Building Geodatabase on Village Information System using Geospatial Technology: an example of Bajoon Village, Central Himalaya, India

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Abstract: Village Information System (VIS) is a process which incorporates the spatial and non-spatial information of a village in a GIS platform. This work is the part of a pilot research project assigned by Department of Science and Technology, Govt of India. Ten villages are selected from the Outer and Lesser Himalayan domain. In this work only one village i.e. Bajoon is incorporated for the discussion and tentative findings. Using collected information from satellite data, census 2011, field survey, a detailed digital land parcels wise data base is created and incorporated in the cadastral map. Information of each land parcels i.e. landuse/landcover (LULC), soil characteristics, rainfall, house, temple, spring water discharge, road and other infrastructural facilities have been collected. Socio-economic survey of each household is also conducted. All Collected information is stored in a digital cadastral layer using GIS technique. This work is very important for planning and management of village resources and creation of infrastructure for the sustainable development.

Keywords: Cadastral Maps, LULC, Soil, Water, Rainfall, Infiltration, Socio Economic

I. INTRODUCTION

Village information system is an initiative to develop village wise GIS geo-database, acquiring all the information of each and every household assets, land holding, infrastructure etc. Village level information database is prepared using primary and secondary data collected from various sources for e-governance. Cadastral map of study area is about 60 years old which is present on the paper and in dilapidated situation. With the development of technology in the field of computer science the system of keeping information in the form of text, map & media etc has been helpful. Advancement in the field of space technology is too helpful to map the earth surface using satellite data with high accuracy and can be linked with the field attribute data. Cadastral map consists of each land parcel having an official number with the records of owner and amount of an area of a person or group.In this study an attempt is made to develop an interactive cadastral map creating parcel wise geo-database consisting information regarding land use, water, soil, rainfall, building, amenities etc. The digital database of land information is easy to update and contains less error. It can also reduce the local land disputes once updated properly because the GIS system of mapping is far more accurate than traditional /old one. The old system of keeping records of land parcels is lacking of coordinates system. Cadastral maps (Scale: 64 inch=1 mile) of the village is collected from district land record office. It is scanned and geo-referenced to bring in a GIS platform. Coordinates of ground control points (crossing of bi-junction and tri-Junction of land parcels, roads and rivers) are collect from geo-coded satellite data.

Development of geo-database is very important as it stores village level spatial and non-spatial information and can be updated regularly or routinely when needed. Digital database accelerates the administrative processes and services to implement village level developmental plans.

II. 2. Study Area

The study area is situated in the central Himalayan region along the Main Boundary Thrust (MBT) consisting Siwalik and Lesser Himalayan region at an average altitude of 1600 metre above mean sea level. The spatial extension of Bajoon Village is 79˚23´55 to 79˚24´45 **E.** longitude and 29˚22´00 to 29˚22´45 N**.** latitude (fig.1).

It is situated along the gentle slope landscape towards the NNW direction. In this village about 61% villagers are engaged in agricultural practices for their livelihood. The road and transport communication are good. Hence, villagers can export their agricultural product to nearby hills as well as plain area. The village population consists of mainly youth and most of them are students in different educational institutions.

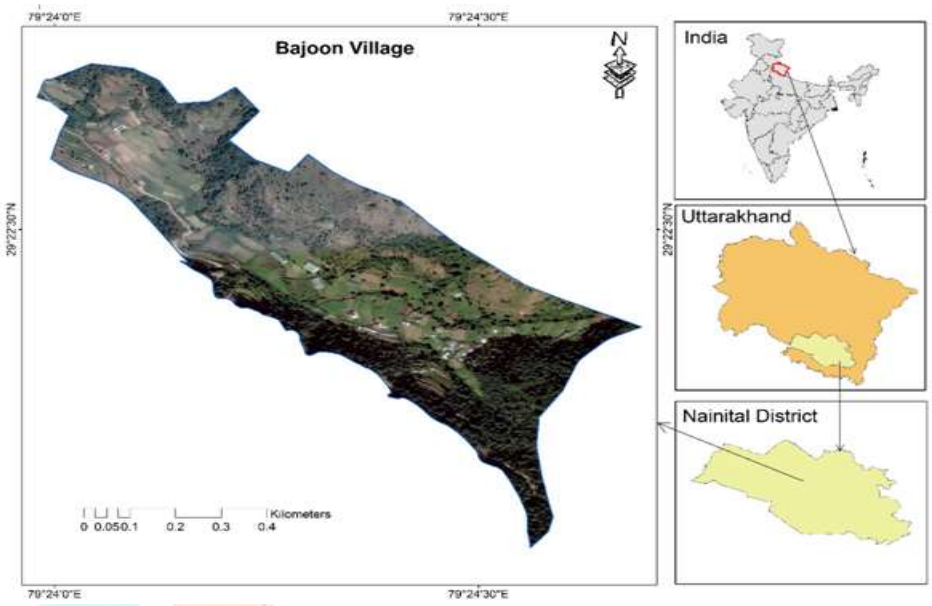


Figure 1. Location Map

III. Data Base and Methodology

i. Quickbird satellite data used for matching with land parcels and to analyse the land use and land cover. Sentinel-2 data having a resolution of 10m for RGB and NIR has been used for vegetation analysis.

