

APPLIED RESEARCH

Why ArcGIS in hydrometeorological services? For easy and quick solution

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Abstract

"Necessity is the mother of Invention". Here necessity is to incorporate the rain gauge stations with different administrative boundaries like State, Met-subdivision (36), District (738), Blocks (5961) and river basin and sub-basins (162) in the Hydro-meteorological services. India Meteorological Department (IMD) has 6372 rain gauge stations throughout India. IMD has to prepare the rainfall statistics, maps, charts etc. in different spatial mentioned above and temporal (Daily, Weekly, Monthly, Seasonal and annual) domains and disseminate to different Ministries, Prime Minister Office, Cabinet Secretariat, NITI Ayog and different insurance companies. Many Academic, Insurance and Banking institutions are also downloading these statistics and maps from the IMD website.

The purpose of this paper is to present how to overcome the problems of overshoots and undershoots of Districts and Blocks by using ArcGIS platform and get a good solution for the preparation of station level data by incorporating all the Block, Districts, Met-Sub-Divisions, States, Homogeneous Region, River Basins and sub-basins data. It will be very useful for GIS Analysts for preparing different spatial and temporal scale analysis.

Introduction

India Meteorological Department (IMD) is the nodal agency for preparing the rainfall statistics, maps, charts etc. in different spatial (District, Met-subdivision, State, Homogeneous Region and country) and temporal (Daily, Weekly, Monthly, Seasonal and Annual) domains and disseminate to the different ministries, Cabinet Secretariat, Neeti Ayog and different insurance

companies. Many Academic, Insurance and Banking institutions are also using these data on a day to day basis. Different methods like Arithmetic Mean, Thiessen Polygon, Isohyetal and Isopercental are there for calculating the point rainfall to average areal rainfall. IMD is using the Arithmetic mean for calculating the rainfall statistics and maps by using ArcGIS. IMD is preparing the rainfall statistics for the 738 districts, 36 Met sub-divisions, 36 states & Union territories (UTs), four homogeneous regions and the country as whole by using these 6372 station level rainfall data.

For spatial analysis over river sub-basins and district level during heavy rainfall events over India, Isohyetal technique is used. For the Design Storm Analysis, over any catchment for construction of dams, reservoir, barrage, station level rainfall data is the main input. For getting better results, station level correct Latitude and Longitude is required. In the station level data, information for the Blocks, Districts, Sub-basins, States, Met-subdivisions are to be incorporated. To complete this job, Geographical Information System (ArcGIS) is used for easy and quick solution.



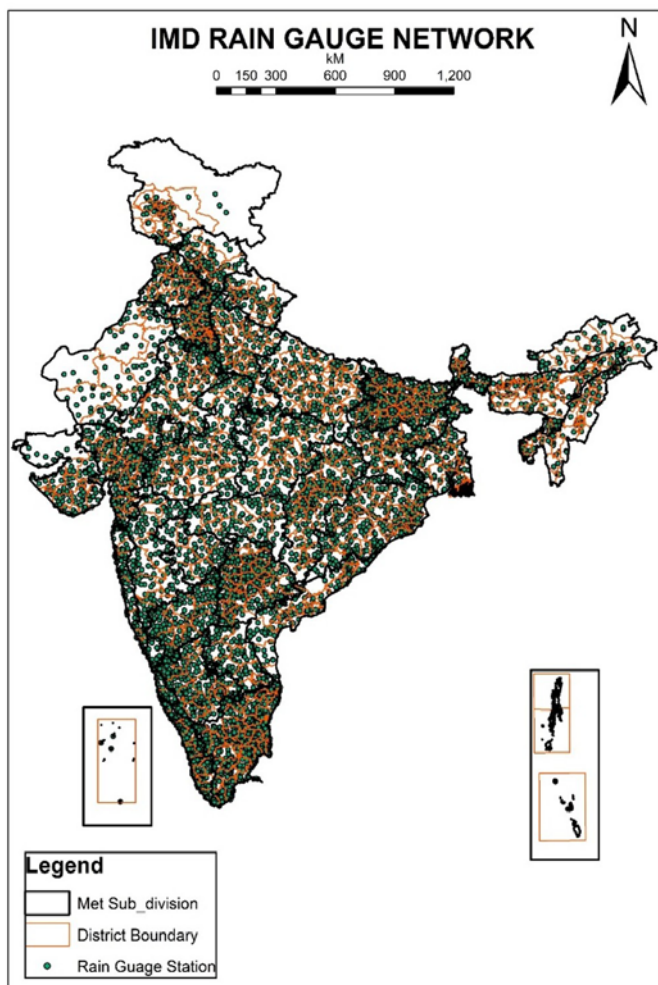


Fig 1: Rain Gauge Network of IMD

District level shape files have the information of the States, Met-subdivisions and Homogeneous Regions like East-North-East Region, North-West Region, Central Region and Southern Peninsular Region (Table-2). Only single information 'Name of the Blocks' (Table-1 Only for one district is shown) is available in the Block Shape files. There were undershoots and overshoots of block Shape files with the district Shape files file (Figure-1). There was no problem if there were no undershoots and overshoots of the block level Shape files with district Shape files. The aim of this work is to integrate information about the Block name, District name and sub-basin names with the station rain gauge data. It is the Necessity.

