

RISK ZONE MODELLING OF VISCERAL LEISHMANIASIS (KALA-AZAR) DISEASE IN BIHAR USING REMOTE SENSING AND GIS

**A. Jeyaram,
General Manager
Regional Remote Sensing Centre-East
NRSC/ISRO, Kolkata**

Disease Scenario & Vulnerability

World Scenario

WHO: 12 million people are affected by leishmaniasis in 88 countries, 72 of which are developing countries. The overall incidence of VL is 500,000 and an estimate of 40,000 to 80,000 deaths a year. More than 90 per cent of the world's cases of VL are in India, Bangladesh, Nepal, Sudan and Brazil.

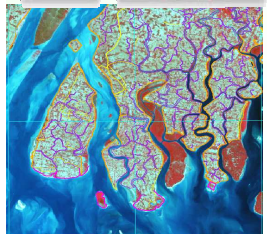
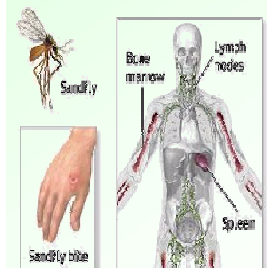
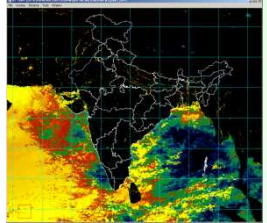
The global estimate for the incidence and prevalence of Kala-azar cases per year is 0.5 million and 2.5 million, respectively.

Indian Scenario

The incidence of kala-azar in India is among the highest in the world. Kala-azar is widely prevalent in Bihar, West Bengal and Uttar Pradesh in eastern States of the country.

48 districts have been declared endemic;

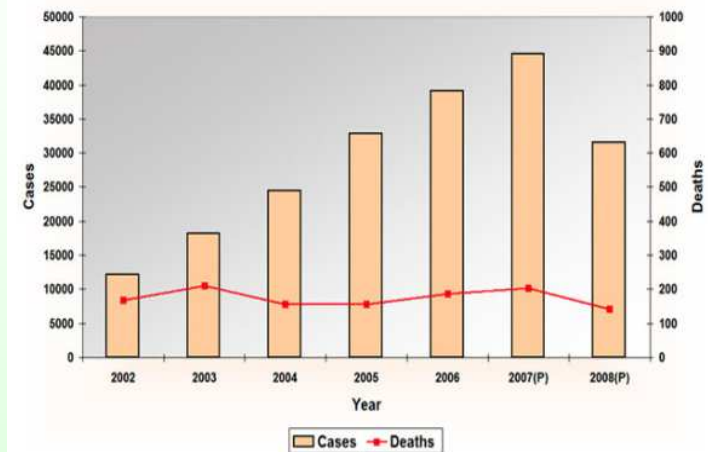
Estimated 165.4 million population at risk in 4 states.



Disease transmission

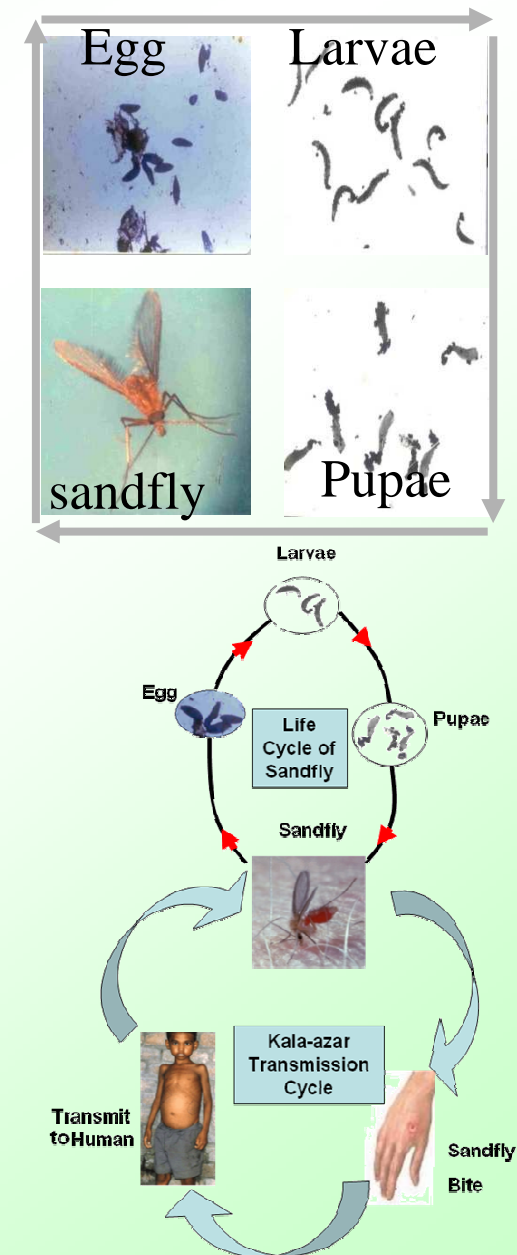
- Through bite of infected *P.argentipes*
- Leishmanial form enters the gut
- In gut of sandfly, leishmanial form develops and multiplies by binary fission and large number of flagellates are produced.
- When infected *P.argentipes* bites uninfected people, disease may be transmitted.

Trend showing Kala-azar cases & deaths in India since 2002



Sandfly Characteristics

- All species of sandflies feed on plant sugar and the females often feed on vertebrate hosts including man. (hop & Fly)
 - Prefers to rest in indoors, about 8-10 times higher in cattle dwellings than in human dwellings (soil cracks, mud walls, crevices etc).
 - The species is more active during the second and third quadrants of night with greater biting preferences
 - The species is mainly zoophilic preferring to feed on cattle blood (67%), the second preference being that of human (15.5%).
- **Vector:** *Leishmania donovani*
 - **Parasite:** Transmitted by female *Phlebotomus argentipes* sand flies.



OBJECTIVES

- Understanding of epidemiology and its significance
- Identification of geo-environmental and climatic variables
- Mapping of geo-environmental parameters using high resolution satellite data
- Development of multivariate regression models
- Development of software package incorporating multivariate regression models and geospatial modeling (Fuzzy logic) for the estimation of village wise Kala-azar genic conditions