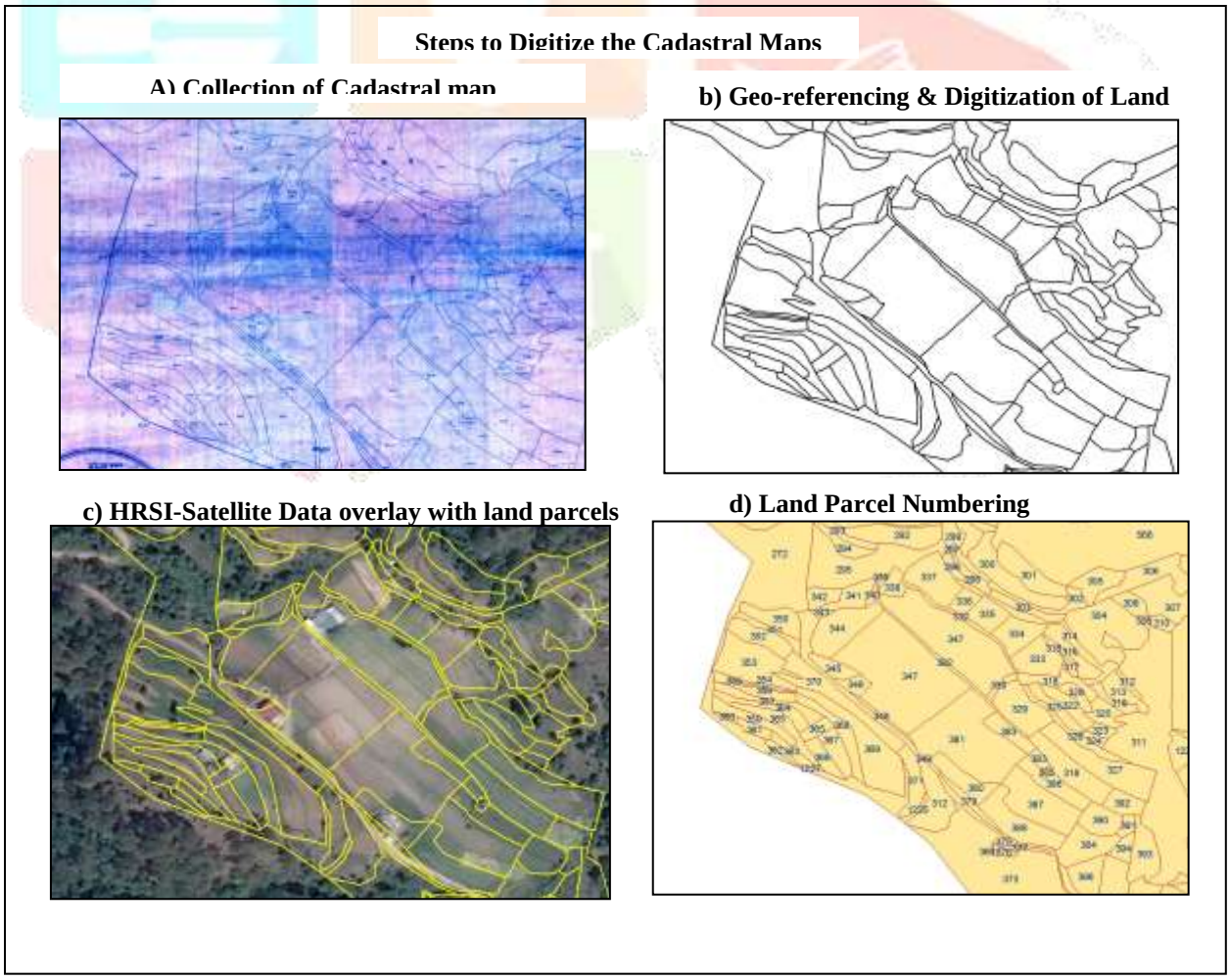


Figure 2 Process to bring cadastral maps in GIS platform

ii. The Survey of India toposheet (1955-60) is used to delineate the village boundary and validate the other infrastructure such as roads and foot tracks.

iii. The water samples are collected from the natural perennial water spring for analysis. The regular water discharge is also measured to understand the amount and nature of flow of water in correlation with changing season.

iv. Five (05) soil samples from different altitude of the village are collected to understand the variation in the soil characteristics. Soil filtration capacity is also measured using double ring infiltrometer as it helps to understand the water porosity and holding capacity.

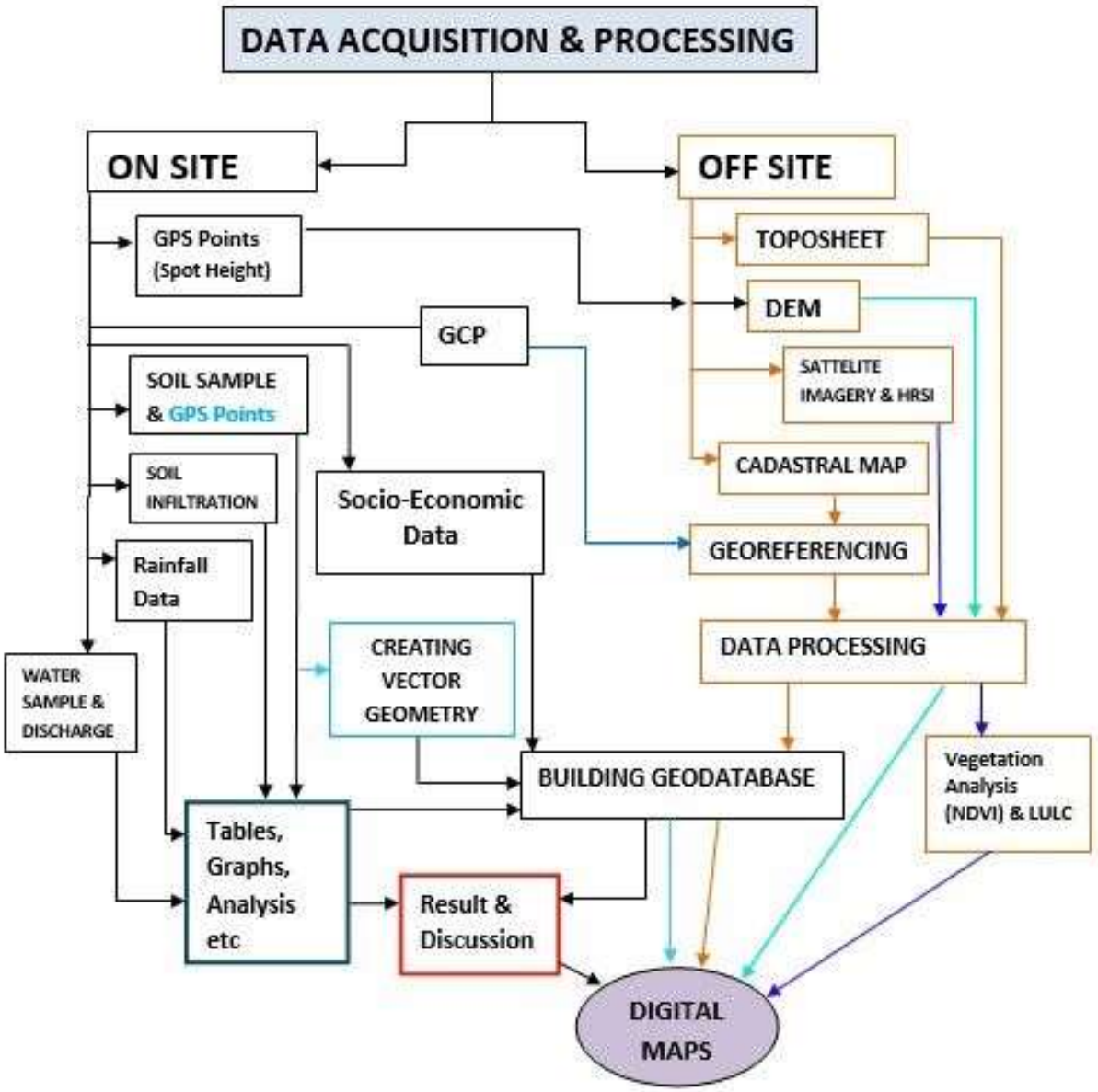


Figure 3. Data Acquisition and Processing

IV. Altitudinal Zone

Digital elevation model is generated with a spatial resolution of 5m with the help of interpolation technique. The elevation map is created at an interval of 50m. The point altitude information is collected from field with GPS and also from Google earth pro. The spatial extent of the village is very short hence altitude (spot Height) information in very short distance is collected for elevation model.

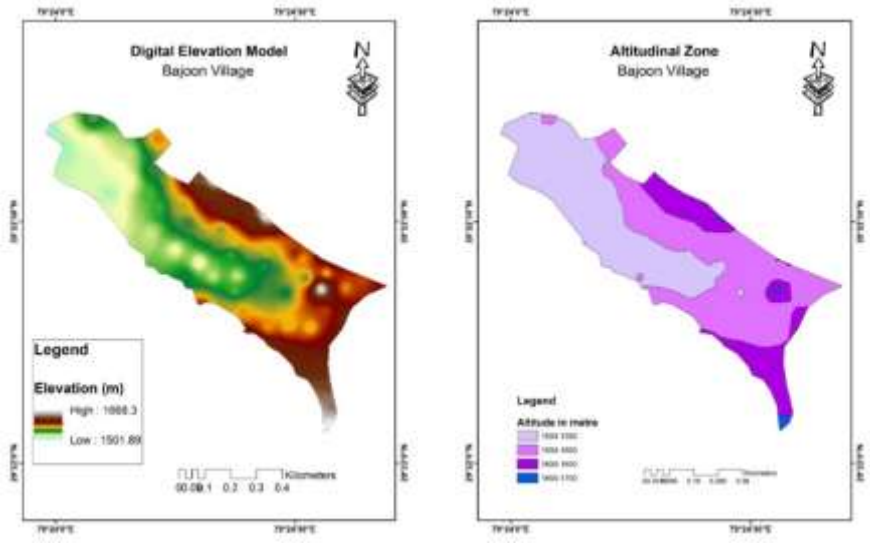


Figure 4. Digital Elevation Model and altitudinal Zone Map

V. Water Sample analysis

Water sample is collected from the natural source available in the village (Table 1).