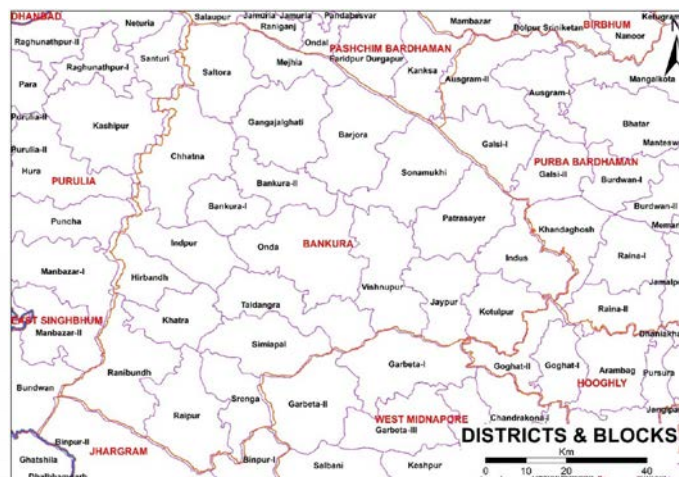


Fig 2: Undershoots & Overshoots of the Shape Files

Data and Methodology

Hydromet Division, IMD has 6372 rain gauge station network. Rainfall data of these stations are collected from different Meteorological Centers (MCs) through emails. IMD has 22 Met Centres (MC) under 6 Regional Meteorological Centers (RMCs) namely Delhi, Mumbai, Kolkata, Chennai, Guwahati, and Nagpur. For the preparation of district level rainfall statistics, Hydromet division is using Shape files of 738 districts. IMD has collected the State, District and Block level Shape files from Survey of India (Sol). River sub-basins Shape files have been collected from Central Water Commission which are used to give Quantitative Precipitation Forecast (QPF) and Hydromet bulletin for 162 River sub-basins with 7 days lead time. IMD has corrected the Latitude, Longitude of the rainfall stations by plotting the data using ArcGIS platform.

FID	Shape	Block
584	Polygon	Patrasayer
781	Polygon	Sonamukhi
782	Polygon	Indpur
783	Polygon	Hirbandh
784	Polygon	Raipur
785	Polygon	Ranibundh
786	Polygon	Srenga
787	Polygon	Khatra
3148	Polygon	Indus
3149	Polygon	Jaypur
3150	Polygon	Kotulpur

Table 1: Attribute in Block Shape Files

FID		Shape	Block
4354		Polygon	Saltora
4355		Polygon	Mejhia
4356		Polygon	Barjora
4357		Polygon	Chhatna
4358		Polygon	Bankura-I
4365		Polygon	Bankura-II
4377		Polygon	Gangajalghati
4378		Polygon	Simiapal
4379		Polygon	Taldangra
4380		Polygon	Onda
4381		Polygon	Vishnupur

Table 1: Attribute in Block Shape Files



Shape	Region	Met subdivision	States	District	District Code	RMC_MC
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PURBA BARDHAMAN	20411003	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BIRBHUM	20411002	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	HOOGHLY	20411005	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	20411001	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	HOWRAH	20411006	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	EAST MIDNAPORE	20411004	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	WEST MIDNAPORE	20411013	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PURULIA	20411011	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	MURSHIDABAD	20411008	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	NORTH 24 PARGANAS	20411010	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	NADIA	20411009	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	SOUTH 24 PARGANAS	20411012	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	KOLKATA	20411007	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PASHCHIM BARDHAMAN	20411015	RMC KOLKATA
Polygon	EAST AND NORTHEAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	JHARGRAM	20411014	RMC KOLKATA

Table 2: Attribute in District Shape Files

Step 1: We have to insert all the attribute available in the district Shape files within the block level Shape files. If there are no undershoots and overshoots in the block and district Shape files, then it is very easy to collect the information available in District Shape files to the Block level Shape files.

In the block level data, there are only Block names, no common field is there. So, it is not possible to link the

block level Shape file with district level information. Applying spatial join with block level Shape files to the district Shape files using **System Toolboxes → Analysis Tools → Overlay → Spatial Join** (Fig-3) (Match Option: completely within).