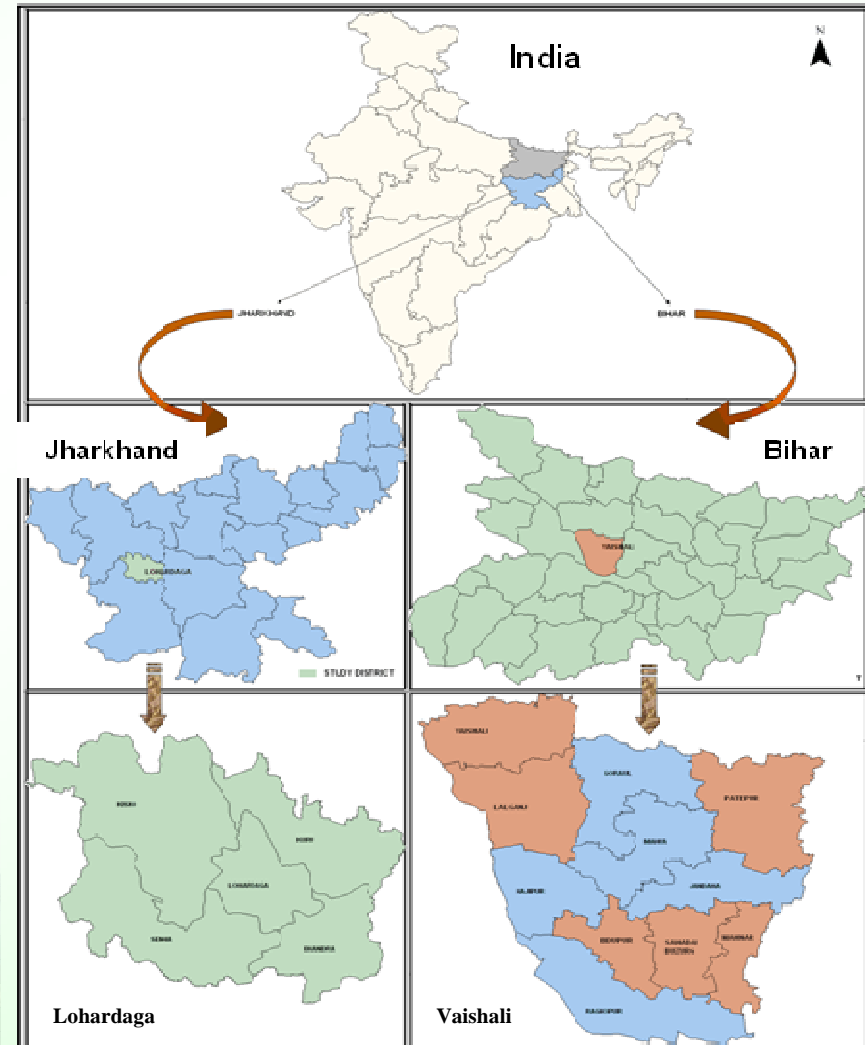
STUDY AREA

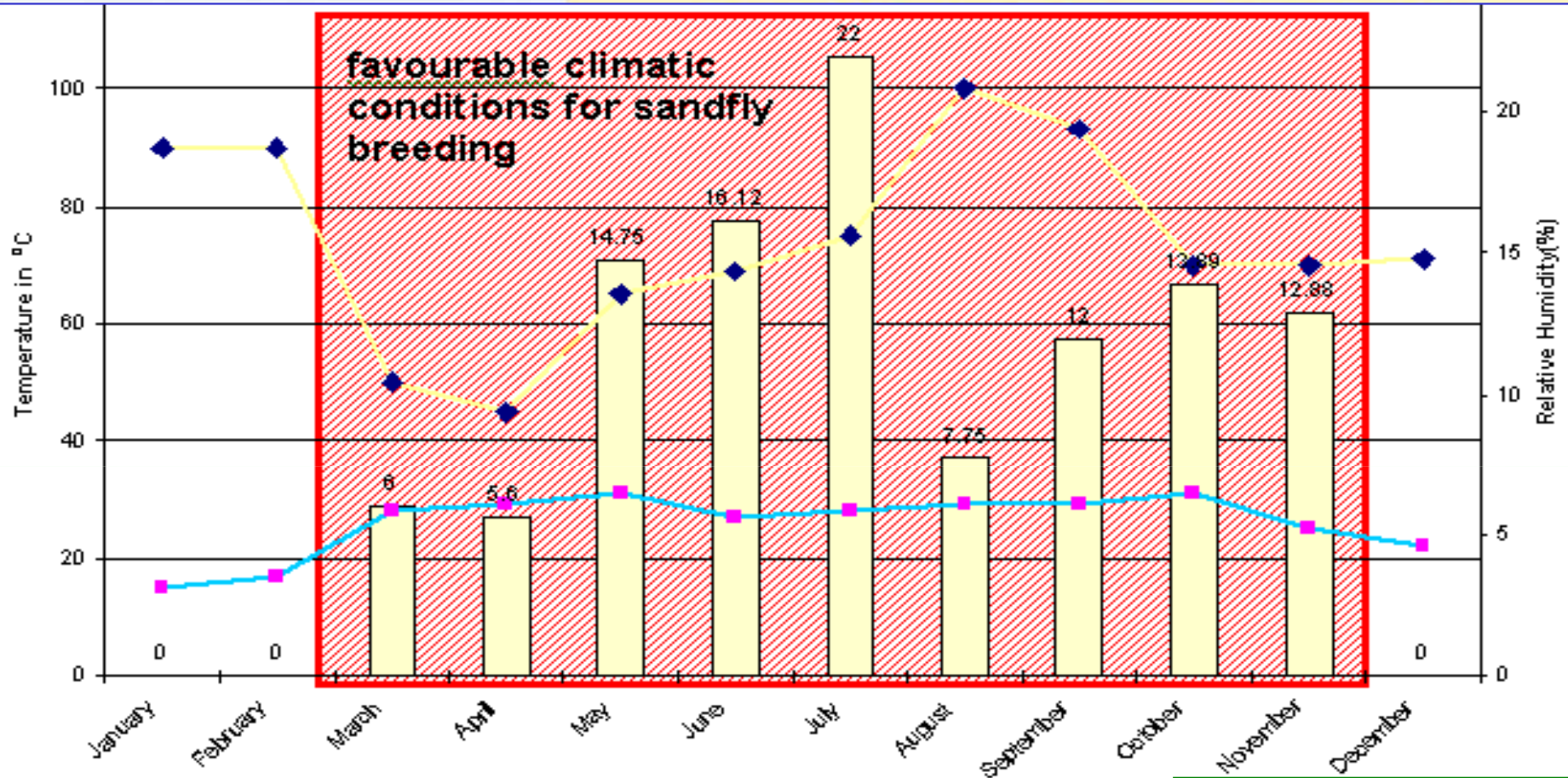
Previous study:-

- Endemic area of Vaishali district (5 villages)
- Non-endemic area of Lohardaga district (5 villages)

Present study:-

- *Endemic area of Vaishali district* having 70.08 sq. km comprising of **12 blocks** covering **all villages**.





Patepur

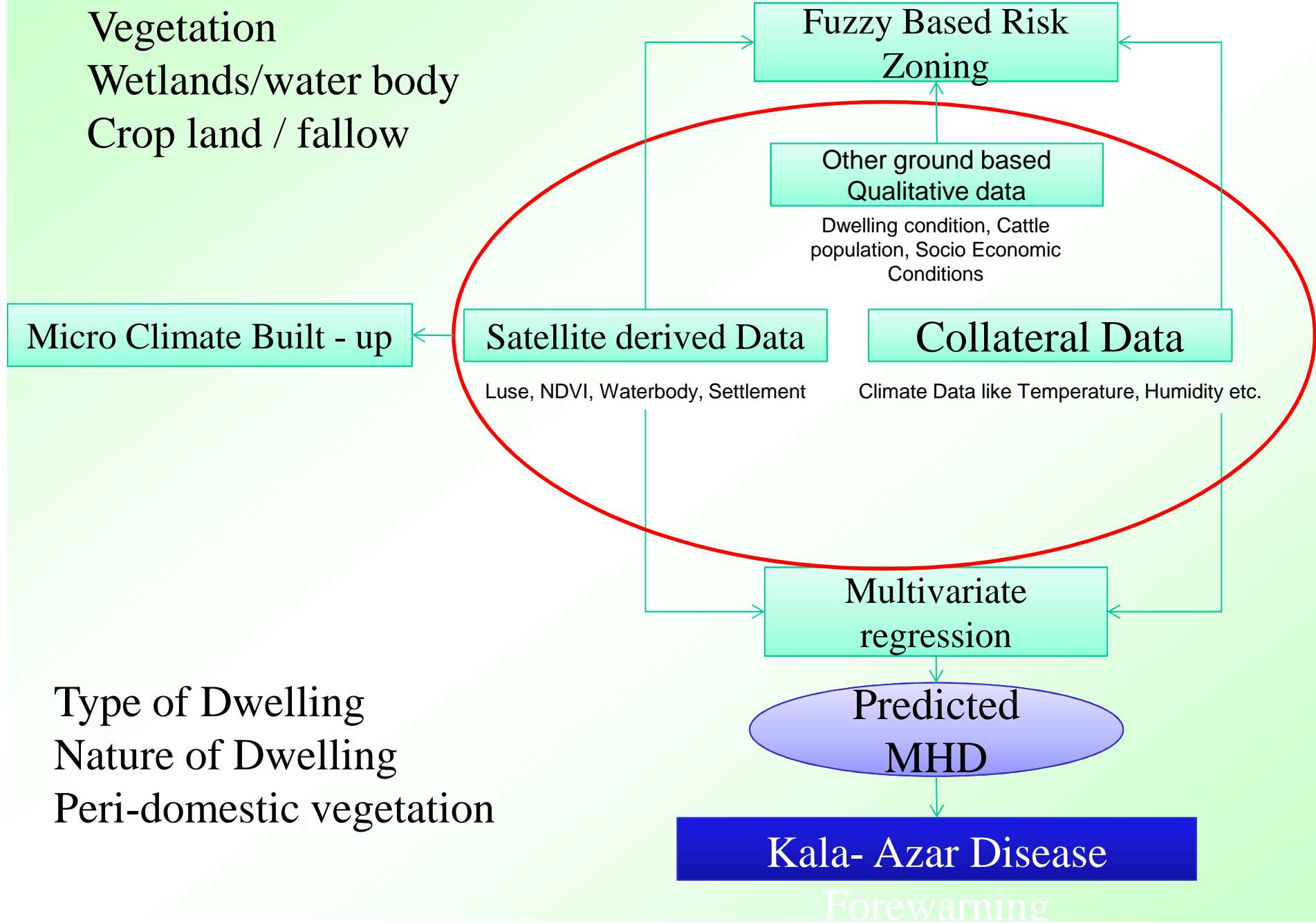
Lohardagga(MHD)
 Summer - 4
 Rainy - 5
 Winter - 0.58
 Annual - 3.19

man hour density
 avg. monthly temp. (°C)
 avg. monthly humidity (%)