Element	Mass	Tune	Conc	Units	CPS
Li	7	2	2.358	Ug/l	2809.21
Be	9	2	0.016	Ug/l	10.00
Al	27	1	7.874	Ug/l	2132.43
V	51	1	0.105	Ug/l	1046.74
Cr	53	1	0.114	Ug/l	253.34
Mn	55	1	0.554	Ug/l	3407.12
Fe	56	1	6.004	Ug/l	54762.23
Co	59	1	0.022	Ug/l	421.14
Ni	60	1	0.145	Ug/l	666.71
Cu	63	1	0.825	Ug/l	9923.06
Zn	66	1	4.159	Ug/l	8609.02
Ga	69	1	4.314	Ug/l	26649.25
As	75	1	0.099	Ug/l	183.34
Se	78	1	0.091	Ug/l	113.34
Rb	85	2	0.318	Ug/l	5054.24
Sr	88	2	81.349	Ug/l	1481283.88
Ag	107	2	<0.000	Ug/l	860.06
Cd	111	2	0.010	Ug/l	25.56
Cs	133	2	0.009	Ug/l	200.01
Ba	137	2	19.851	Ug/l	48764.74
Pb	208	2	<0.000	Ug/l	2424.63
U	238	2	0.319	Ug/l	2585.88

Element	Mass	CPS	Det
Sc	45	85829.96	Pulse
In	115	518074.48	Pulse
Bi	209	212548.55	Pulse

Spring water is being collected by pipeline in the tank from where people manually collecting water. However, some of them have taken water to their houses through pipeline. Two springs discharge is being monitored to find out the availability and monthly variation.

VI. Soil

Soil samples have been collected from 5 different locations. According to (Batjes, N.H.1995, Sakin, E.2012) important parameters of soil are i.e, pH, Organic carbon, Nitrogen, phosphorus pentoxide, Electric conductivity and potassium oxide. It is found

that the pH level in Bajoon is ranging in between 6.3 to 7.6 which indicate moderately acidic to moderately alkaline (See Table 2& figure 5).

Village: Bajoon					
pH	7.6	7.4	7.5	7.0	6.3
O.C %	1.87	2.57	3.04	3.00	1.95
Available N Kg/h	286.00	390.12	381.33	352.47	352.47
P_2O_5 %	.0210	.0211	.0192	.0213	.0122
K_2O %	.0440	.0224	.0172	.0132	.0097
EC dS/m	.063	.126	.056	.066	.071

Table-2 Pre-Monsoon Soil analysis report of Bajoon Village

The organic content found in soil sample is ranging in between 1.87 to 1.95 percent. Available Nitrogen present in soil is ranging between 286 to 352 kg/hectare. The variation in nitrogen content is directly related to organic carbon present in soil. Organic carbon is also used as an index of Nitrogen availability because the content of Nitrogen in soil organic matter is relatively constant.