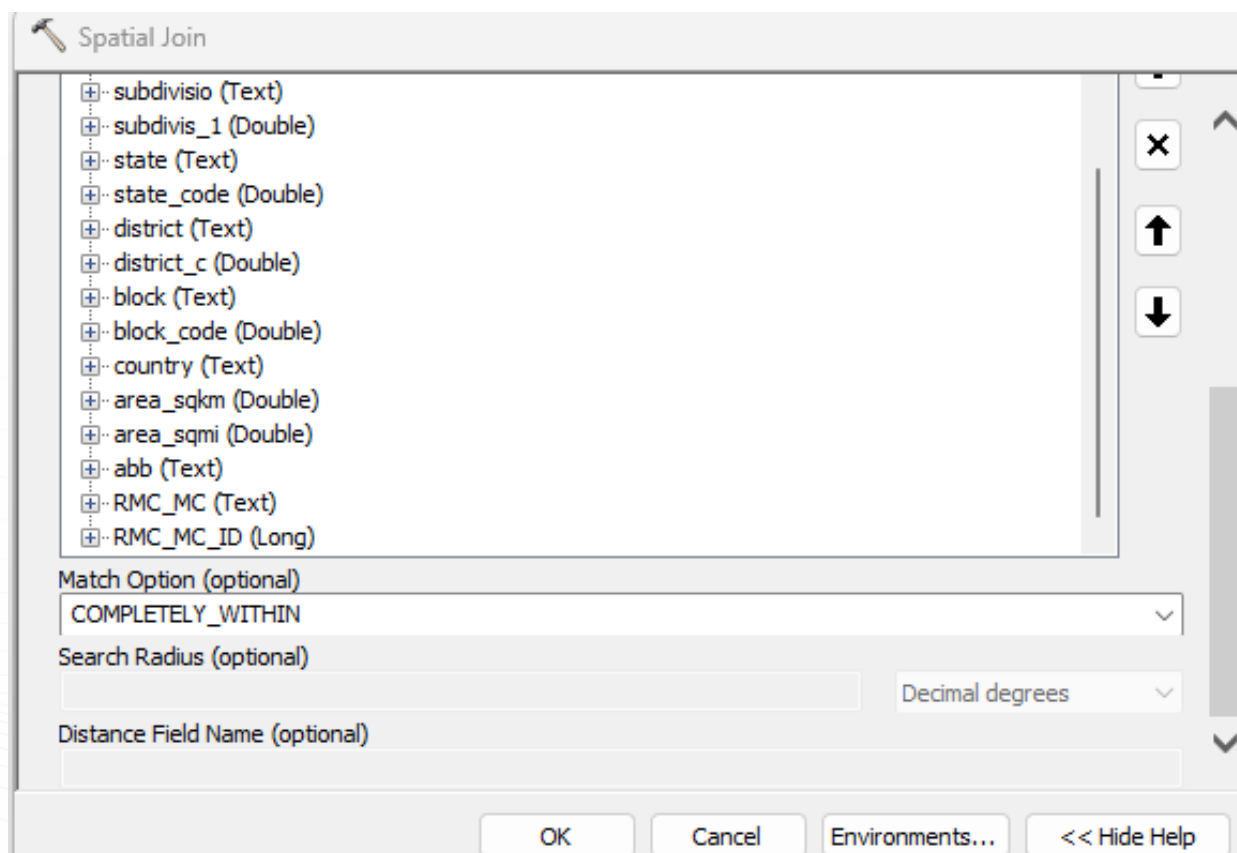
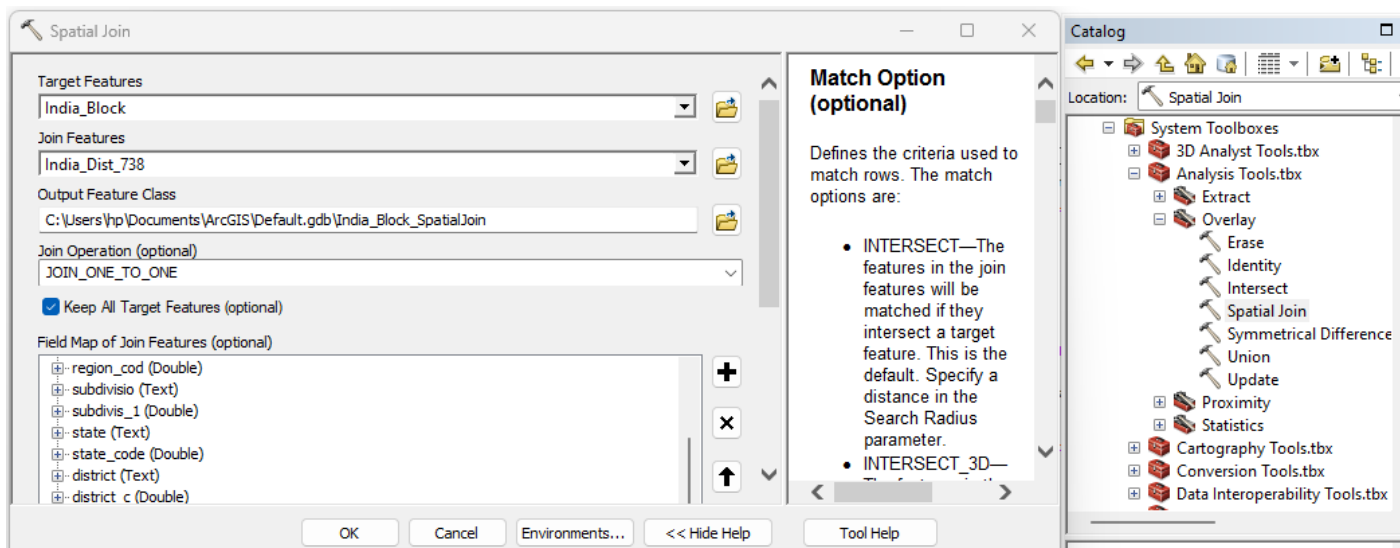


Fig 3: Spatial Join of Block Shape Files with District

After spatial join, many of the blocks are not joined with the correct district as they are not completely within the district polygon. Many of the blocks have taken null

(Highlighted in green) or the district name adjacent to that district (Lying less percentage area) which is reflected in the logical column of the Table-3.