Atleast 8 MHD is required
for transmit

Patepur (MHD)
 Summer - 21.22
 Rainy - 20.55
 Winter - 5.11
 Annual - 15.63

Figure 2 – Flow Chart

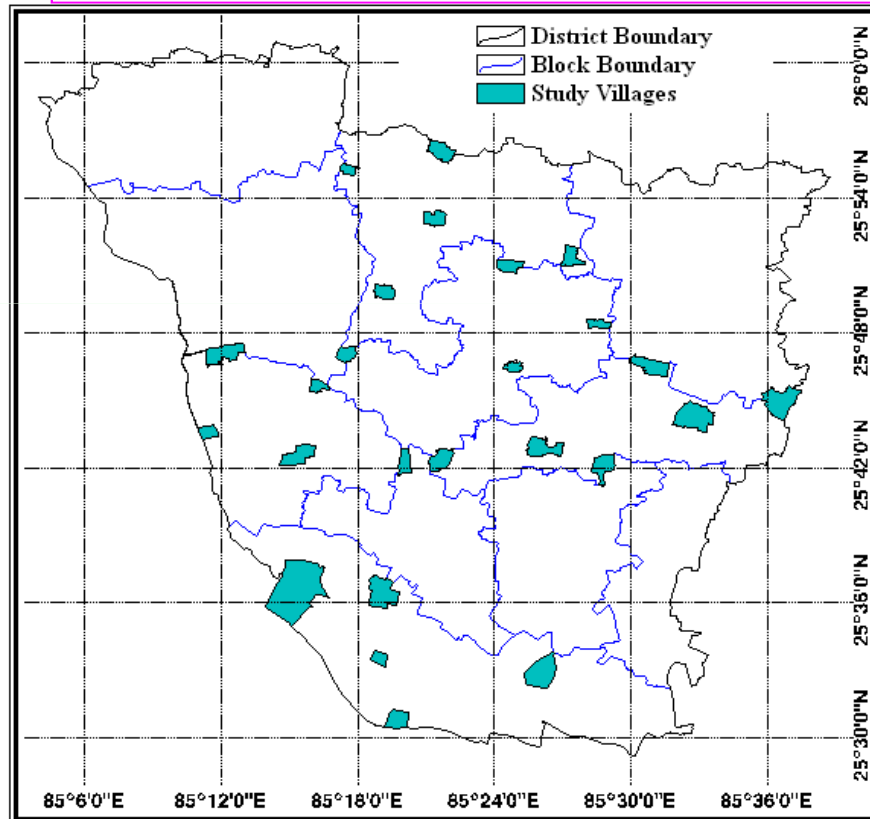


INPUT data

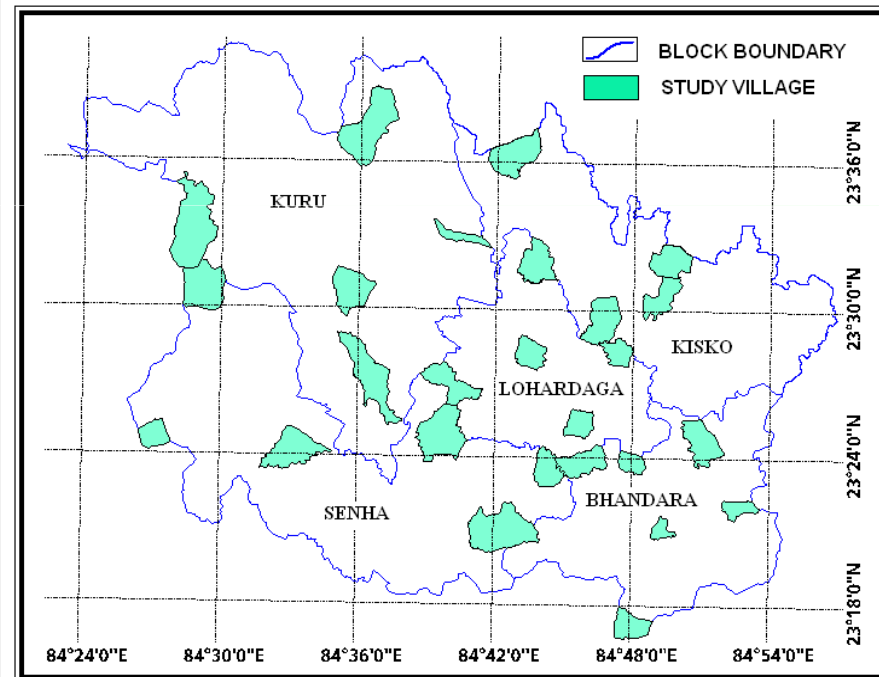
IRS LISS III, IV and Cartosat-1 data (two seasons)

Collateral data (administration, disease incidence, climate data etc...)

Ground truth collection

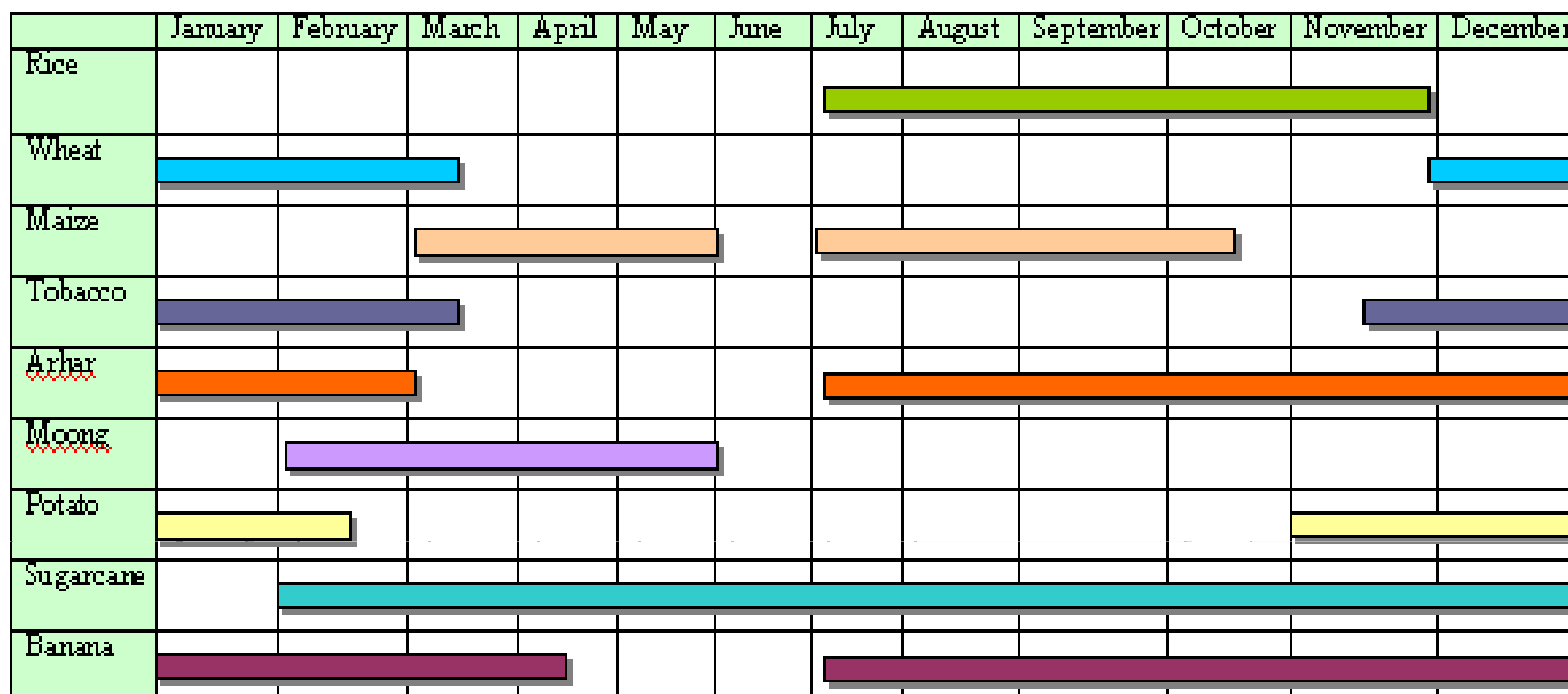


**Sample sites of endemic area
Vaisali District, Bihar**



**Sample sites of non-endemic area
Lohardagga dist, Jharkhand**

Crop Calendar in endemic foci



Percentage sown area cropwise in endemic study area.

<u>Kharif Crop</u>	<u>Rabi Crop</u>	<u>Summer Crop</u>
Rice(low lying areas) 70%	Wheat 55%	Vegetables – gourd, cucumber, <u>parwal</u> , ladyfinger etc.
Sugarcane(low lying areas) 10%	Maize 10%	
Maize(upland areas) 15%	Tobacco 20%	
Arhar(upland areas) 5%	Potato 10%	
	Moong dal 5%	

INPUT data

IRS LISS III and PAN data (two seasons)

Collateral data (administration, disease, etc...