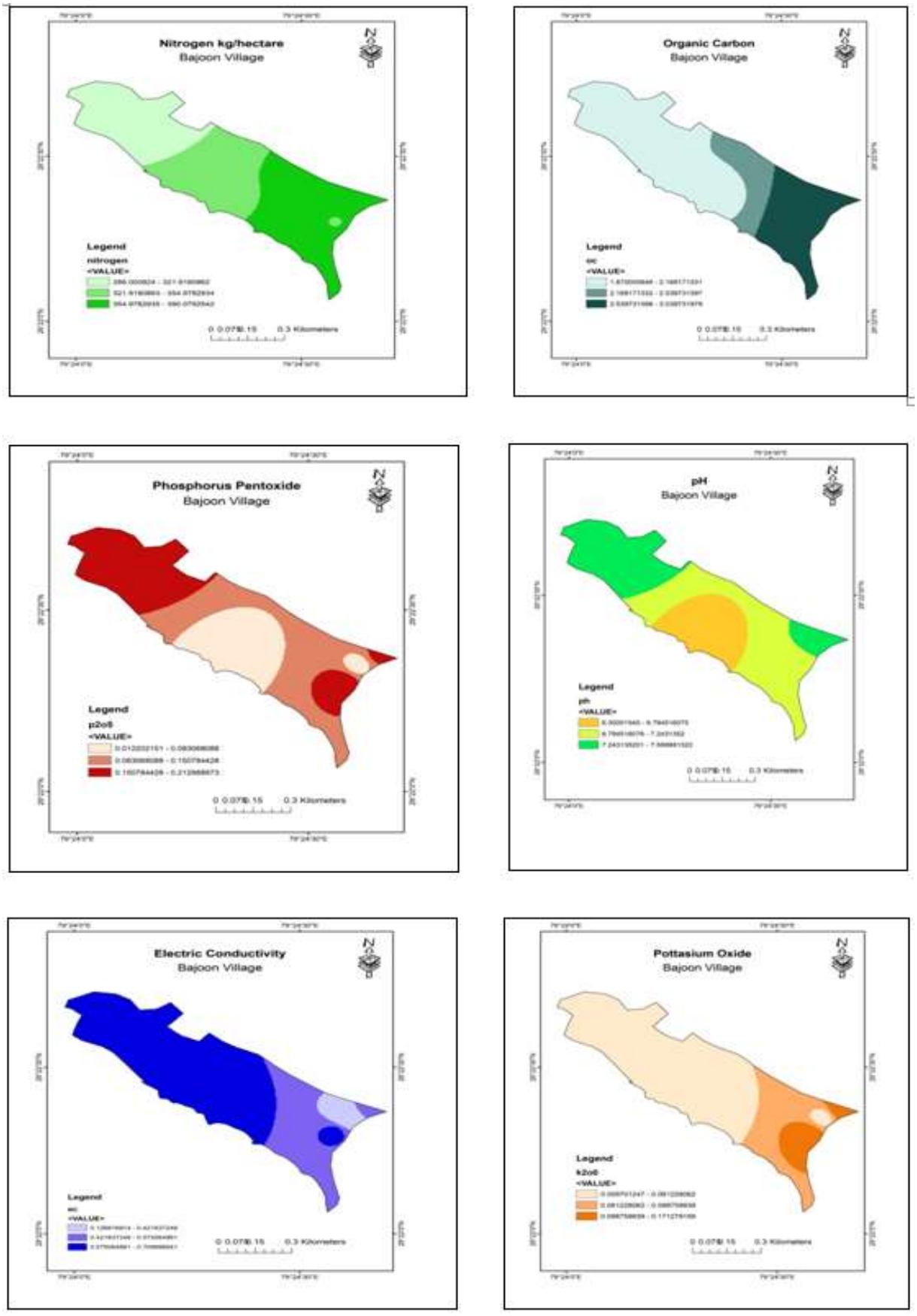


Figure 5. Soil Map

VII. Rainfall

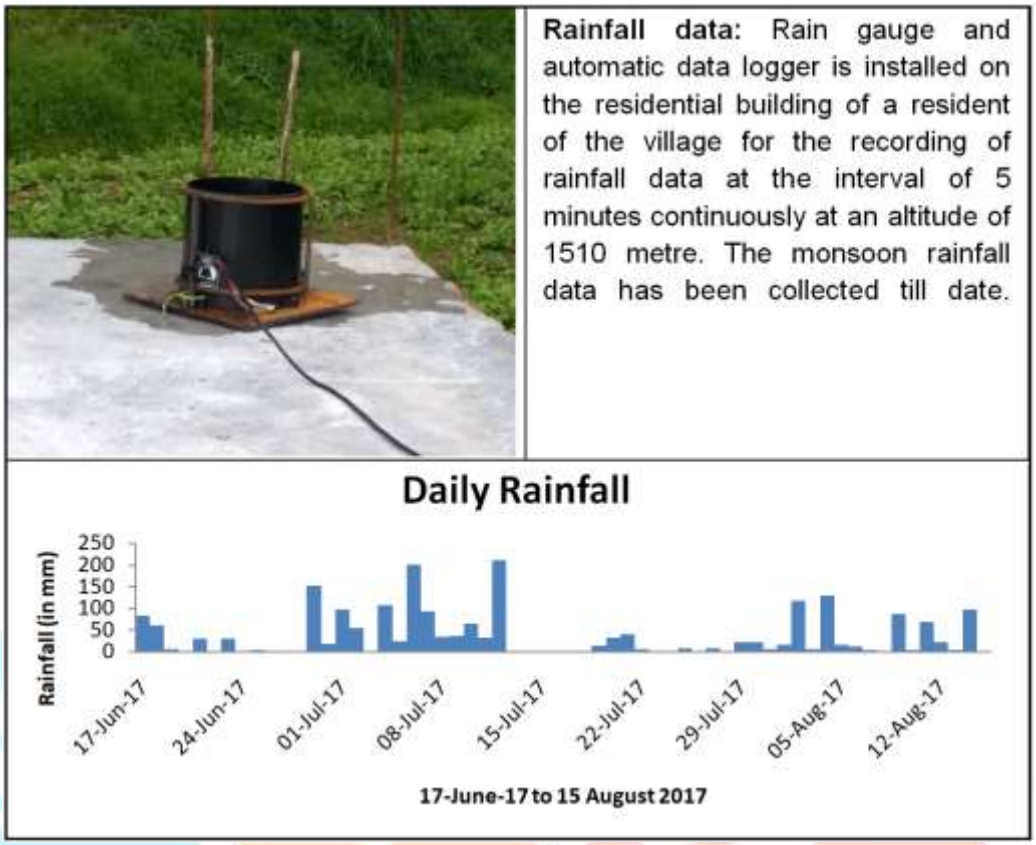


Figure 6. Daily Rainfall Distribution

VIII. Soil Infiltration capacity

Double ring infiltrometer is used to observe the potential of water absorption or the amount of water holding capacity. This technique defines the infiltration capacity and rate mm/cm in minutes/hours (Mangala et.al. 2016). The result obtained by this process also defines the types of soil is present (Table 3& Figure 7).

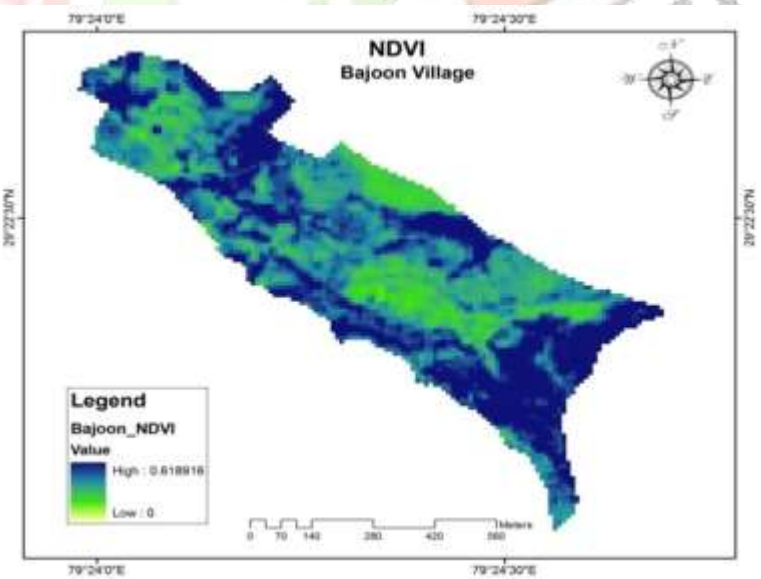
Filtration Minute	Infiltration Level (in Cm)	Total Time (In Minute)
0.18	1	0.18
0.4	2	0.58
0.8	3	0.76
1.5	4	2.26
4.5	5	6.76
5.16	6	11.92
5.6	7	17.52
5.7	8	23.22
6.75	9	29.97
7.93	10	37.9
7.06	11	44.96
5.43	12	50.39
5.15	13	55.54
3.9	14	59.44
3	15	64.44

Soil type	Basic Infiltration rate (mm/hour)
Sandy Loam	20-30
Loam	10-20
Clay Loam	5-10
Clay	1-5

Table 3. Basic Infiltration rate for various soil types

IX. Vegetation Analysis

Sentinel-2 MSI data with 10m resolution of Red and Near Infrared band is used for NDVI analysis. The NDVI value always comes between -1 to +1. The positive value represents healthy and rich vegetation and the negative values represent the other feature of earth surface. Digital Image processing is carried out as per the following equation: NDVI=NIR-RED/NIR+RED. The NDVI values that defines the feature on earth surface are: (i) Very low values (0.1 and lower) - Barren Area, Sand, Snow, (ii) Moderate values (0.2-0.3) - Shrub and Grasslands, (iii) High Values (0.6-0.8) - Temperate and Tropical forests, (iv) Very low positive or even slightly negative - Waterbody.



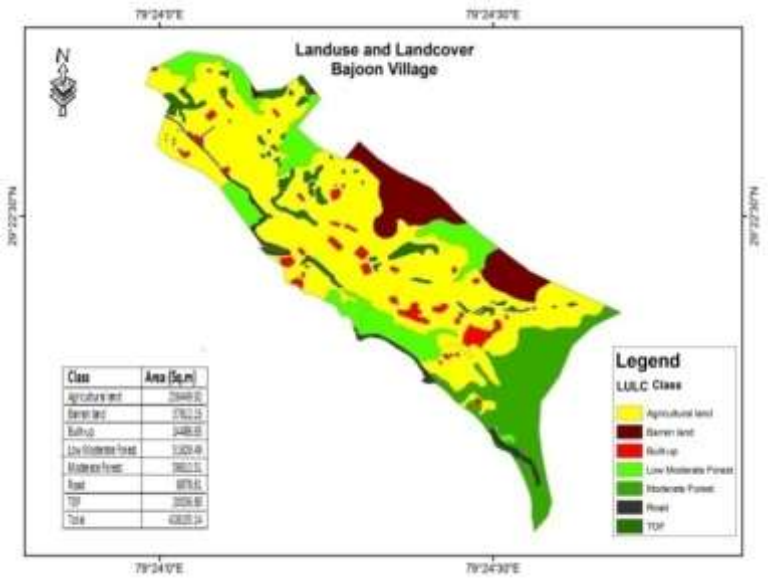


Figure 8. Landuse

X. Vegetation Analysis from NDVI

The reflectance response in the NIR is not good enough (Jaafari et.al. 2014), the greenness in the area is less the highest value analysed by the model is 0.61 which represents the area has present temperate to tropical forest. The area is less covered by forest, the forest is scattered but in some elevated area the percentage is good.