Block Name	Region	Subdivision	State	District	RMC_MC
Patrasayer	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Sonamukhi	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Indpur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Hirbandh					
Raipur					
Ranibundh	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PURULIA	RMC KOLKATA
Srenga					
Khatra	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Indus	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PURBA BARDHAMAN	RMC KOLKATA
Jaypur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Kotulpur					
Saltora	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Mejhia	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	PASHCHIM BARDHAMAN	RMC KOLKATA
Barjora					
Chhatna	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Bankura-I	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Bankura-II					
Gangajalghati	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Simiapal	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Taldangra	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Onda					
Vishnupur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA

Table 3: Attribute in Block Shape Wrongly Joined with District Shape Files

To rectify the district information in block shape file we have to place the **centroid** by using Feature to Point by

using **System Tool boxes** → **Data Management tool** → **Features** → **Features to Point** in ArcGIS Tool box.

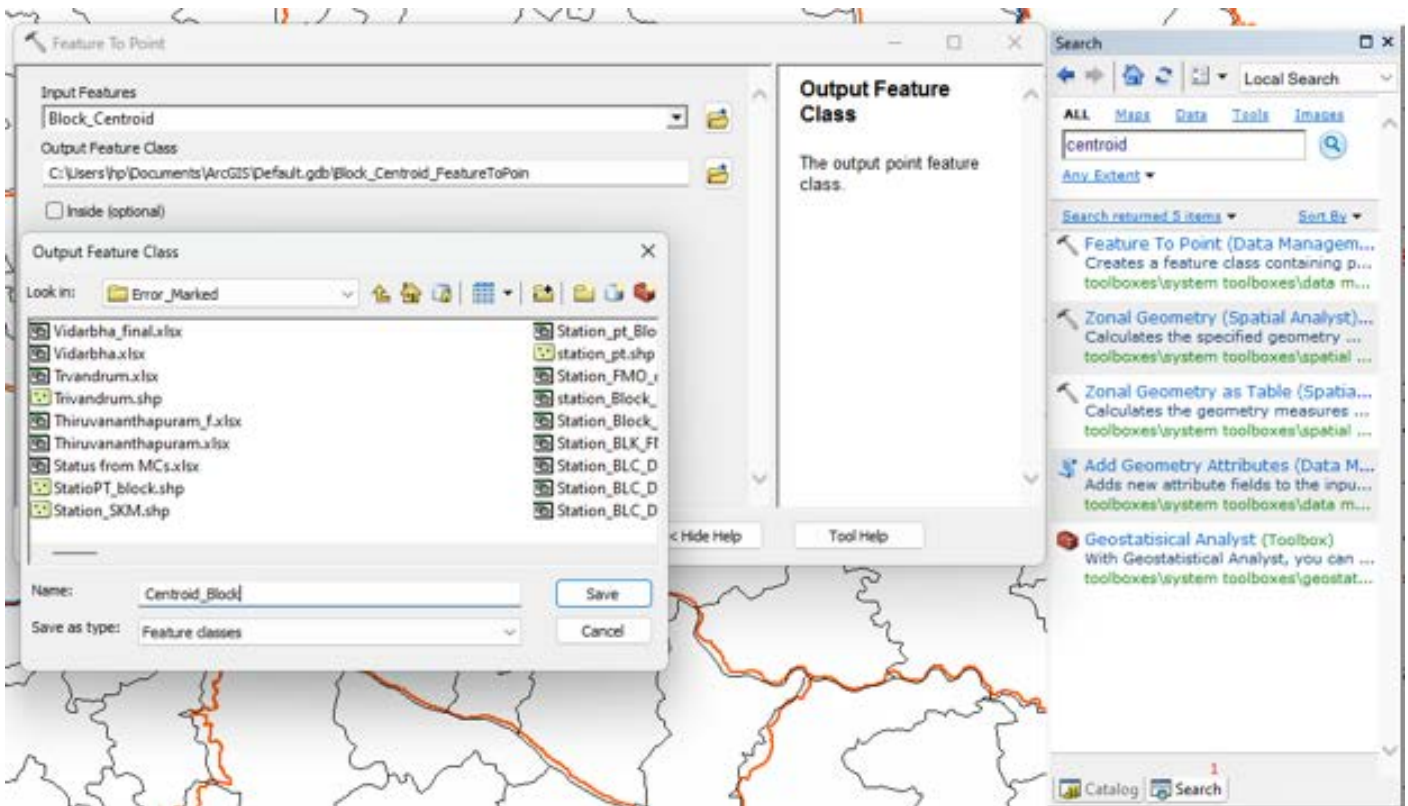


Fig 4: Placing Centroid of the Block Shape Files

After running this function, centroid point of the block Shape files placed inside the block area and a new feature class (Centroid Block) is created. The attribute data available with block Shape file has been transported

to the centroid points (Shape files). Now, we applied the **spatial join** again with the Centroid point to the District Shape files (Fig 5).

