bakavand	Bakavand	1174	846847.60	303	27391.76	60	4207.06	13	9549.12	5	3121.77	2	158.13								1557	891675.44
Bastar	Bastar	1586	842578.43	401	36251.15	99	6941.65	27	20663.55	4	2497.41	2	158.13	1	1133.88						2120	910284.20
Bastar	Bastar	1432	958987.90	332	30013.42	71	4978.35	14	10714.44	6	3746.12	3	237.20	2	2267.75	1	1442.77				1861	1012387.95
Bastar	Derbha	3033	1808715.27	734	66354.96	189	13252.23	50	38265.84	16	9989.66	6	474.40	2	2267.75						4030	1939201.11
Bastar	Jagdajpur	1640	933352.79	372	33629.49	82	5749.65	18	13775.70	3	1873.06										2115	988380.69
Bastar	Lohandajuda	1688	987568.32	418	37787.98	100	7011.76	32	24490.14	5	3121.77	1	79.07	2	2267.75						2246	1062326.78
Bastar	Tokpal	419	250063.98	108	9763.40	27	1893.18	3	2295.95	1	624.35	1	79.07								559	264719.93
Bastar Total		10972	6628114.28	2668	141192.16	628	44033.88	157	120154.74	40	24974.14	15	1186.00	7	7937.13	1	1442.77			14488	7069035.10	
Bemetara	Bemetara	331	301721.98	74	6689.74	12	841.41	4	3061.27												426	314819.35
Bemetara	Berla	333	352474.14	81	3732.55	17	1192.00	4	3061.27	1	624.35	1	79.07	2	2267.75						439	367021.13
Bemetara	Nawagarh	166	197745.44	26	2350.45	4	280.47														196	200376.36
Bemetara	Saja	239	251683.68	57	5152.91	18	1262.12	4	3061.27	2	1248.71	1	79.07								321	262487.75
Bemetara Total		1069	1103625.25	238	21515.64	51	3576.00	12	9183.80177	44	1873.06	5	395.33	4	4535.50					1382	1144704.58	
Bijapur	Bhairnagarh	12628	6698316.62	3060	276629.69	725	50835.29	184	140818.2938	44	27871.56	10	790.67	2	2267.75	1	1442.77				16655	7199457.70
Bijapur	Bhopalpatnam	6122	3763302.96	1480	133794.75	364	25522.82	79	60460.02832	13	8116.60	2	158.13	1	1133.88						8061	3992489.17
Bijapur	Jagdajpur	4763	2882552.87	1180	106674.19	283	19843.29	59	45153.69204	13	8116.60	4	316.27								6302	3062656.91
Bijapur	Usur	8322	5110931.05	1915	173119.56	432	30990.82	104	79592.94867	22	13735.78	4	316.27	2	2267.75	1	1442.77				10802	5411696.94
Bijapur Total		31835	18455103.50	7635	690218.19	1804	126492.21	426	326024.9628	92	57440.53	20	1581.33	5	5669.38	2	2885.54	1	885.06962	41820	19666300.72	
Bilaspur	Bilha	348	325173.87	102	9220.99	22	1542.59	4	3061.27	1	624.35										480	343024.69
Bilaspur	Kota	3160	1815433.87	750	67801.39	190	13322.35	47	35969.89027	10	6243.54	5	395.33								4162	1939164.38
Bilaspur	Masturi	723	571474.14	185	16724.34	40	2804.71	13	9949.118584	3	1873.06	1	79.07								965	602904.44
Bilaspur	Takhatpur	240	257222.41	61	5514.51	15	1051.76	3	2295.950443	4	2497.41	2	158.13								325	237240.19
Bilaspur Total		4471	2937802.29	1098	99261.24	267	18721.41	67	51276.2655	18	11238.37	8	632.53	3	3401.63					5932	3122333.69	
Dakshin Bastar	Dantewada	3505	190769.10	842	76118.37	198	13883.29	44	33673.93982	11	6667.89	3	237.20	1	1133.88						4604	2039613.66
Dakshin Bastar	Dantewada	2257	1361513.94	559	50534.64	137	9606.12	29	22194.18761	7	4370.48	1	79.07								2990	1448298.42
Dakshin Bastar	Dantewada	2073	1216589.22	496	44839.32	113	7923.29	20	15306.33628	6	3746.12	1	79.07								2709	1288483.36