XI. Land use and Land Cover

GIS based classification has been done with HRSI imagery with a spatial resolution of 2.65 m. The major 6 landuse classes are indentified based on the visual interpretation (figure 8).

XII. Mapping of theme wise information of Households

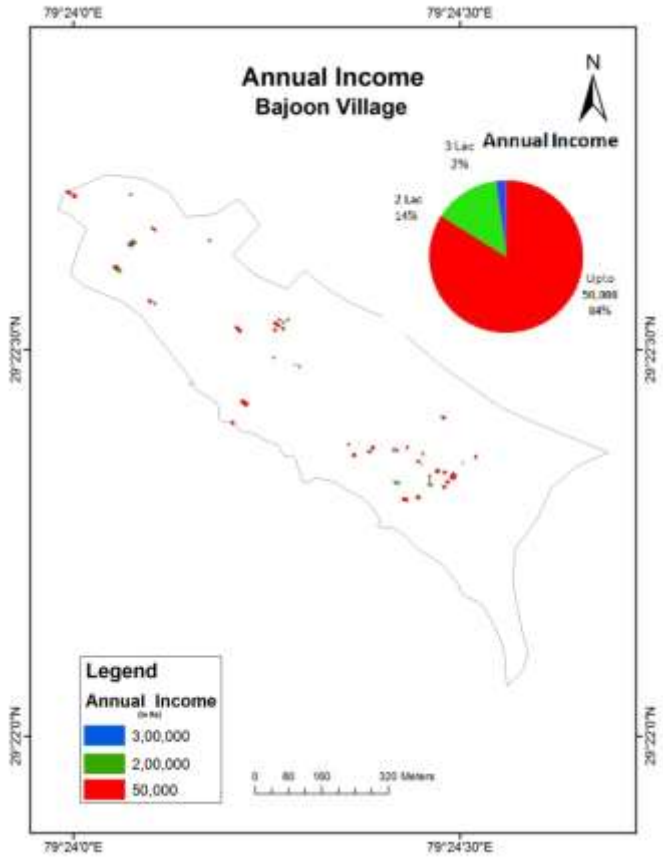
Thematic maps are prepared on the basis of data collected through socio-economic field survey. The following data has been collected from each household. 1) Ration card 2) Caste 3) LPG connection 4) Water connection 5) Number of rooms in each house 6) occupation of family head 7) Annual Income 8) Storey 9) Toilet facility 10) Mobile phones and 12) Literacy (table 4 &figure 9).

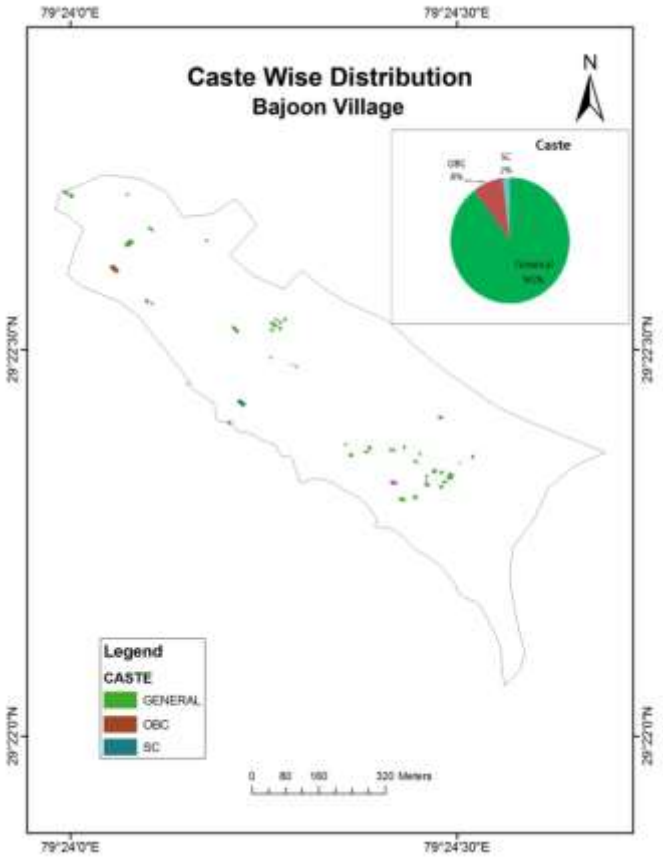
Theme based information is collected from socio-economic survey from each household through field visit. The information includes number of family members and head, Aadhar card number, voter Id, LPG connection, Ration card etc. (Table-4). Digital layers are created to bring vector geometry of spatial data (Point, Line and Polygon) in GIS platform. Non-spatial data is information about the characteristics of features stored in the GIS layers

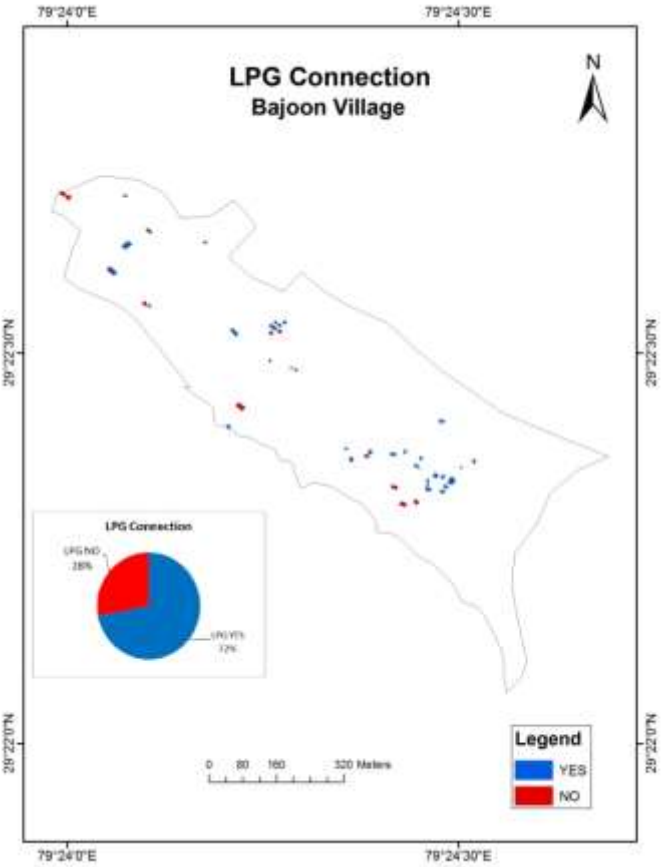
	Theme			
1	LPG Connection			
	YES	72 %	NO	28 %
2	Annual Income (Rs)			
	50,000		84 %	
	2,00,000		14 %	
	3,00,000		2 %	
3	Caste			
	General		90 %	
	OBC		8 %	
	SC		2 %	
4	Number of family members in all family			
	No. of members		In total family	
	1		4 %	
	2		2 %	
	3		10 %	
	4		23 %	
	5		39 %	
	6		16 %	
	7		6 %	
5	Mobile Connection			
	YES		60 %	
	NO		40 %	
6	Water connection			
	YES		92 %	
	NO		8 %	
7	Literacy			
	10^{th}		63 %	
	12^{th}		17 %	
	Graduate		2 %	
	PG		4 %	
	Illiterate		14 %	