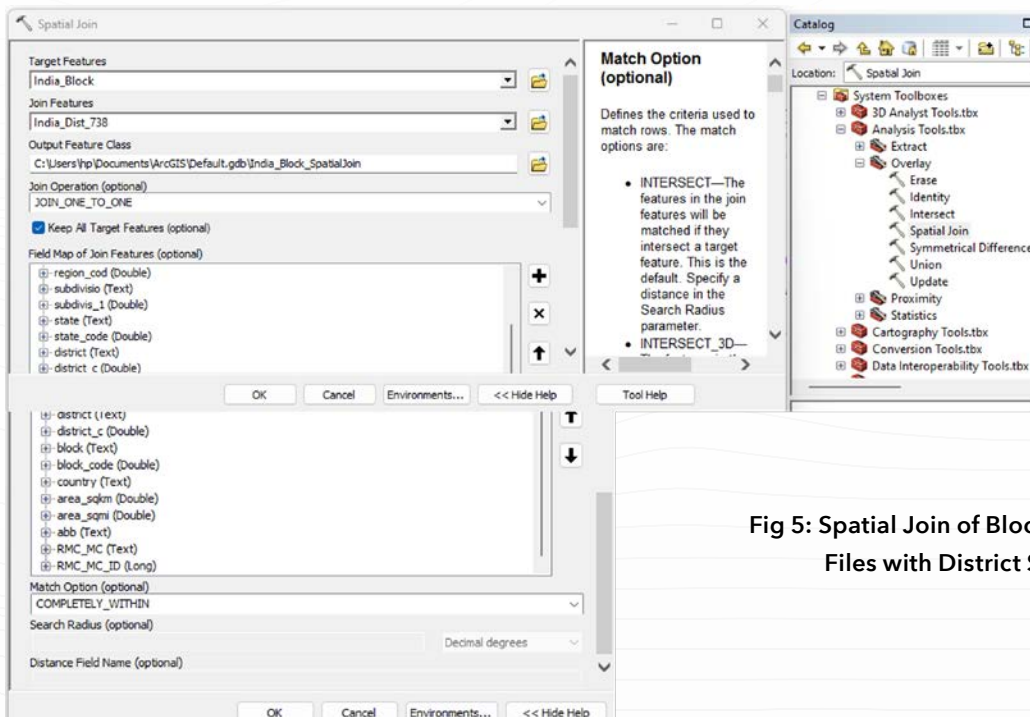


Fig 5: Spatial Join of Block Centroid Shape Files with District Shape Files

Block Name	Region	Subdivision	State	District	RMC_MC
Patrasayer	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Sonamukhi	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Indpur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Hirbandh	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Raipur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Ranibundh	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Srenga	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Khatra	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Indus	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Jaypur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Kotulpur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Saltora	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Mejhia	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Barjora	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Chhatna	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Bankura-I	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Bankura-II	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Gangajalghati	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Simiapal	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Taldangra	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Onda	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA
Vishnupur	EAST AND NORTH EAST INDIA	GANGETIC WEST BENGAL	WEST BENGAL	BANKURA	RMC KOLKATA

Table 4: Attribute of Block Shape Correctly Joined with District Shape Files Attribute

Now the attribute of the District Shape files is linked/ attached with all the Block centroid files (Here results of a district has been shown in Table 4). This attribute table is to be exported in the Excel file which is to be linked later with the original block Shape files by **<Selecting**

the shape file> → 'Right click' → Joins and Relates → Join with the common field 'Block Name'. Now District, Met sub-divisions, States information for all 5972 blocks are filled in the attribute table.

FID	BLOCK	SUB_DISTRICT	Region	Sub division	Sub division Code	State	State code	District	District Code	RMC_MC	Logical
584	Patrasayer	Patrasayer	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
781	Sonamukhi	Sonamukhi	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
782	Indpur	Indpur	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
783	Hirbandh	Hirbandh	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
784	Raipur	Raipur	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
785	Ranibundh	Ranibundh	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
786	Srenga	Srenga	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
787	Khatra	Khatra	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
3148	Indus	Indus	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
3149	Jaypur	Jaypur	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
3150	Kotulpur	Kotulpur	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4354	Saltora	Saltora	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4355	Mejhia	Mejhia	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4356	Barjora	Barjora	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4357	Chhatna	Chhatna	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4358	Bankura-I	Bankura-I	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4365	Bankura-II	Bankura-II	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4377	Gangajalghati	Gangajalghati	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4378	Simiapal	Simiapal	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4379	Taldangra	Taldangra	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4380	Onda	Onda	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True
4381	Vishnupur	Vishnupur	EAST AND NORTH EAST INDIA	GANGEIC WEST BENGAL	204	WEST BENGAL	20411	BANKURA	20411001	RMC KOLKATA	True

Table 5: Attribute of Block Centroids (Column 2 & 3) are Same as the Block Shape Files

Now, there are the 6745 point features for the rain gauge stations which contain the attribute of Lat/Long, District, Met-subdivisions, States, Homogeneous Regions except Block level information. We have to link the block level information to the station data. Now, we apply again the **spatial join** of the station data with the block Shape files (Fig-6). Here few stations lying in actual district may

come to the other block which is not under that district. After applying the spatial join only **143 stations** out of **6745 stations** whose districts are not matching (Shown in Table 6) with the districts reflected in the Block Shape files. Manually we corrected the districts names of these stations.