Dakshin Bastar	Dantewada	2321	1404427.08	546	49359.42	118	8273.88	27	20663.55398	5	3121.77										3017	1485845.70
Dakshin Bastar Dantewada Total		10156	5892923.33	2443	220851.74	566	39686.58	120	91838.0177	29	18106.25	5	395.33	1	1133.88					13320	6262411.14	
Dhamtari	Dhamtari	375	304212.65	101	9130.59	30	2103.53	9	6887.851328	3	1873.06	2	158.13								520	324365.82
Dhamtari	Kurud	203	207615.60	47	4248.89	13	911.53	5	3826.584071	3	1873.06										271	218475.66

Advance GIS Analysis for Computing Strahler Stream (Narwa) Order in Chhattisgarh State

Korba Total	17572	10315951.35	4255	384659.91	998	69977.40	239	182910.7186	53	33090.74	13	1027.87	4	4535.50				23134	10992153.49	
Koriya	2972	1498845.27	711	64275.72	172	12066.23	38	29082.03894	8	4994.83	2	158.13						3903	1609416.22	
Koriya	10288	5227045.15	2366	213890.80	541	37933.64	116	88776.75044	30	18730.61	8	632.53	2	2267.75				13351	5589277.23	
Koriya	5202	2197195.86	1247	112731.12	281	19703.06	56	42857.74159	9	5659.18	6	474.40	2	2267.75				6803	2380849.11	
Koriya	4254	2243592.06	957	86514.58	218	15285.64	54	41327.10797	12	7492.24	4	316.27	1	1133.88				5500	2395661.78	
Koriya	5664	2769844.72	1223	110561.47	263	18300.70	58	44388.37522	14	8740.95	2	158.13						7222	2951994.36	
Koriya Total	28380	13996523.05	6504	587973.69	322	103283.28	322	246432.0142	73	45377.81	22	1739.47	5	5669.38				36779	14927198.70	
Mahasamund	2197	1351400.65	580	52433.08	147	10307.29	36	27551.40531	6	3746.12	1	79.07						2967	1445517.61	
Mahasamund	1094	817549.69	306	27662.97	68	4768.00	23	17602.8873	5	3121.77	1	79.07						1594	870783.78	
Mahasamund	1191	813824.76	277	25041.31	70	4908.23	13	9949.11854	2	1248.71	2	158.13						1458	855130.27	
Mahasamund	2321	1361775.63	589	53246.69	127	8904.94	23	17602.8873	8	4994.83	2	158.13						3070	1446682.51	
Mahasamund	2137	1387638.65	521	47099.37	139	9746.35	31	23724.82124	9	5619.18	3	237.20	2	2267.75				2842	1476331.33	
Mahasamund Total	8940	5732187.38	2773	205483.43	551	38634.82	126	96429.91859	30	18730.61	9	711.60	2	2267.75				11931	6094445.51	
Mungeli	3877	2257451.69	874	79011.22	219	15355.76	61	46684.32566	17	10614.01	4	316.27						5052	2409433.28	
Mungeli	174	151385.47	32	2892.86	4	280.47	1	765.3168142										211	155324.11	
Mungeli	145	152803.48	36	3254.47	3	210.35												184	156268.30	
Mungeli Total	4196	2561640.63	942	85158.55	226	15946.59	62	47449.64248	17	10614.01	4	316.27						5447	2721025.69	
Narayanpur	3295	1929357.72	831	75123.94	201	14093.64	47	35969.89027	15	9365.30	5	395.33	1	1133.88				4395	2065439.72	
Narayanpur	11865	5847698.76	2666	241011.36	564	39546.35	127	97195.2354	23	14360.13	3	237.20						15249	6241491.79	
Narayanpur Total	15160	7777056.48	3497	316135.30	765	53639.99	174	133165.1257	38	23725.44	8	632.53	1	1133.88				19644	8306931.51	
Raigarh	893	626611.04	202	18261.18	55	3856.47	17	13010.88584	5	3121.77	1	79.07						1173	664939.91	
Raigarh	1844	1009755.71	460	41584.86	109	7642.82	29	22194.18761	10	6243.54	2	158.13						2454	1087579.25	