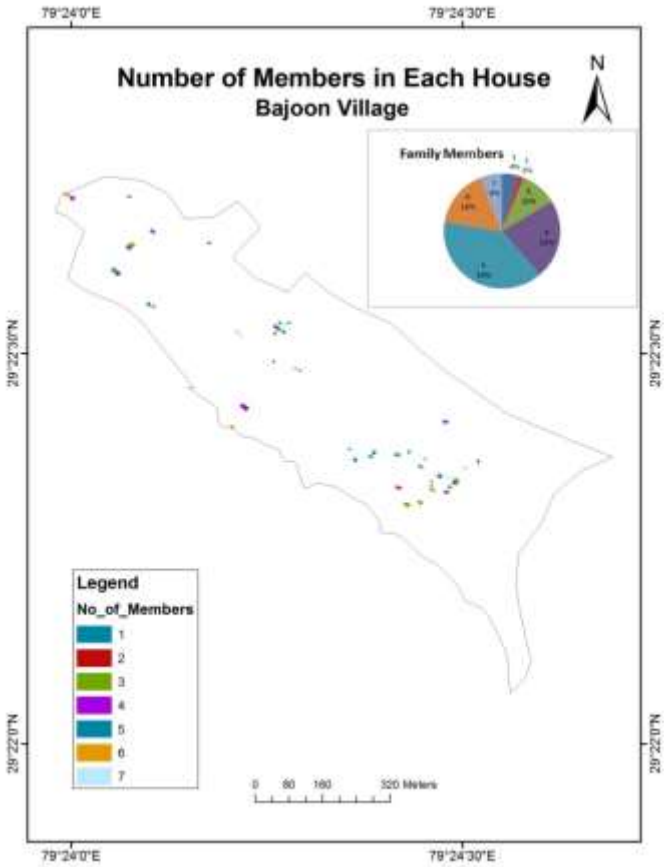
	Theme	
8	Distribution of rooms in Each House	
	Rooms	In total houses
	1	2 %
	2	3 %
	3	32 %
	4	26 %
	5	6 %
	6	0 %
	7	0 %
	8	2 %
	9	2 %
9	Occupation	
	Farmer	61 %
	Govt. (Retired)	4 %
	Govt.	6 %
	Labour	6 %
	Labour/Farmer	6 %
	Private	13 %
	Private/Farmer	4 %
10	Ration Card	
	APL	67 %
	BPL	27 %
	AAY	6 %
11	Building storey House	
	Single	66 %
	Double	34 %
12	Toilet Facility	
	YES	84 %
	NO	16 %

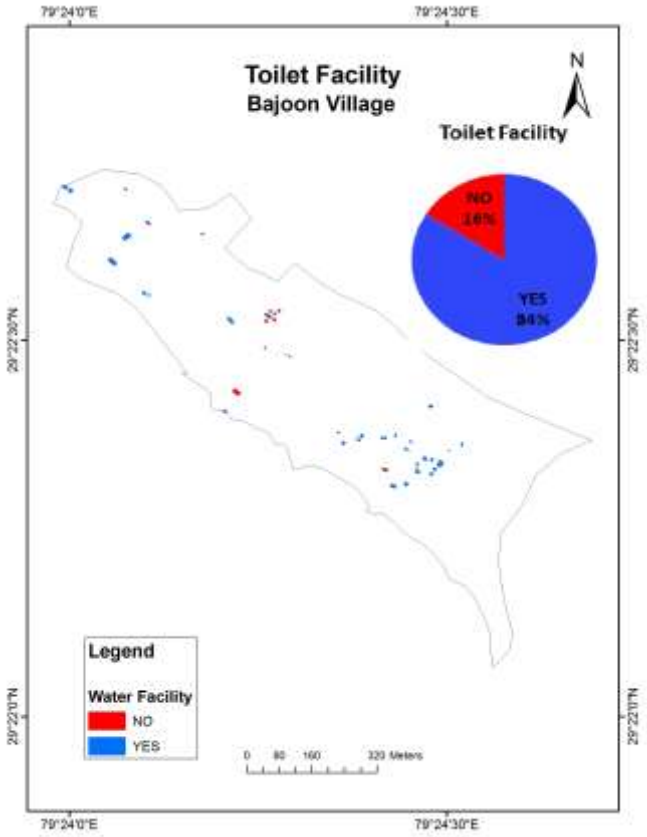
Table 4. Theme wise Socio-economic survey of Bajoon Village

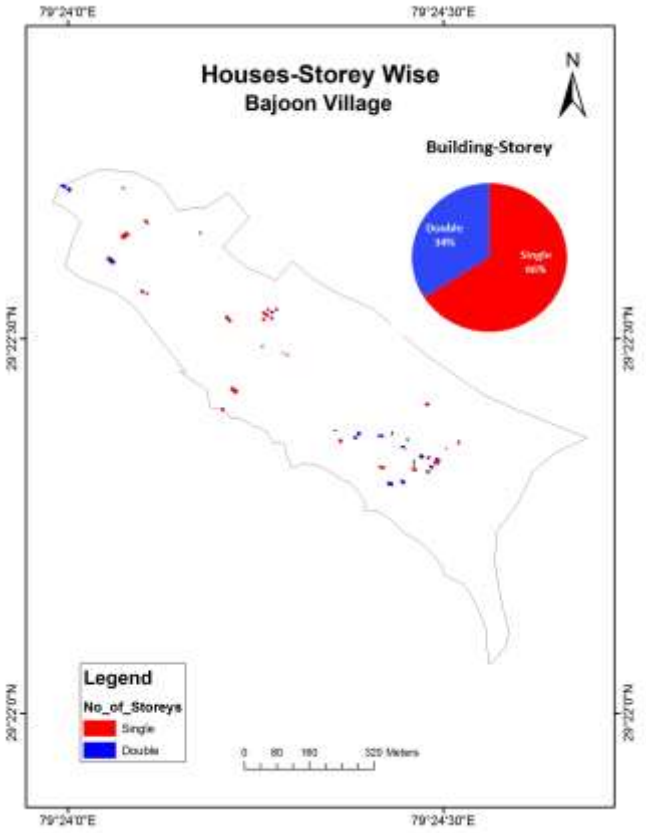

Annual Income
Bajoon Village
N
Annual Income
3 Lac 2%
2 Lac 14%
Upto 50,000 84%
Legend
Annual Income
3,00,000
2,00,000
50,000
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N
0 80 160 320 Meters

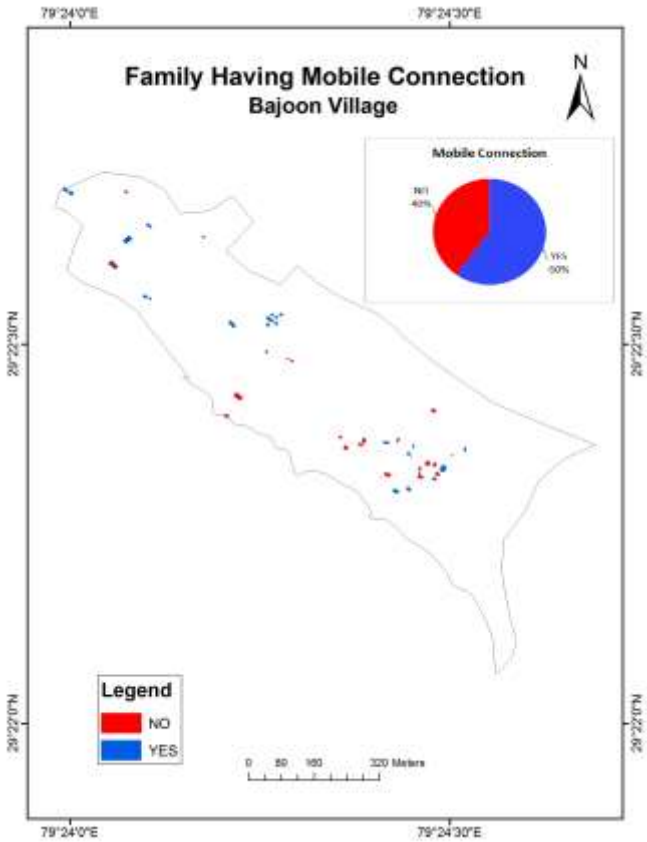

Caste Wise Distribution
Bajoon Village
N
Caste
Legend
CASTE
GENERAL
OBC
SC
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N
0 80 160 320 Meters

