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GEOINFORMATICS AS A CATALYST FOR PREPARATION OF DISTRICT DISASTER RISK MANAGEMENT PLAN : A CASE OF KARUR DISTRICT, TAMIL NADU

Balasundareshwaran A.[1], Balasubramani K.[1], Kumaraswamy K.[2] and Abdul Rahaman S.[2]

[1] Department of Geography, Central University of Tamil Nadu, Thiruvarur - 610 101
[2] Department of Geography, Bharathidasan University, Thiruchirappalli - 620 024
E-mail: balasundareshwaran@gmail.com, geobalas@cutn.ac.in

Abstract

Disaster risk management involves assessment and mapping of hazards, identification of elements at risk and vulnerabilities of the community to a specific hazard, and suggesting risk-reduction as well as implementing measures. It also requires a multi-hazard as well as inclusive risk-informed decision-making approach based on easily accessible, up-to-date and comprehensible information. The application of geoinformatics in disaster risk management resides as a very helpful catalyst to generate, analyse and disseminate the risk related information. It provides technical and scientific capacity to capitalize on and consolidate existing knowledge and to develop and apply methodologies and models to assess disaster risks, vulnerabilities and exposure to all hazards. In this paper, we tried to explicit the role of geoinformatics in preparation of Disaster Management Plan for Karur District. The methodology scours through the possibilities of applying geoinformatics in mapping each disaster risk the District is prone, to evaluate the associated vulnerability, to visualise the multi-hazards scenario at village level and to formulate centralised decision support mechanism. The study uses a wide range of spatial data that are generated from various sources including toposheets, census portal, crowdsourcing such as open street map and Google maps, geospatial portals such as Bhuvan and ArcGIS online, conventional data, satellite images, field data and publications. It also adopts and suggests appropriate tools and techniques, processing methods, indices and spatial analytical procedures for disaster risk management. The results revealed that the District is more susceptible to droughts followed by floods, epidemics and man-made accidents. Based on the hazard and vulnerability profiles, a village-level multi-hazard vulnerability analysis was also attempted in order to prioritize the risk areas for careful monitoring and implementation of mitigation measures.

Keywords: Multi-Hazards, Vulnerability, Risk Reduction, Disaster Management Plan

Introduction

Every disaster, natural or manmade, shatters the physical, cultural, social, psychological, and economic condition of a local community at any particular point of time

or for a prolonged period of time (NIDM, 2009). According to the 2015 report by the Centre for Research on the Epidemiology of Disasters (CRED), about 200 million people a year are affected by natural disasters (CRED, 2015). In the last two decades, more than 15,000 extreme weather events resulted in more than 5,25,000 deaths worldwide and economic losses of more than $2.97 trillion (UNDP, 2015). The disaster is inevitable and sometimes an unpredictable event, for which the governmental body or a commoner is meant to be prepared for (Hewitt, 1997). A disaster plan for any region is vital, with the purpose to avoid maximum disasters, reduce their impact, and to recuperate from its losses. Disaster risk management involves assessment and mapping of hazards, identification of elements at risk and vulnerabilities of the community to a specific hazard and suggesting risk-reduction as well as implementing measures (UNISDR, 2015). Disaster risk management always requires a multi-hazard as well as inclusive risk-informed decision-making approach based on easily accessible, up-to-date and comprehensible information (Manyanye, 2015).

India is vulnerable to various disasters due to different hazard scenarios and varied socio-economical settings. As a whole, more than 60 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent) of its land is prone to floods and river erosion; close to 5,700 km, out of the 7,516 km long coastline is prone to cyclones and tsunamis; 68 per cent of its cultivable area is vulnerable to droughts; and, its most of the hilly areas are at risk from landslides and avalanches. Therefore, it is necessary to prepare a detailed plan to effectively deal with complex disaster risk scenarios. National Disaster management (DM) Act, 2005 mandates for development of comprehensive District Disaster Management Plan (DDMP) to reduce the impact of disasters on the communities, to facilitate effective response and relief activities, and to provide path for holistic disaster management through integration of mitigation, preparedness and risk reduction measures into development activities (NDMA, 2010). The plan should be prepared with the purpose to avoid maximum disasters, reduce their impact, and to recuperate from its losses (Smith, 1992; CRED, 2015). The application of geoinformatics in disaster risk management resides as a very helpful catalyst to generate, analyse and disseminate the risk related information (Balasubramani, 2014; UNDP, 2016). It provides a technical and scientific capacity to and consolidate existing knowledge and to develop and apply methodologies and models to assess disaster risks, vulnerabilities and exposure to all hazards (Peters et al. 2002; Bhanumurthy et al., 2010; Murthy and SeshaSai, 2010; UNDP, 2016). The core components of geoinformatics such as remote sensing, Geographic Information System (GIS) and Global Navigation Satellite System (GNSS) can be readily utilised to develop spatial decision support system which allows very efficient knowledge transformation between decision makers (Hendriks and Vriens, 2000; Frigerio et al., 2016). It also provides the technical capability to understand interdependencies between spatial, socioeconomic, and cultural factors in decision-making processes (Zhang et al., 2018).