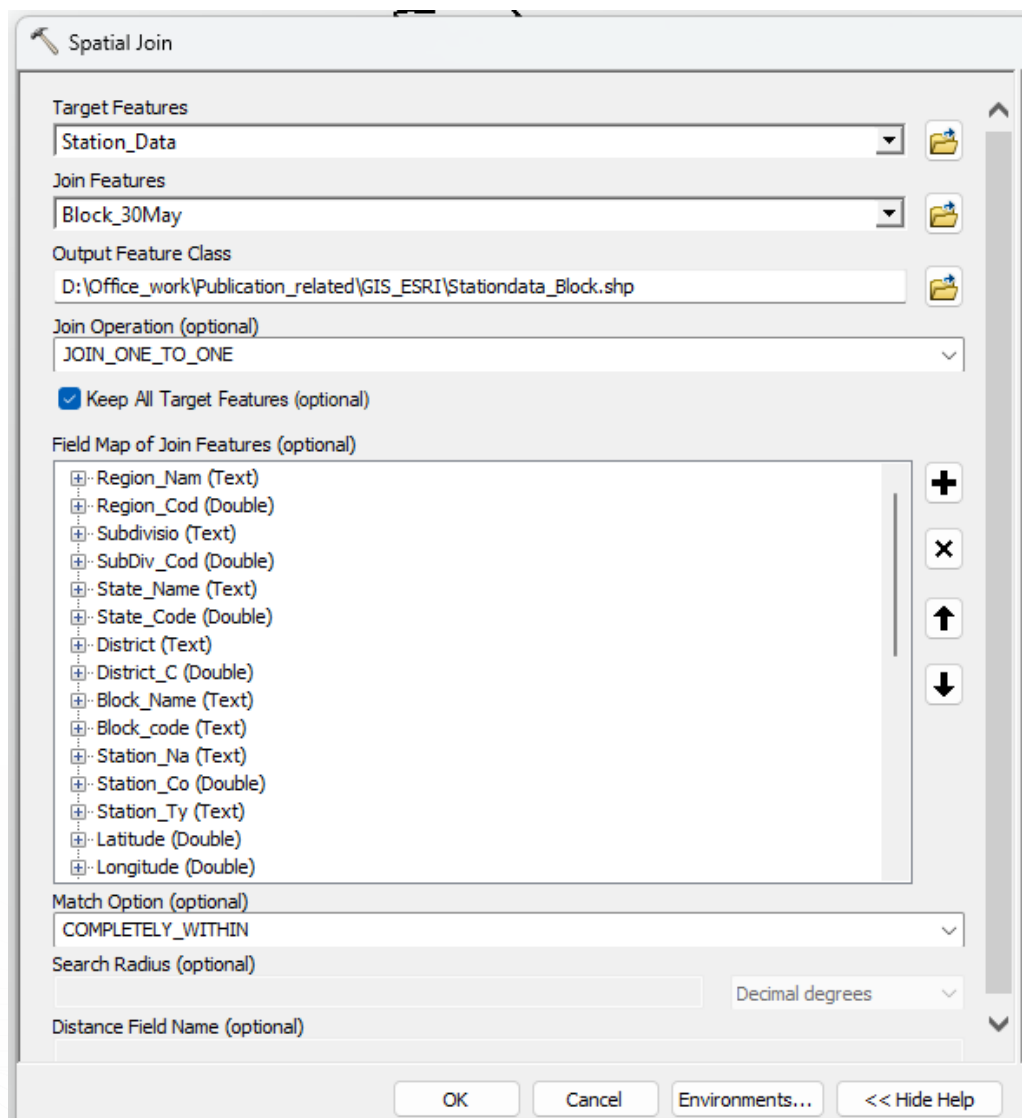


Fig 6: Spatial Join of Station Shape Files with Block Shape Files

Region_Nam	Subdivisio	State_Name	District	Station_Na	Station_Ty	Latitude	Longitude	district_1	block_Na_1	Dist_Logical
CENTRAL INDIA	CHHATTISGARH	CHHATTISGARH	KORIYA	PONDI BACHRA	ORG	23.04	82.49	MANENDRAGARH-BHARATPUR	Khadgawan	FALSE
CENTRAL INDIA	CHHATTISGARH	CHHATTISGARH	SUKMA	TONGPAAL	ORG	18.75	81.79	BASTAR	Darbha	FALSE
CENTRAL INDIA	GUJARAT REGION	GUJARAT	MAHISAGAR	WANAKBORI	ORG	22.9478	73.4193	KHEDA	Thasra	FALSE
CENTRAL INDIA	KONKAN & GOA	MAHARASHTRA	SINDHUDURG	DODAMARG	ORG	15.68306	73.96694	NORTH GOA	Dicholi	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	AKOLE	ORG	19.53833	74.00444	AHMEDNAGAR	Akola	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	JAMKHED	ORG	18.73694	75.31389	AHMEDNAGAR	Jamkhed	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	KOPARGAON	ORG	19.87861	74.47944	AHMEDNAGAR	Kopargaon	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	AHMEDNAGAR - IMD PT	ORG	19.08694	74.80583	AHMEDNAGAR	Nagar	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	CHAS_AGRI	ORG	19.03556	74.65056	AHMEDNAGAR	Nagar	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	KARJAT	ORG	19.55361	75.00889	AHMEDNAGAR	Nevasa	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	NEVASA	ORG	19.5525	74.92972	AHMEDNAGAR	Nevasa	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	PARNER	ORG	19.0025	74.43472	AHMEDNAGAR	Parner	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	PATHARDI	ORG	19.1775	75.17056	AHMEDNAGAR	Pathardi	FALSE

CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	RAHATA	ORG	19.70806	74.48167	AHMEDNAGAR	Rahta	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SAVLIVIHIR_AGRI	ORG	19.8022	74.4711	AHMEDNAGAR	Rahta	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SHIRDI AWS	ORG	19.76139	74.45444	AHMEDNAGAR	Rahta	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	RAHURI	ORG	19.39222	74.65056	AHMEDNAGAR	Rahuri	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SANGAMNER	ORG	19.57028	74.20306	AHMEDNAGAR	Sangamner	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SHEVGAON	ORG	19.35028	75.21917	AHMEDNAGAR	Shevgaon	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SHRIGONDA	ORG	18.62111	74.71167	AHMEDNAGAR	Shrigonda	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	AHILYANAGAR	SHRIRAMPUR	ORG	19.62444	74.66167	AHMEDNAGAR	Thrirampur	FALSE
CENTRAL INDIA	MADHYA MAHARASHTRA	MAHARASHTRA	NANDURBAR	AKKALKUWA	ORG	21.55333	74.13333	TAPI	Nizar	FALSE
CENTRAL INDIA	ODISHA	ODISHA	BHADRAK	BONTH	ORG	21.12	86.31	KEONJHARGARH	Nandipada	FALSE
CENTRAL INDIA	ODISHA	ODISHA	BOUDH	HARABHANGA	ORG	20.63	84.62	ANGUL	Athmallik	FALSE
CENTRAL INDIA	ODISHA	ODISHA	DEOGARH	BARKOTE	ORG	21.33	85.01	ANGUL	Palalahada	FALSE
CENTRAL INDIA	ODISHA	ODISHA	JHARSUGUDA	KOLABIRA ARG	ARG	21.8	84.16667	SAMBALPUR	Kolabira	FALSE
CENTRAL INDIA	ODISHA	ODISHA	KEONJHARGARH	CHAMPUA	ORG	22.065	85.666	WEST SINGHBHUM	Jagannathpur	FALSE
CENTRAL INDIA	SAURASHTRA & KUTCH	GUJARAT	AMRELI	VADIA	ORG	21.6876	70.8132	RAJKOT	Jetpur	FALSE
CENTRAL INDIA	SAURASHTRA & KUTCH	GUJARAT	BHAVNAGAR	JESAR	ORG	21.36667	71.66667	AMRELI	Savar kundla	FALSE
CENTRAL INDIA	SAURASHTRA & KUTCH	GUJARAT	BOTAD	GADHDA	ORG	21.96667	71.4	AMRELI	Babra	FALSE
CENTRAL INDIA	SAURASHTRA & KUTCH	GUJARAT	SURENDRANAGAR	KHARAGHODA	ORG	23.16667	71.71667	KUTCH	Unknown	FALSE
CENTRAL INDIA	WEST MADHYA PRADESH	MADHYA PRADESH	DATIA	BHANDER	ORG	25.73333	78.75	JHANSI	Moth	FALSE

**Table 6: District Name of the Stations that are Not Matching with the District of Block Shape File
(32 out of 143 are shown)**



Now we have to update the information of the River basin and sub-basins in the point i.e. station rain gauge data. Again, we have applied the spatial join to the

station Shape files with the river sub-basin Shape files. In the output files all the stations are updated which are lying within the river sub-basins.