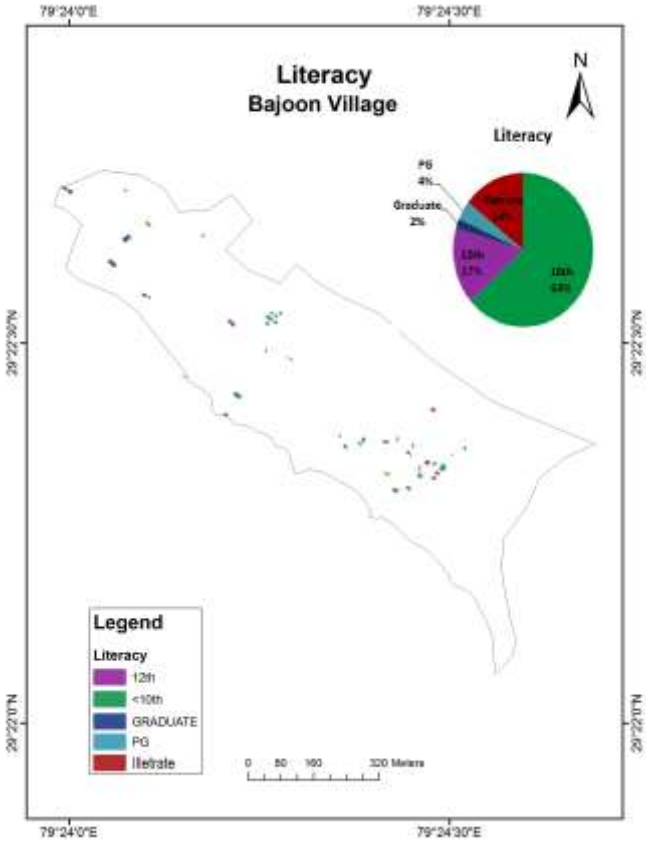

LPG Connection
Bajoon Village
N
LPG Connection
LPG NO 28%
LPG YES 72%
Legend
YES
NO
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N
0 80 160 320 Meters


Number of Members in Each House
Bajoon Village
N
Family Members
Legend
No_of_Members
1
2
3
4
5
6
7
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N
0 80 160 320 Meters


Toilet Facility
Bajoon Village
Toilet Facility
NO
16%
YES
84%
Legend
Water Facility
NO
YES
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N


Houses-Storey Wise
Bajoon Village
Building-Storey
Legend
No_of_Storeys
Single
Double
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N


Family Having Mobile Connection
Bajoon Village
Mobile Connection
Legend
NO
YES
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N


Literacy
Bajoon Village
Literacy
PG
4%
Graduate
2%
Legend
Literacy
12th
<10th
GRADUATE
PG
Illetrate
79°24'0"E
79°24'30"E
29°22'30"N
29°22'0"N