In this paper, we tried to explicit the role of geoinformatics in preparation of a disaster risk management plan for Karur District. The main objectives of the paper are to

identify and delineate the major hazards in the District, to measure the vulnerability upsetting at village level, to evaluate the multi-hazard vulnerability for each village for effective management and to help the policymakers, and concern administrative authorities to understand the disaster with a spatial perspective for effectively plan and develop strategies.

Study Area

Karur is a landlocked District (Figure 1) covering 2,895 sq.km. geographical area with a few natural disasters viz. hydro-meteorological (flood and drought) and epidemics (dengue). Apart from natural disasters, with the acceleration in development and use of technology has increased the vulnerability towards man-made hazards like industrial accidents, fire, explosions, oil and gas leakage, Chemical-Biological-Radiological (CBR) accidents, transport accidents, stampede etc (Table 1). The District consists of 2 revenue divisions and 6 taluks (Karur, Aravakurichi, Kulithalai, Krishnarayapuram, Kadavur and Manmangalam), 21 firkas, 8 Community Development Blocks, 4 Municipalities, 11 Town Panchayats and 4 Census Towns and 175 Revenue Villages. The average elevation of the District ranges between 100 m and 200 m above mean sea level. The river Cauvery forms the northern boundary of the District along with the Amaravathi and Kodavanar Rivers which are other important rivers draining on the western part of the District. The rivers are seasonal and carry substantial flows during the monsoon period. The daytime heat is oppressive and the temperature is reached as high as 43.9°C (Table 2). The average annual rainfall of Karur District is 655 mm with a higher contribution of rainfall from Northeast monsoon season (Table 3). The District has only 2.38 per cent of its land under forest cover. The digital land use/land cover database of National Remote Sensing Centre (NRSC) reveals that about 57 and 22 per cent area of total geographical area of the District falls under cropland and fallow land respectively in 2015-2016. The establishment of cement, sugar, paper, and textile mills in addition to the establishment of a number of industries in the medium and small-scale sectors has accelerated the rate of industrialisation in the District. Karur is an important road junction on the two National highways NH-7 (Varanasi - Kanyakumari) and NH-67 (Nagapattinam - Tiruchirappalli - Karur - Coimbatore) and has heavy road traffic throughout the year.

Table 1. Types of Disasters Experienced in the District

Natural Disasters		Man-made Disasters	
Earthquake	⊗	Food Poisoning	✓
Flood	✓	Environmental Pollution	✓
Cyclone	✓	Oil / Gas Leakage	✓
Drought	✓	Communal Riot	⊗
Heat Wave	✓	Rail & Road Accident	✓
Epidemic	✓	Fire	✓
Forest Fire	⊗	Industrial Disaster	✓
Landslides	⊗	Nuclear Hazard	⊗

Table 2. Mean Maximum and Minimum Temperatures (in Degree Celsius) Recorded at K.Paramathi Weather Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max.	30.5	33.4	36.2	37.2	36.3	33.5	32.5	32.5	33.1	31.3	29.6	29.4
Min.	18.7	20.3	22.6	25	25.2	24.7	24.0	23.7	23.7	23	21.5	19.7