Region_Na m	Subdivision	Unique Stn Code	State Name	District Name	Block Name	Station Name	Station Type	Latitude	Longitud e	RMC_ MC	FMO	BASIN	SUB_BASI N
CENTRAL INDIA	CHHATTISGAR H	101CHH000 1	CHHATTISGAR H	BALOD	Dohdiluhara	MARRI BANGLA DEORI	ORG	20.91	81.05	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 2	CHHATTISGAR H	BALOD	Dondi	DOUNDI	ORG	20.6166 7	81.05	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 3	CHHATTISGAR H	BALOD	Gunderdchi	ARJUNDA	ORG	20.95	81.2	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 4	CHHATTISGAR H	BALOD	Gunderdchi	DONDILOHARA	ORG	21	81.33333	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 5	CHHATTISGAR H	BALOD	Gunderdchi	GUNДАРDEHI	ORG	20.95	81.28333	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 6	CHHATTISGAR H	BALOD	Gurur	GURUR	ORG	20.6833 3	81.4	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 7	CHHATTISGAR H	BALOD	Sanjaribad	BALOD	ORG	20.729	81.2044	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 8	CHHATTISGAR H	BALODA BAZAR	Baloda_Baza r	BALODA BAZAR	ORG	21.6666 7	82.16667	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH000 9	CHHATTISGAR H	BALODA BAZAR	Baloda_Baza r	LAWAN	ORG	21.64	82.34	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 0	CHHATTISGAR H	BALODA BAZAR	Bhatapara	BHATAPARA	ORG	21.7333 3	81.95	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 1	CHHATTISGAR H	BALODA BAZAR	Kasdol	GIDHORI TUNDRA	ORG	21.68	82.61	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 2	CHHATTISGAR H	BALODA BAZAR	Kasdol	KASHDOL	ORG	21.6166 7	82.43333	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 3	CHHATTISGAR H	BALODA BAZAR	Kasdol	SONAKHAN	ORG	21.51	82.55	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 4	CHHATTISGAR H	BALODA BAZAR	Palari	PALLARI/PALARI	ORG	21.5333 3	82.16667	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 5	CHHATTISGAR H	BALODA BAZAR	Simga	SIMGA	ORG	21.6333 3	81.7	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 6	CHHATTISGAR H	BALODA BAZAR	Simga	SUHELA	ORG	21.61	81.97	MC RAIPU R	Bhubaneshw ar	Mahana di	Upper Mahanadi
CENTRAL INDIA	CHHATTISGAR H	101CHH001 7	CHHATTISGAR H	BALRAMPU R	Balrampur	BALRAMPUR	ORG	23.6	83.61667	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH001 8	CHHATTISGAR H	BALRAMPU R	Balrampur	DOURA KOCHALI	ORG	23.52	83.46	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH001 9	CHHATTISGAR H	BALRAMPU R	Rajpur	RAJPUR	ORG	23.3	83.41667	MC RAIPU R	Patna	Ganga	Upper Sone
CENTRAL INDIA	CHHATTISGAR H	101CHH002 0	CHHATTISGAR H	BALRAMPU R	Ramanujgan ji	RAMANUJGANJ	ORG	23.8	83.7	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH002 1	CHHATTISGAR H	BALRAMPU R	Ramanujgan ji	RAMCHANDRAPU R	ORG	23.93	83.49	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH002 2	CHHATTISGAR H	BALRAMPU R	Samari	CHANDO	ORG	23.54	83.83	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH002 3	CHHATTISGAR H	BALRAMPU R	Samari	KUSMI	ORG	23.3	83.88333	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH002 4	CHHATTISGAR H	BALRAMPU R	Samari	SAMARI	ORG	23.41	83.93	MC RAIPU R	Patna	Ganga	Kanhar
CENTRAL INDIA	CHHATTISGAR H	101CHH002 5	CHHATTISGAR H	BALRAMPU R	Shankargarh	SHANKARGARH	ORG	23.3	83.6	MC RAIPU R	Patna	Ganga	Upper Sone
CENTRAL INDIA	CHHATTISGAR H	101CHH002 6	CHHATTISGAR H	BALRAMPU R	Wadrafinag ar	CHALGALI	ORG	23.6	83.36	MC RAIPU R	Patna	Ganga	Upper Sone
CENTRAL INDIA	CHHATTISGAR H	101CHH002 7	CHHATTISGAR H	BALRAMPU R	Wadrafinag ar	RAGHUNATH NAGAR	ORG	23.83	82.93	MC RAIPU R	Patna	Ganga	Upper Sone
CENTRAL INDIA	CHHATTISGAR H	101CHH002 8	CHHATTISGAR H	BALRAMPU R	Wadrafinag ar	WANDRAFAGAR	ORG	23.75	83.2	MC RAIPU R	Patna	Ganga	Upper Sone
CENTRAL INDIA	CHHATTISGAR H	101CHH002 9	CHHATTISGAR H	BASTAR	Bakaband	KARPAWAND	ORG	19.38	82.08	MC RAIPU R	Hyderabad	Godavari	Indravati
CENTRAL INDIA	CHHATTISGAR H	101CHH003 0	CHHATTISGAR H	BASTAR	Bastanar	BASTANAR	ORG	18.9666 7	81.55	MC RAIPU R	Hyderabad	Godavari	Indravati

Table 7: Stations Data with Blocks, District, River Baisns/Sub-basins (30 out of 6372 are shown)

Conclusion

At the end of the process, we have added the attribute (District, Met sub-division, Homogeneous Region, RMC/MC etc.) to the block level Shape files. Secondly, in station level rain gauge data, we have added correct information of the Blocks in which it is lying. Finally, the information available in the river Basins/sub-basins Shape files is also incorporated in the station level data which is a big achievement.

By using ArcGIS, we can easily solve the problems of overshoots and undershoots of the block Shape files and district Shape files information in the station level data. Now, these stations data may be used for the preparation of rainfall statistics by using arithmetic mean method for the block level and river sub-basin level for the daily, weekly, monthly, seasonal and annual basis and specified period also.

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