Raigarh	1095	601446.63	246	22238.86	60	4207.06	17	13010.88584	1	624.35								1359	641527.29	
Raigarh	3279	1680126.15	773	69880.64	187	13112.00	56	42857.74159	12	7492.24								4307	1813468.77	
Raigarh	871	530529.15	188	16995.55	45	3155.29	3	2295.95043	1	624.35								1059	554734.18	
Raigarh	2036	1137397.15	439	39686.42	92	6450.82	22	16836.96991	5	3121.77	1	79.07						2595	1204112.20	
Raigarh	964	715197.05	224	20250.02	44	3085.18	8	6122.534513	1	624.35								1261	745279.13	
Raigarh	1793	964693.82	466	42127.27	104	7292.23	25	19132.92095	6	3746.12	2	158.13						2396	1037150.50	
Udaipur																				
Raigarh (Dharmanjgarh)	5887	3220640.14	1357	122675.32	305	21385.88	75	57398.76106	12	7492.24	2	158.13						7638	3429750.48	
Raigarh Total	18572	10486936.85	4355	393700.10	1001	70187.75	252	192859.8372	53	33090.74	8	632.53	1	1133.88				24242	11178541.69	
Raipur	299	261607.30	68	6147.33	14	981.65	5	3826.584071	1	624.35								387	273187.21	
Raipur	412	379398.35	90	8136.17	18	1262.12	4	3061.267257										524	391857.90	
Raipur	212	241611.88	46	4158.49	10	701.18	1	765.3168142										269	247236.86	
Raipur	432	408641.00	99	8949.78	20	1402.35	2	1530.633628	1	624.35	1	79.07						555	421227.19	
Raipur Total	1355	1291256.54	303	27991.76	62	4347.29	12	9183.80177	2	1248.71	1	79.07						1735	1333509.17	
Rajnandgaon	1825	927538.00	432	39053.60	100	7011.76	30	22959.50443	9	5619.18	2	158.13	1	1133.88				2399	1003474.06	
Rajnandgaon	4913	2346371.77	1157	104594.95	263	18440.94	67	51276.26655	13	8116.60	5	395.33						6418	2529195.82	
Rajnandgaon	2796	1505575.62	624	56410.76	130	9115.29	29	22194.18761	7	4370.48	4	316.27	1	1133.88				3591	1599116.48	
Rajnandgaon	344	246586.81	85	7684.16	17	1192.00	4	3061.267257	1	624.35	1	79.07						452	259227.65	
Rajnandgaon	2673	1515150.81	620	56049.15	146	10237.17	36	27551.40531	9	5619.18	2	158.13						3486	1614765.85	
Rajnandgaon	1750	1110984.72	406	36703.15	91	6380.70	24	18367.60354	7	4370.48	3	237.20						2281	1177043.86	
Rajnandgaon	5399	2802801.76	1202	108663.03	291	20404.23	60	45919.00885	14	8740.95	4	316.27						6970	2968645.25	
Rajnandgaon	2921	1546062.31	648	58580.40	153	10728.00	40	30612.67257	3	1873.06								3765	2647856.45	
Rajnandgaon	392	351035.77	87	7864.96	21	1472.47	1	765.3168142										501	361138.52	
Rajnandgaon Total	23013	12352107.56	5261	475604.18	1212	84982.57	291	222707.1929	63	39334.28	21	1660.40	2	2267.75				29863	13178663.94	
Sukma	2323	1618994.80	568	51348.26	128	8975.06	29	22194.18761	6	3746.12	6	3746.12						3056	1707835.07	
Sukma	13677	7609433.40	3119	281963.40	735	51536.46	164	125511.9575	38	23725.44	10	790.67	1	1133.88				17745	8095537.97	
Sukma	3148	1894242.07	751	67891.80	170	11920.00	30	22959.50443	2	1248.71	1	79.07						4103	1999783.91	
Sukma Total	19148	11122670.27	4438	401203.45	1033	72431.52	223	170665.6496	46	28720.27	11	869.73	2	2267.75	3	4328.30		24904	11803156.95	
Surajpur	1205	649132.16	281	25402.92	78	5469.18	15	11479.7321	4	2497.41	1	79.07						1585	695194.37	