Ground truth collection

Thematic layers

Land use / Land cover

Wet lands

Normal Difference

Vegetation Index (NDVI)

Drainage/water bodies

DEM

Soil map

Climate data

Rainfall

Temperature

Humidity

Disease data

Incidence

Man-hour-Density

Administrative layers

State boundary

District boundary

Village boundary

Village locations

Settlement area

Infrastructure

Road

Rail

Attribute Information

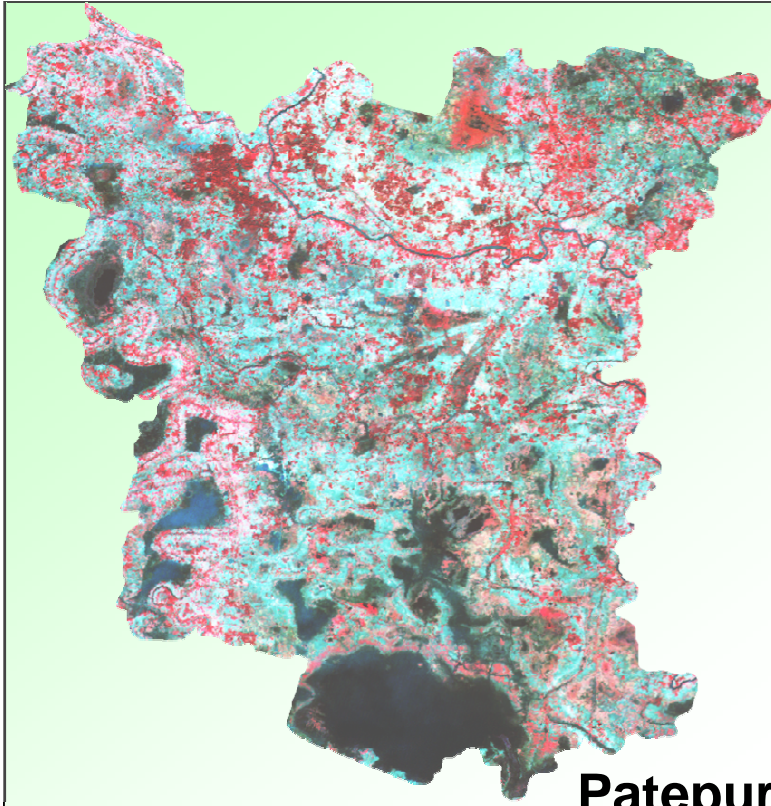
Peri-domestic vegetation

Population data

Type of dwellings

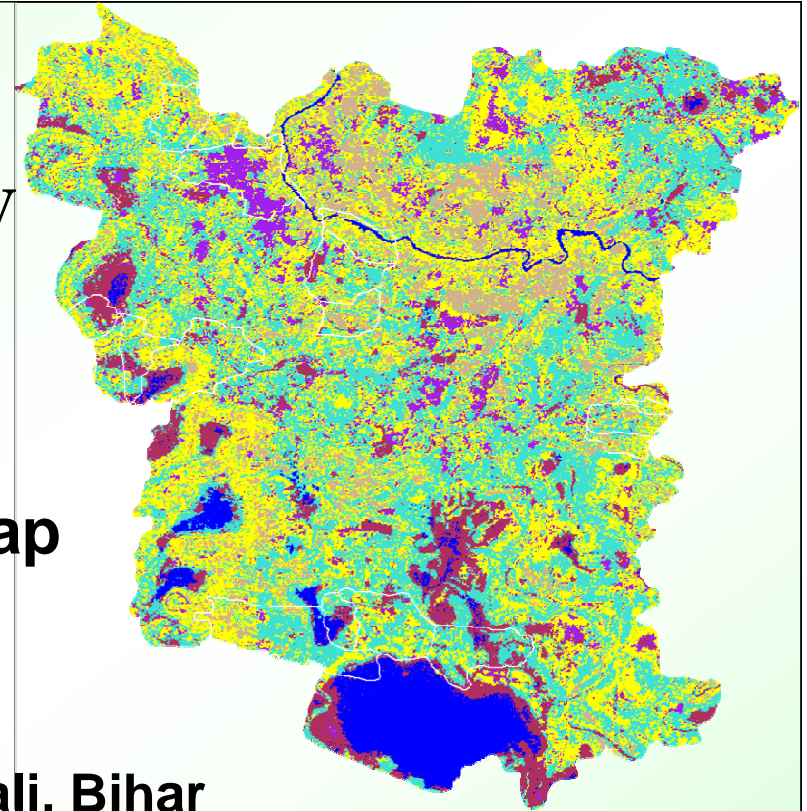
Nature of dwellings

Crop calendar



IRS LISS IV

Landuse Map



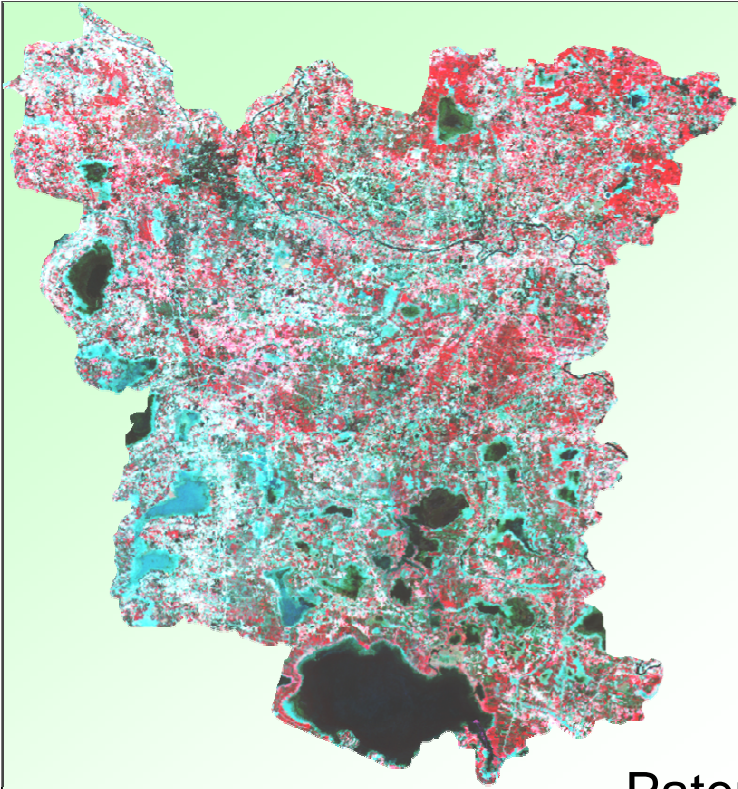
**Patepur Block, Vaishali, Bihar
Post Monsoon**