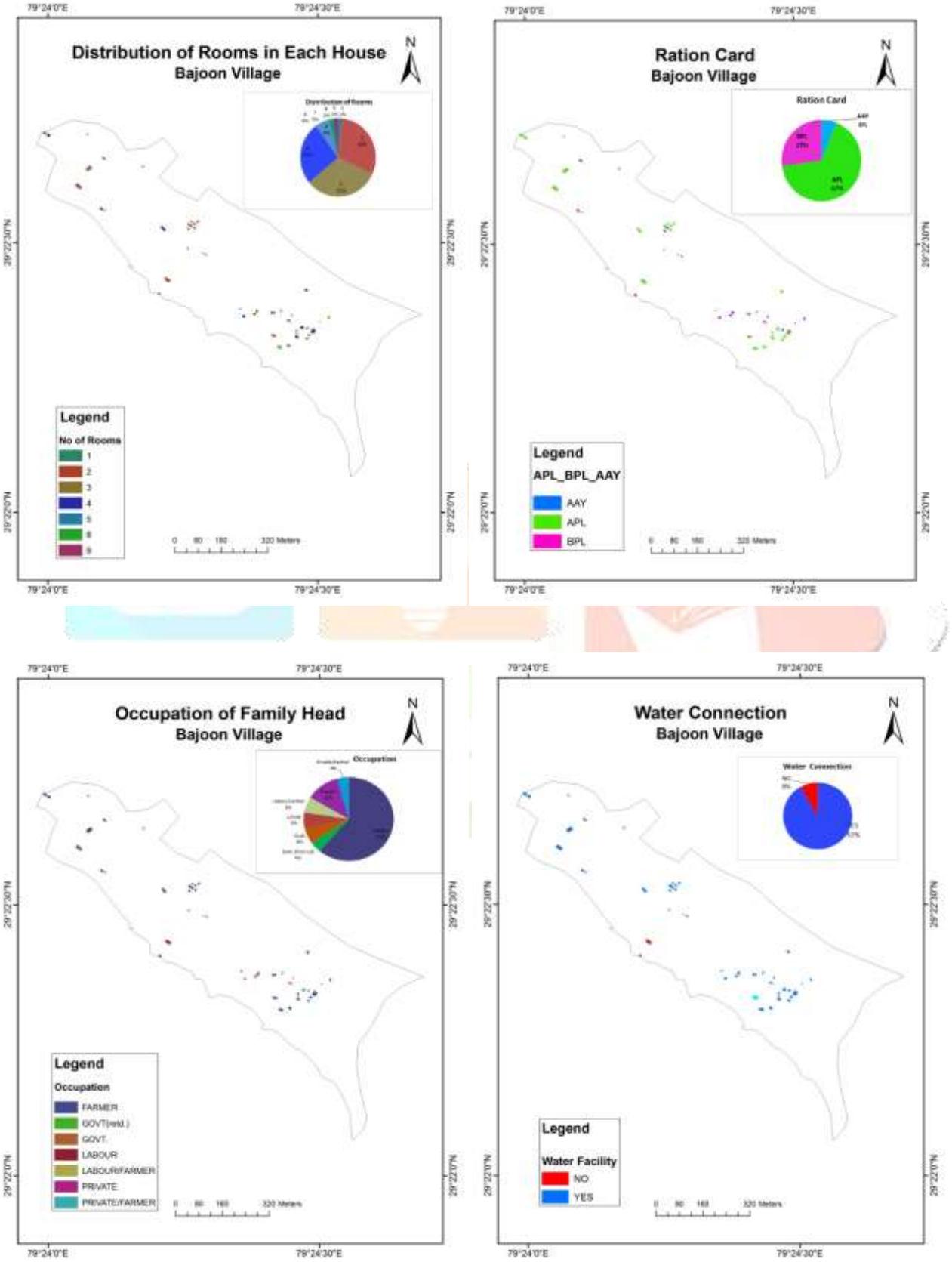


Figure 9. Thematic Maps

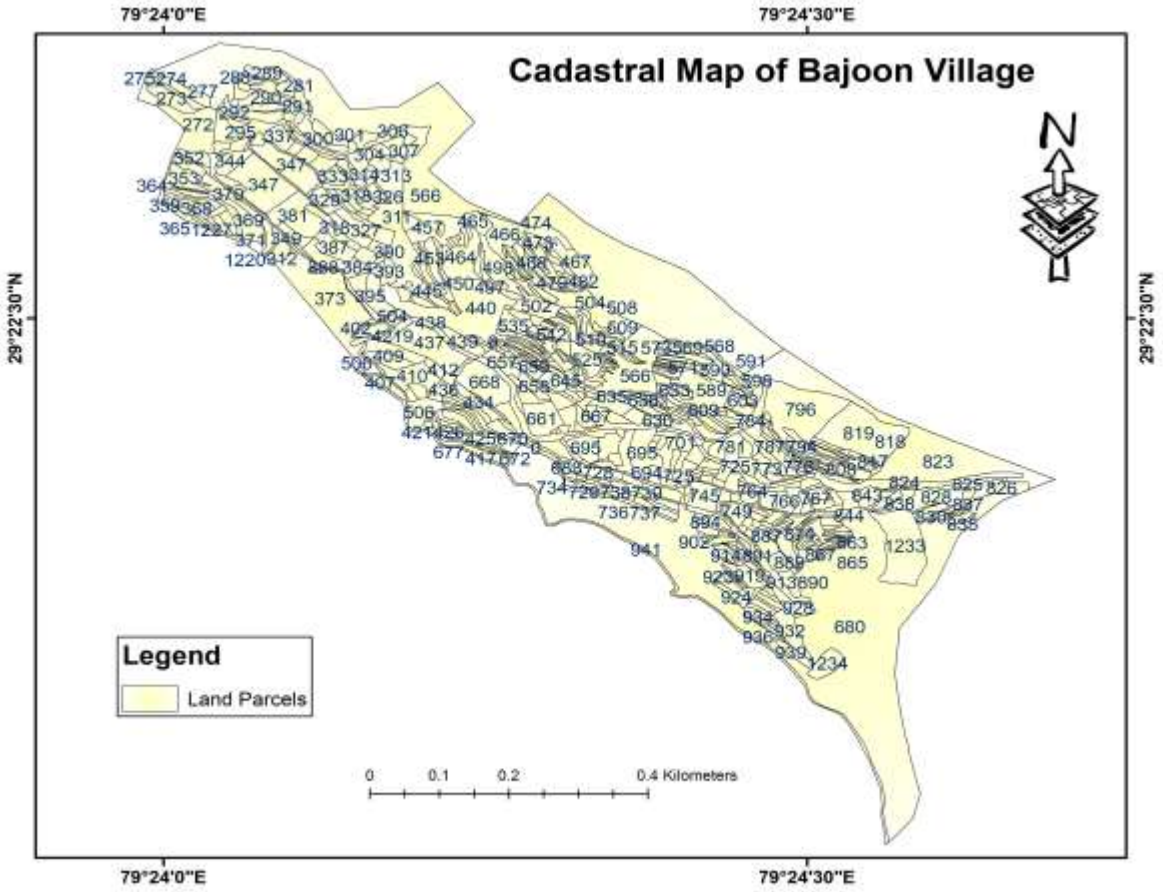


Figure 10 Cadastral Maps with officially assigned Parcel number

XIII. Land Parcels Information

a) Cadastral Map

A cadastral map contains land parcels, owners ID respectively and carry a unique official number to record the land and owner information in an official database/record book. (fig 10)

After creating digital cadastral map with ID number house location also added on it. All residential buildings are identified on land parcels. It was also verified and validated on the ground during field visit with the help of GPS. Photographs of houses are also geotagged in GIS platform. Household information is collected by conducting door to door survey and uploaded in geodata base.

XIV. Conclusion

A digital interactive map is prepared based on physical and economic data generated using toposheet, cadastral map, satellite data and primary data. It helps us to visualize the current scenario of the landscape as well as socio economic condition. GIS platform makes easy and provide services to store both spatial and non-spatial information in one domain, it also makes easy to access and modify the information while necessary. The data/information we store in a digital database is more safe and secure. GIS database can also be used to compare and identify the changes occurred over time period.

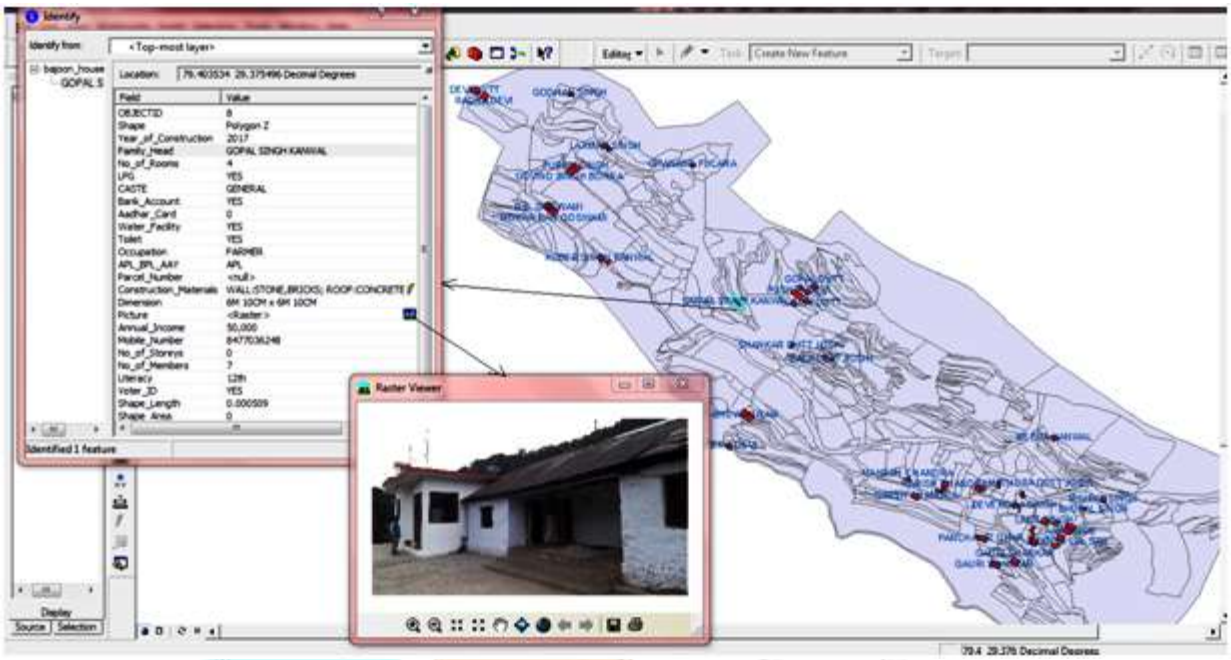


Figure 11. Attribute Table in a GIS domain with land parcels and owners information

The digital database is very useful for the government official to implement any services at the village level. Digital interactive map is also very important for planning and management of village level resources.

XIV. Acknowledgement

Village information system is an initiative undertaken by Natural Resource Data Management System (NRDMS) division of Department of Science & Technology (DST), New Delhi. Authors are grateful to Prof. P. Rajendra Prasad, Dr. Bhoop Singh and Dr. A. K. Singh for their help to bring out this work. This work forms a part of the research project funded by DST, New Delhi.

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