Surajpur	10036	4258224.03	2240	202500.16	496	34778.35	108	82654.21593	24	14984.49	9	711.60	5	5669.38				12921	4603850.52	
Surajpur	4905	2218160.50	1133	102425.31	222	15566.12	46	35204.57345	11	6867.89	2	158.13						6319	237682.52	
Surajpur	2983	1406417.78	670	60569.25	146	10237.17	32	24490.13805	4	2497.41	1	79.07						3836	1504290.82	
Surajpur	1563	797985.05	339	30646.23	78	5469.18	20	15306.36628	3	1873.06								2003	851259.85	
Surajpur	1202	694066.92	284	25674.13	65	4557.65	23	17602.8873	3	1873.06	4	316.27	5	5669.38				1586	749759.69	

Surgajpur Total	21894	10023966.44	4947	447218.00	1085	76077.63	244	1867373027	49	30593.33	17	1344.13	11	12472.63	3	4328.30	28250	10782737.77
Surguja	1918	879030.89	470	42488.87	110	7712.94	39	29847.35575	9	5619.18	3	237.20	2	2267.75			2551	967204.19
Surguja	1251	649675.01	273	24679.71	64	4487.53	20	15306.33628	5	3121.77	3	237.20					1616	697507.55
Surguja	2142	1027452.58	492	44477.71	119	8344.00	21	16071.6531	7	4370.48	2	158.13					2783	1100874.55
Surguja	2278	986977.71	518	46828.16	125	8764.70	28	21428.8708	6	3746.12	1	79.07					2956	1067824.63
Surguja	1784	961831.07	371	33539.09	78	5469.18	17	13010.38584	3	1873.06							2253	1015722.78
Surguja	1378	687415.95	323	29199.80	81	5679.53	15	11479.75221	4	2497.41							1801	736272.45
Surguja	2907	1501886.33	693	62648.49	148	10377.41	35	26786.0885	9	5619.18							3792	1607317.50
Surguja Total	13658	6694269.54	3140	283861.84	725	50835.29	175	133930.4425	43	26847.21	9	711.60	2	2267.75			17752	7192723.66
Uttar Bastar																		
Kanker	5665	3122840.51	1315	118878.44	292	20474.35	71	54337.49381	18	11238.37	6	474.40	1	1133.88			7368	3329377.44
Uttar Bastar																		
Kanker	2962	1616304.86	691	62467.68	160	11218.82	44	33673.93982	9	5619.18	2	158.13	1	1133.88			3869	1730576.49
Uttar Bastar																		
Kanker	1056	631523.71	262	23685.29	64	4487.53	12	9183.80177	2	1248.71	2	158.13					1398	670287.17
Uttar Bastar																		
Kanker	3022	1616452.37	682	61654.07	153	10728.00	37	28316.72212	8	4994.83	2	158.13					3904	1722304.12
Uttar Bastar																		
Kanker	1998	1113416.78	485	43844.90	116	8133.65	22	16836.96991	1	624.35	3	237.20					2625	1183093.85
Uttar Bastar																		
Kanker	2986	1654196.28	721	65179.74	173	12130.35	36	27551.40531	6	3746.12							3922	1762803.90
Uttar Bastar																		
Kanker	8034	4436990.51	1976	178634.07	428	30010.35	93	71174.46372	17	10614.01	6	474.40	1	1133.88			10555	4729031.68
Uttar Bastar-Kanker Total	25723	14191725.01	6132	554344.20	1386	97183.04	315	241074.7965	61	38085.57	21	1660.40	3	3401.63			33641	15127474.65
Grand Total (in Metre)	375086	206214996.38	88229	7976065.62	20383	1429207.77	4737	3625305.7949	1065	1664936.60	282	22296.82	76	86174.52	25	36069.20	2	220056822.79
Grand Total (in Kilometers)	375086	206215.00	88229	7976.07	20383	1429.21	4737	3625.31	1065	1664.94	282	22.30	76	86.17	25	36.07	2	220056.82

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