Peridomestic Vegetation : soft stemmed plants

Storage units for husk and grains

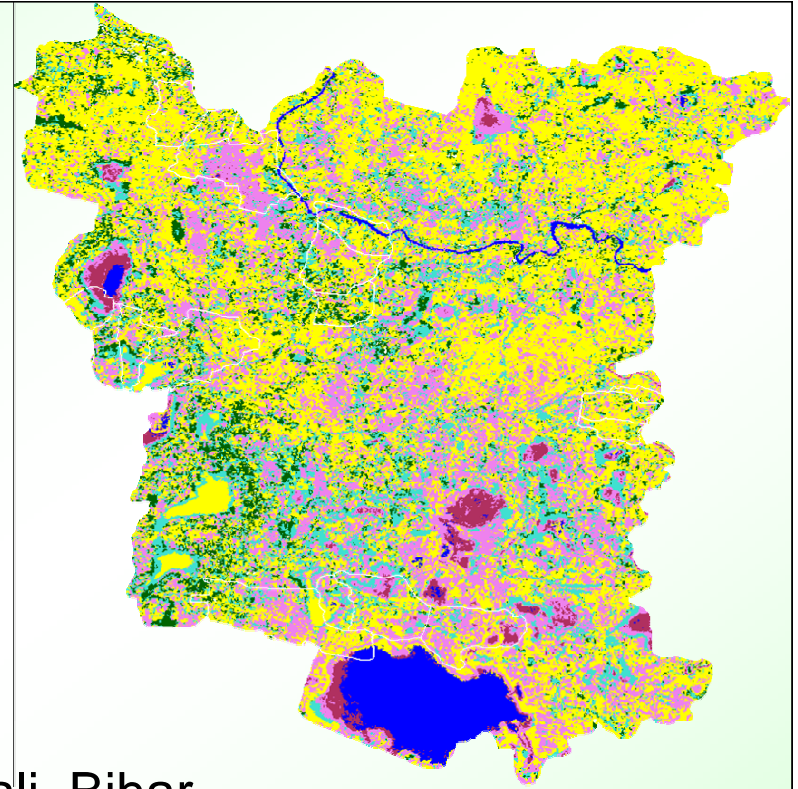
Mixed Dwellings





Mixed Dwellings

Patepur Block, Vaishali, Bihar
Pre Monsoon

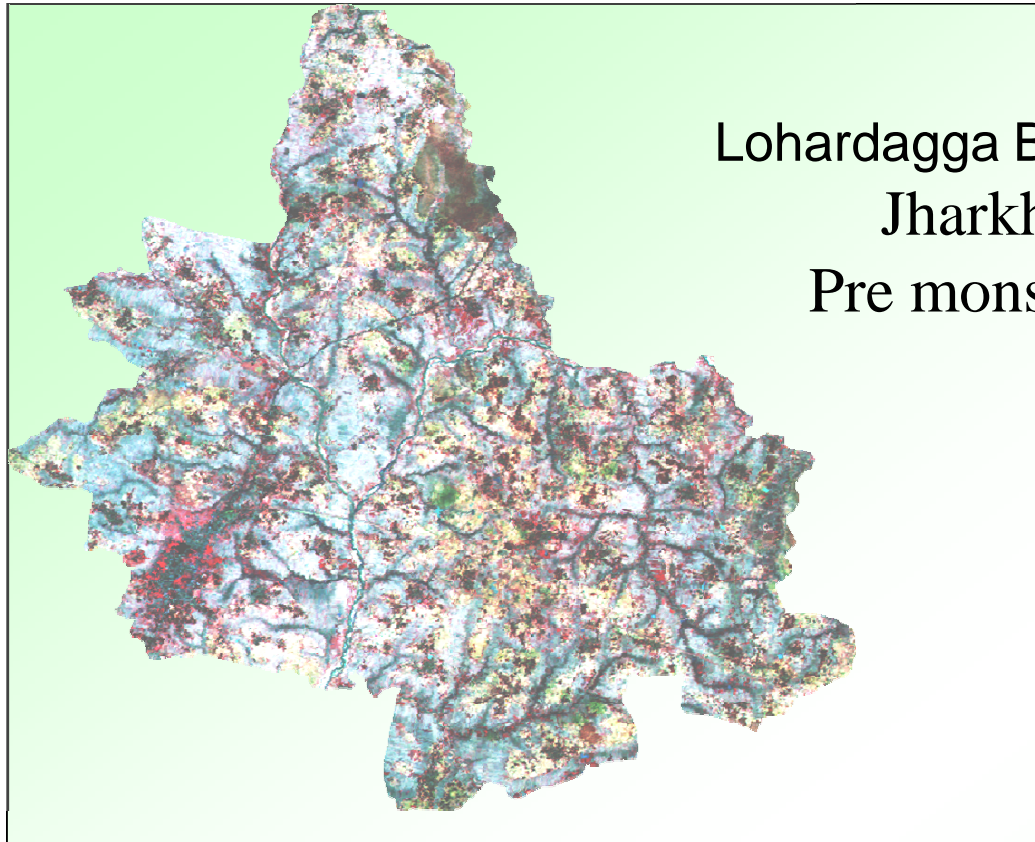


Landuse Map

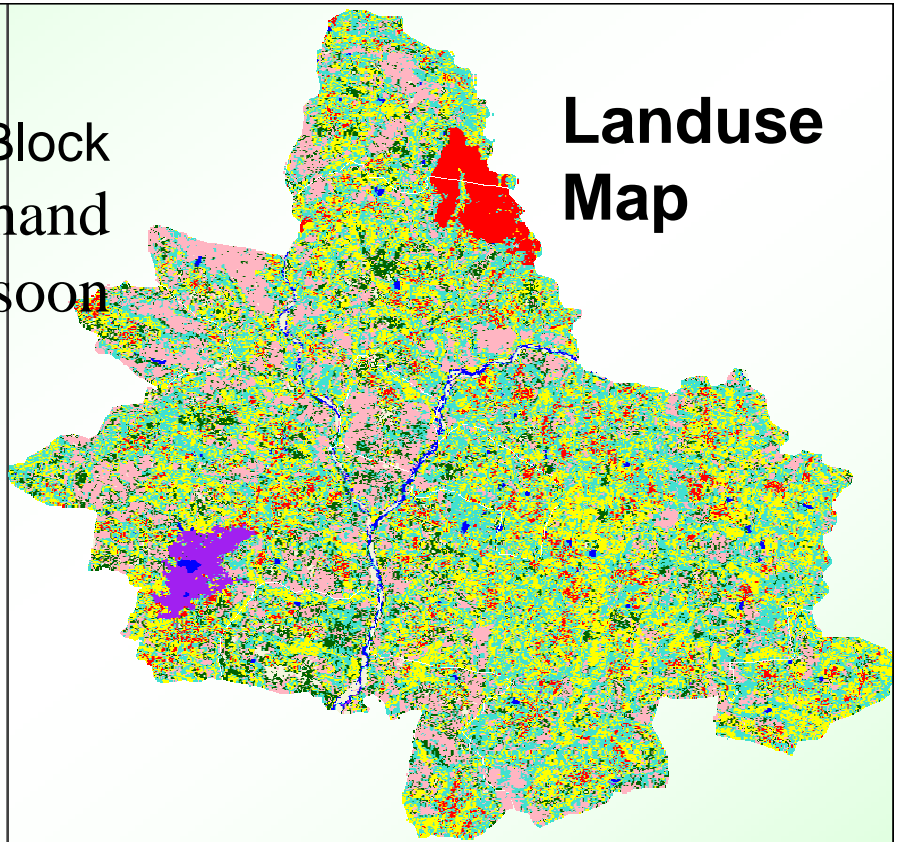


**Abundance of peri-domestic
vegetation**





Lohardagga Block
Jharkhand
Pre monsoon



Landuse
Map

Mixed Dwellings

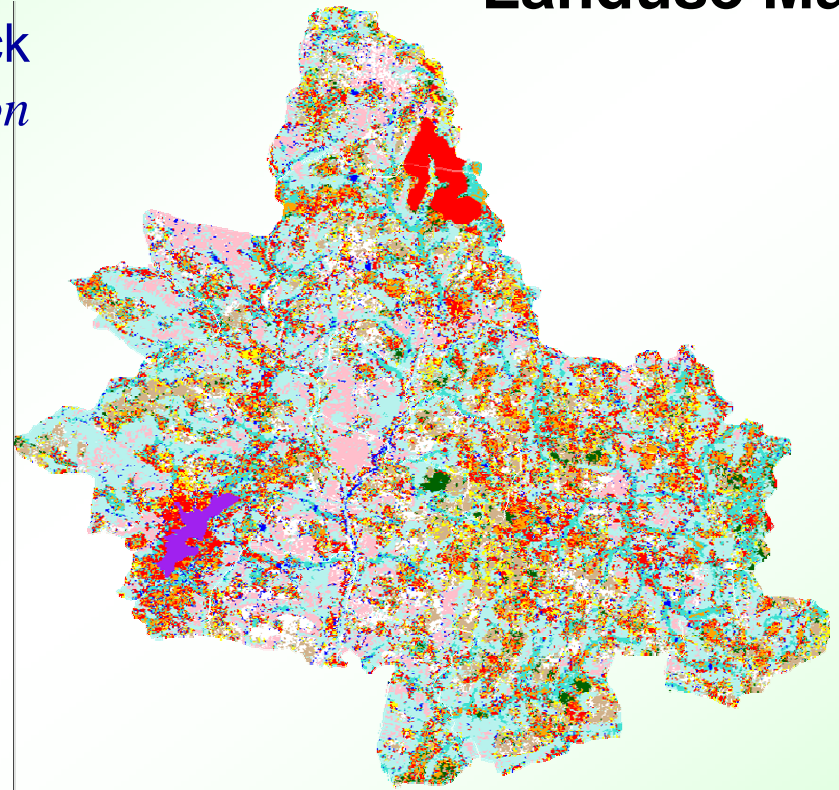
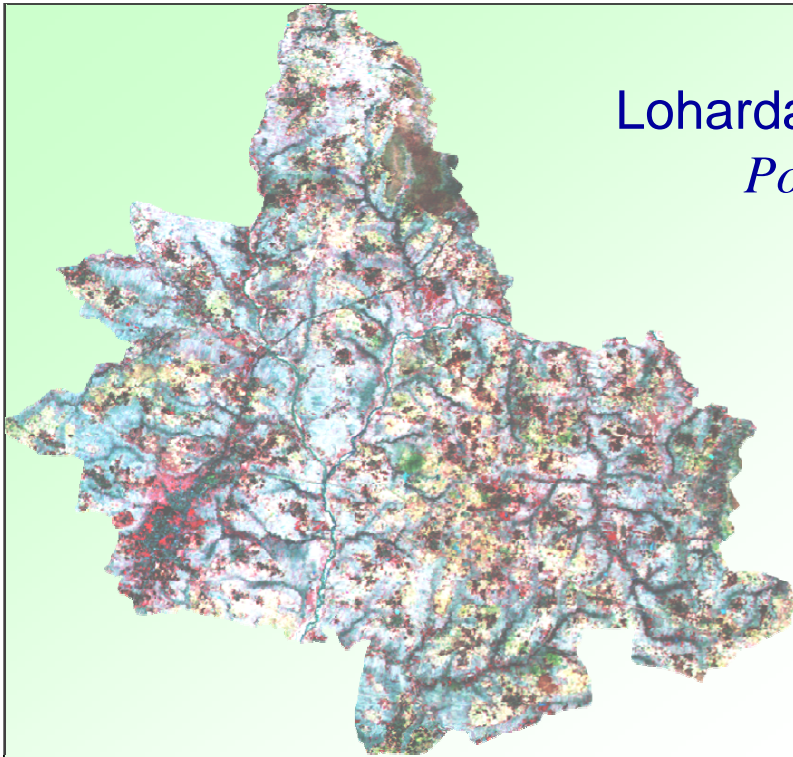


Water bodies



Landuse Map

Lohardagga Block
Post monsoon



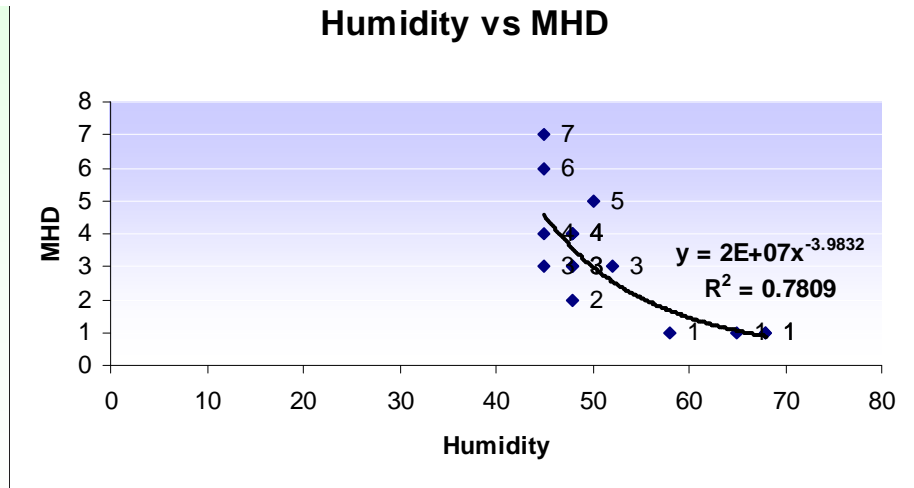
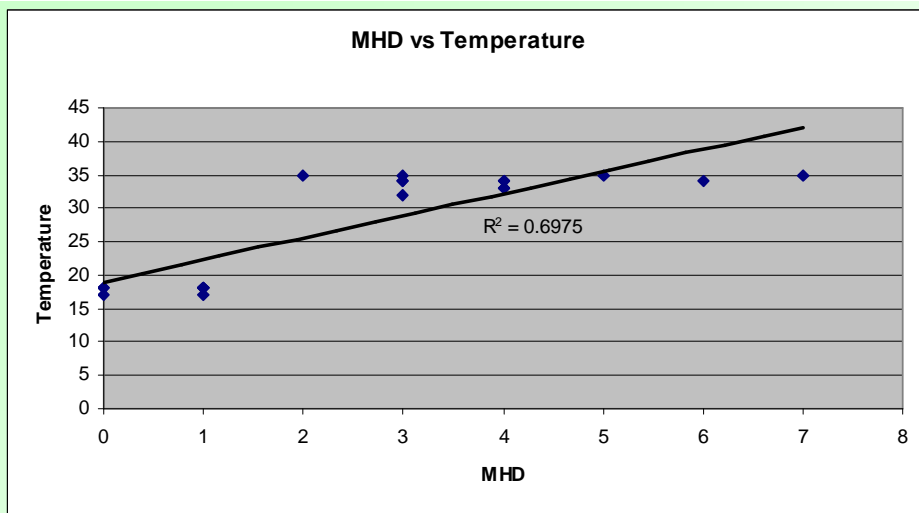
Mixed Dwellings

Peridomestic Vegetation: predominance of deciduous and thorny bushes



Association of *P. argentipes* with the common vegetation types as observed in field survey

Plant Species	Sites positive for vector	Endemic sites	Non-endemic sites	R2 value	P-value
Banana	Present Absent	20 3	2 38	39.63	<0.01
Bamboo	Present Absent	16 4	1 24	24.17	<0.01
Sugarcane	Present Absent	18 2	3 21	23.25	<0.01
Maize	Present Absent	17 2	2 24	26.84	<0.01
Peridomestic Edible Vegetation	Present Absent	18 4	4 36	28.92	<0.01
Grasses	Present Absent	45 5	4 45	53.03	<0.01



Correlation of vector density with different land cover and environmental variables in all sites in both areas

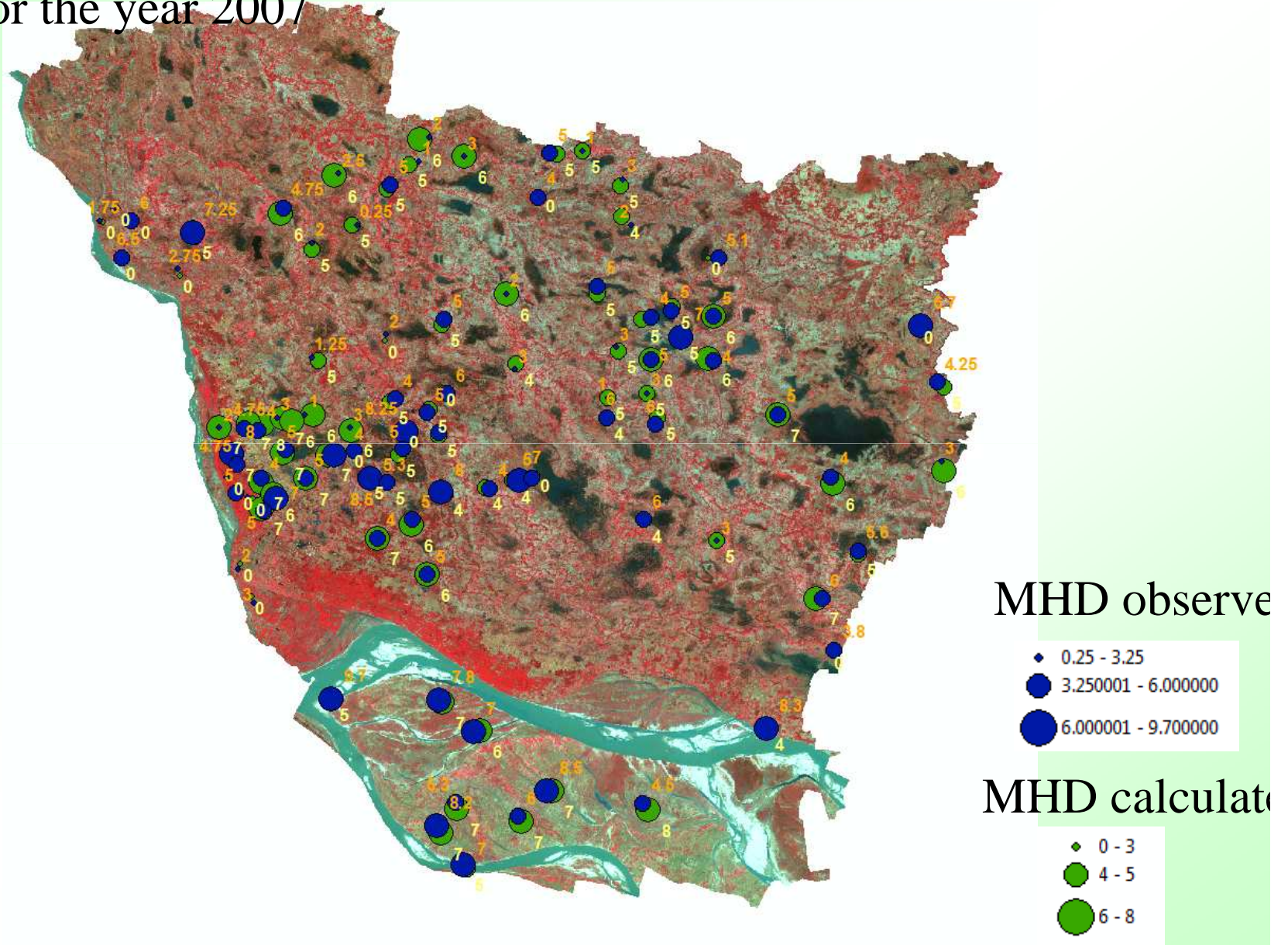
Environmental Variables	Endemic sites	Non-endemic sites	Pearson's coeff. of correlatio	p-value
Temperature (C)	23.83(7.33)	25.71(8.51)	0.532	<0.01
Humidity (%)	65.22(6.11)	56(9.19)	0.567	<0.01
Water body (area)	1.81(3.95)	2.04(1.54)	0.18	0.170
Orchard/Settleme nt	16.44(13.88)	4.11(3.21)	0.734	<0.01
Crop	43.01(13.74)	15.9110.52)	0.537	<0.01
Dry Fallow	9.04(7.00)	23.56(16.01)	-0.433	<0.001
Moist Fallow	24.00(12)	34.45(7.87)	0.657	<0.001
Mean NDVI	0.57(0.025)	0.107(0.091)	-0.253	0.051
Max. NDVI	0.41(0.085)	0.49 (0.088)	-0.210	0.108
Min. NDVI	-0.21(0.075)	-0.32(0.13)	0.439	<0.01
Standard Deviation of NDVI	0.084(0.020)	0.108(0.063)	-0.265	0.041

Six models were generated and the various coefficients estimated and best model is presented here. According to this model, the predicted vector density in terms of MHD is given by the following equation:

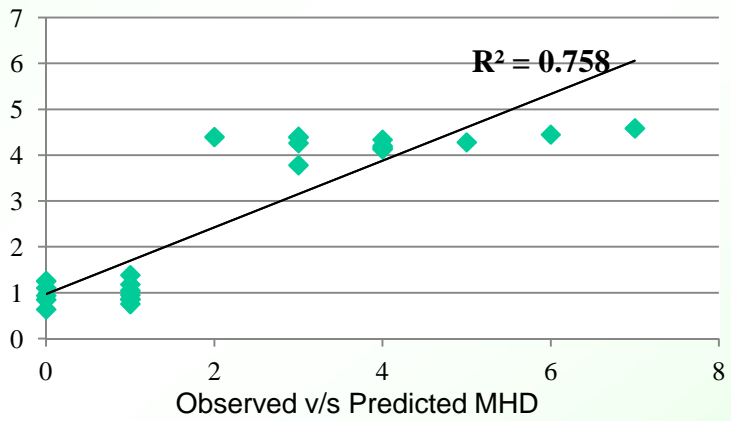
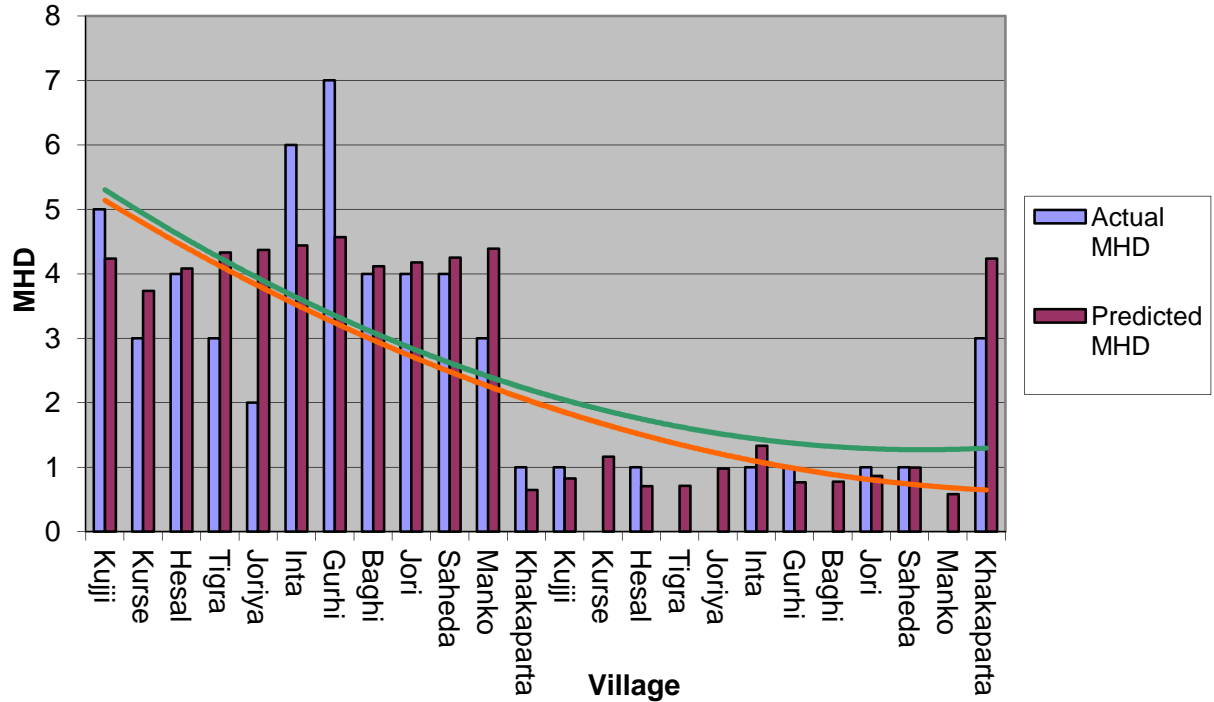
$$Z = - 42.23 + (\text{Temp.} \times 0.597) + (\text{Humd.} \times 0.684) - (\text{dry fallow} \times 0.170) + (\text{NDVI} \times 11.44)$$

Where Z is the estimated man-hour-density.

Comparison of MHD observed versus MHD calculated in Vaishali district for the year 2007



Actual vs Predicted MHD

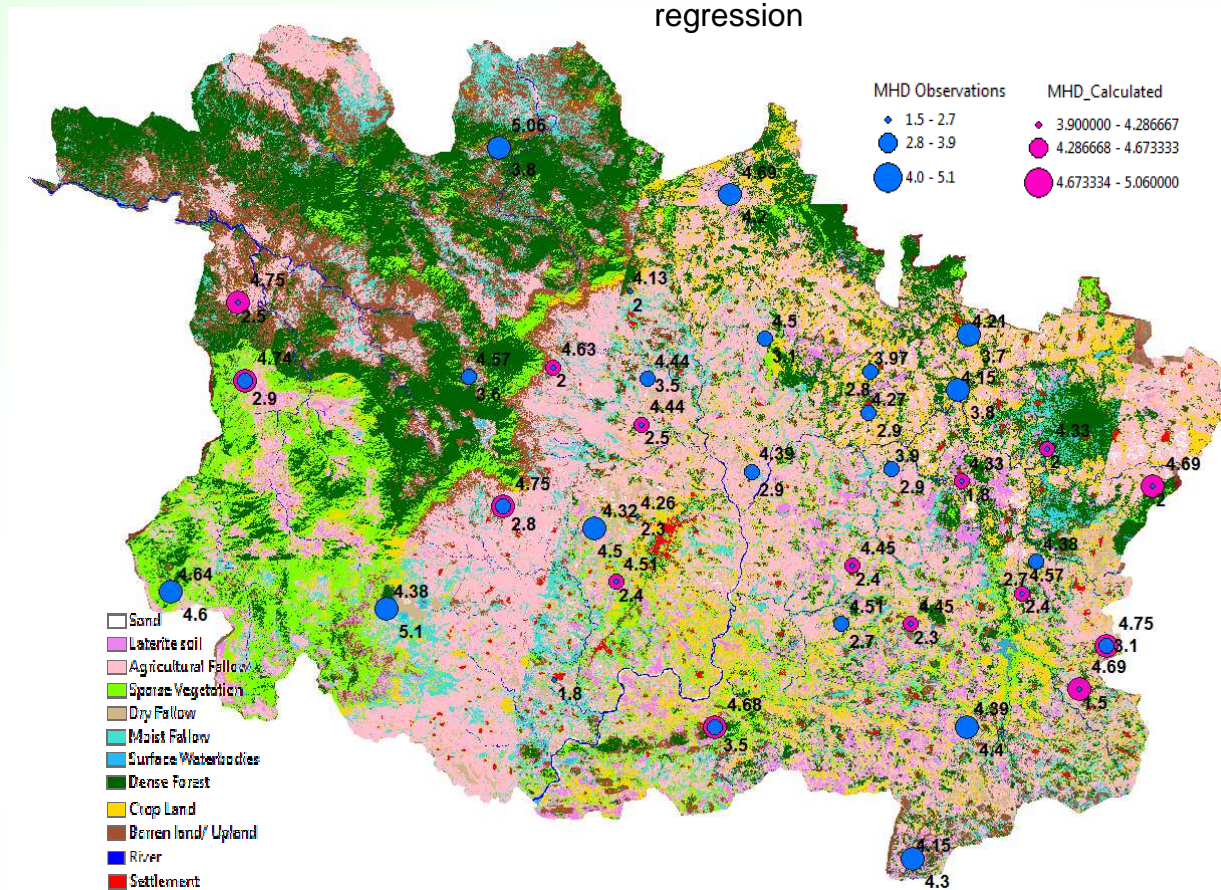


MODEL RESULTS AND EQUATIONS

Multivariate Regression Equation for Vector MHD

$$\text{MHD} = - 42.23 + (\text{Temp.} \times 0.597) + (\text{Humd.} \times 0.684) - (\text{Dry fallow} \times 0.170) + (\text{Min. NDVI} \times 11.44)$$

Comparison of observed versus Calculated Vector Density (MHD) derived using multivariate regression



Home Draw

Toolbar

Pan Zoom In Zoom Out MaxExtents Previous Next Add Identify Select Attribute Measure GeoTag Report Graph

Map Tools

KALA-AZAR EARLY WARNING SYSTEM

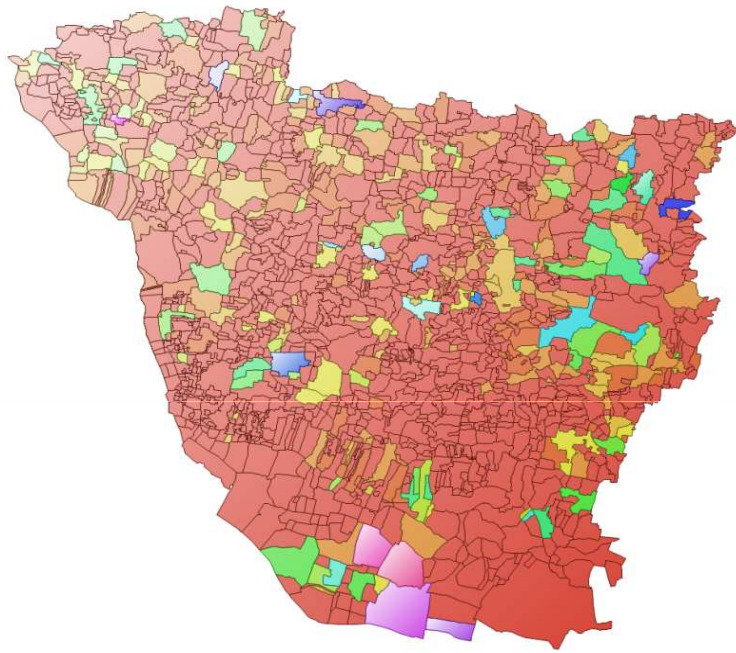
Home Draw

Pan Zoom In Zoom Out MaxExtents Previous Next Add Identify Select Attribute Measure GeoTag Report Graph Extensions

Map Table

Map Layers

- ves_dan
- vil_reprojected
- CASES_08
 - 0
 - 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 26
 - 36
 - 37
 - 39
 - 47
 - 51



Attribute Table Editor

Edit View Selection Tools

Attribute view/Selection

AREA	PERIMETER	VILL_LAY_	VILL_LAY_J	PHC_NAME	VILLAGE_NA	T
3183690	7220.27	2	1	Vaishali	Belaur	20
460897	2871.52	3	3	Vaishali	Chakia	20
882465	6145.68	4	2	Vaishali	Baja Chak	20
3587740	9466.44	5	5	Vaishali	Bhagwatpur	54
4191820	11337.6	6	3	Vaishali	Nagwan	20
6070190	17886.5	7	4	Vaishali	Miraulia Afzalpur	20
111883	1377.15	8	7	Vaishali	Chak Bazid	20
630985	3508.49	9	9	Vaishali	Rasulpur	19
4121200	11963	10	10	Vaishali	Surahata Dharam...	19
2503310	7986.39	11	11	Vaishali	Sein Brauna	19
1071140	5661.69	12	19	Vaishali	Fatehpur	52
685450	3767.03	13	8	Vaishali	Bahor Khan	19
292046	2164.96	14	12	Vaishali	Bhagwanpur Bah...	19
2340090	8248.23	15	13	Vaishali	Miraulia Jaggdsh	20
5917890	13443.6	16	14	Vaishali	Jhatkauli	55
1617870	6177.35	17	17	Vaishali	Chak Ramotias	44

Measure Distance

Measure

Distance Units

Current: 1,029 Meters

Total: 3,938 Meters

Geo-tagging Images

Expression Editor

Field Names:

- NON_WOR_HH
- NON_WOR_AG
- NON_WOR_CL
- NON_WOR_OT
- CASE_05
- CASE_2006
- CASES_07
- CASES_08
- FIDO

Unique Values:

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

Minimum: 0 Maximum: 120

SELECT * FROM [Attributes] WHERE [CASES_08] > 8

Query OK Cancel Apply

Layer Properties

Symbology Detailed Properties

Use Color Range

Hue Range: [Color bar]

Saturation Range: [Color bar]

Lightness Range: [Color bar]

Use Gradients

Angle: -45

Rendering

Symbol	Values	Legend Text	Count
[NULL]	[NULL]	[NULL]	6
[Red]	Biampur	Biampur	130
[Orange]	Goraul	Goraul	189
[Yellow]	Hajpur	Hajpur	270
[Light Green]	Jandaha	Jandaha	158
[Green]	Lalgarj	Lalgarj	179
[Teal]	Mahnar	Mahnar	69
[Blue-Teal]	Mahua	Mahua	212
[Blue]	Patepur	Patepur	169
[Dark Blue]	Raghopur	Raghopur	72
[Purple]	SahdaBuzurg	SahdaBuzurg	115
[Light Purple]	vaishali	vaishali	170
[Pink]	Vaishali	Vaishali	170

OK Cancel Apply

Home Draw

Point Line Polygon Save

Create/Edit Shapefiles

Create Field

Field Name: MHD

Data Type: Integer

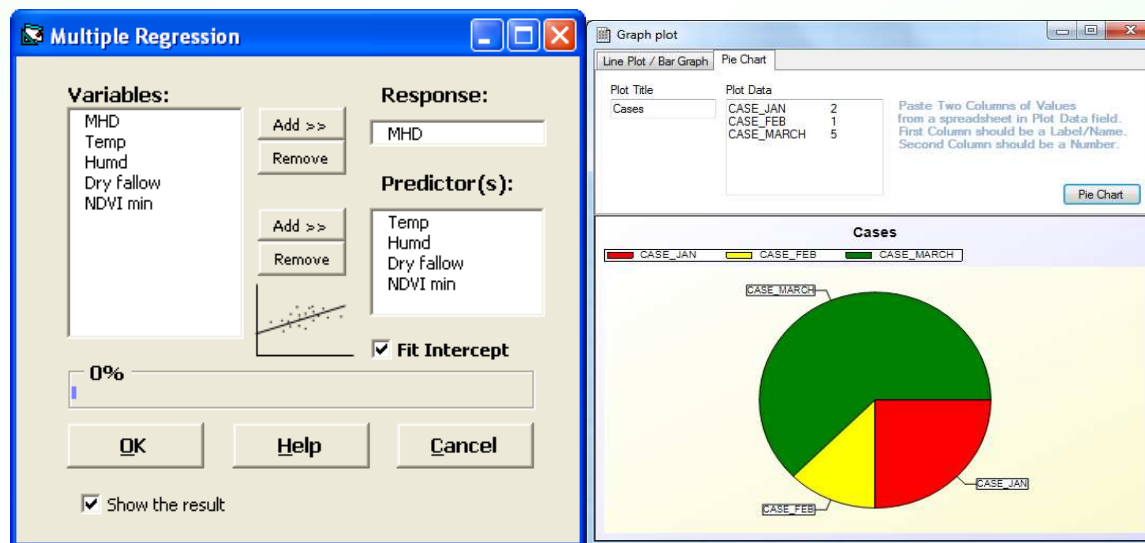
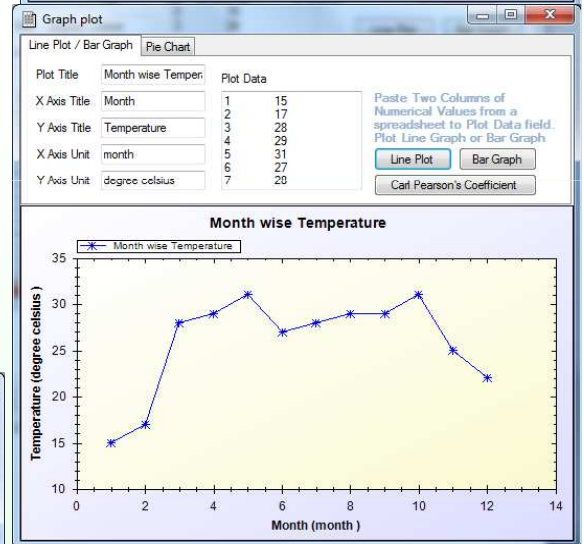
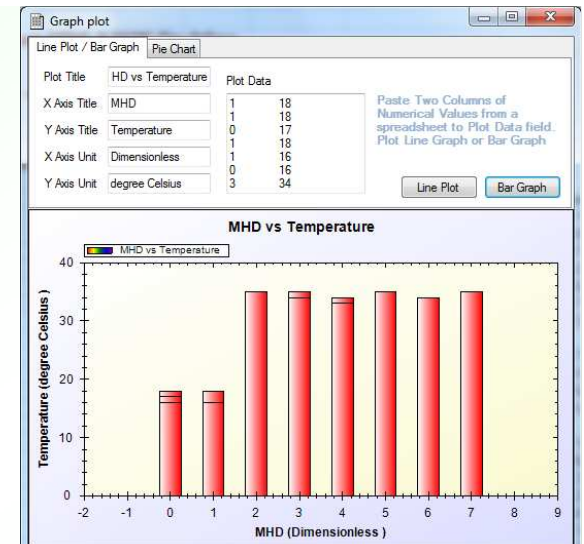
Size: 10

Edit Attributes

OK Cancel Apply

OPEN SOURCE SOFTWARE PACKAGE

- Visualisation of all variables (spatial and charting)
- Attribute editing
- Shape file editing
- Book keeping of Disease incidence data
- Multi-variate regression analysis
- Regression model run
- Fuzzy membership model spatial model
- Village wise Kala-azar genic condition estimation



THANKS