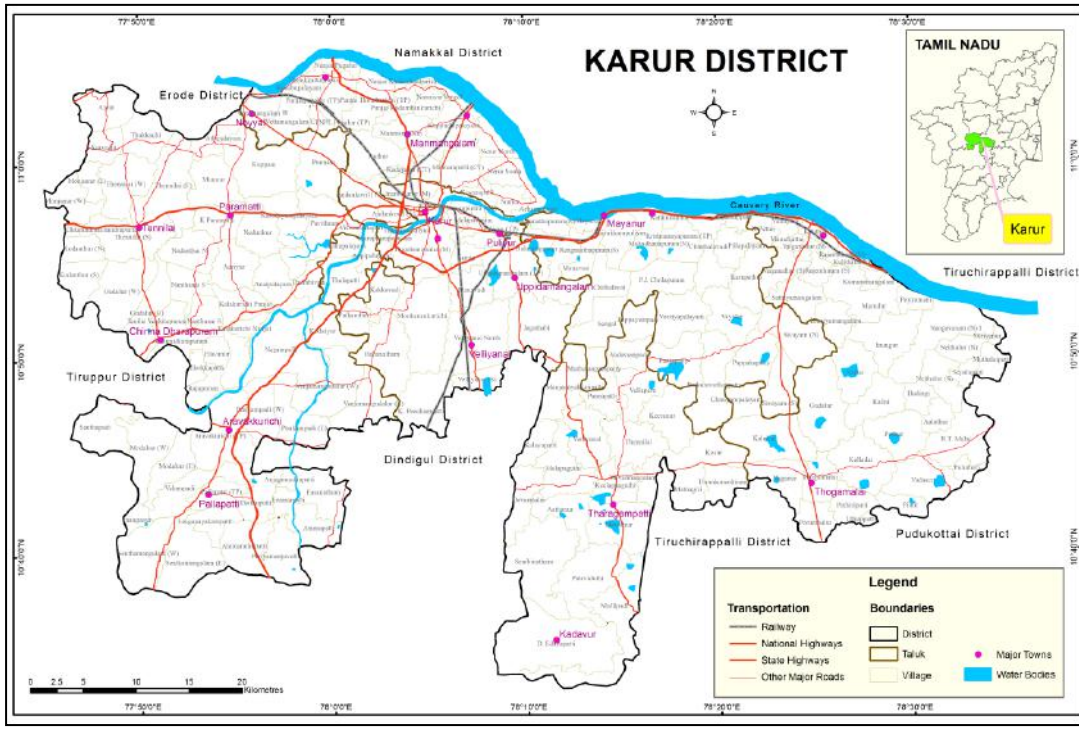

Fig. 1. Location of Karur District

Table 3. Normal and Actual Rainfall in the District During 2005-2016 (in mm)

Season	Month	Normal	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Winter	January	9.7	0	5.17	0.95	4.18	1.56	1.52	0	2.06	0.08	0.25	26.28	0
	February	7.8	0	0	0	1.53	0	0	2.49	0.59	27.06	0	0	0
	Total	17.5	0	5.17	0.95	5.71	1.56	1.52	2.49	2.65	27.14	0.25	26.28	0
Summer	March	10.4	33.98	30.76	0	118.6	2.98	0	4.3	0.17	4.01	0	6.3	0
	April	38.0	112.2	47.83	37.3	6.38	19.37	4.73	105.3	83.17	19.21	0.29	124.79	2.68
	May	60.8	88.01	37.25	57.24	79.64	49.95	131.25	35.71	88.7	47	112.73	112.15	129.93
	Total	109.2	234.2	115.8	94.54	204.6	72.3	135.98	145.3	172.04	70.22	113.02	243.24	132.61
SW Monsoon	June	19.8	13.34	30.87	36.01	14.59	1.75	32.39	11.18	7.44	3.44	23.79	38.42	23.03
	July	35.7	44.47	0	45.67	37.73	0.22	65.6	3.56	3.88	0.33	2.73	0	82.25
	August	51.8	84.49	63.03	98.04	130.9	64.96	32.52	90.09	41.08	73.45	74.68	32.9	12.42
	September	106.3	48.9	87.73	32.52	57.76	107.5	90.96	52.14	40.36	99.39	65.48	116.66	11.78
	Total	213.6	191.2	181.6	212.2	241	174.4	221.47	157	92.76	176.61	166.68	187.98	129.48
NE Monsoon	October	144.6	239.2	156.7	164.1	271.8	43.36	100.08	202.9	192	102.03	219.93	92.1	38.53
	November	119.1	370.9	135	81.05	201.1	272	328	196.4	67.4	72.76	51.14	221.16	14.98
	December	51.0	107.1	5.32	214.7	38.29	47.87	0	23.27	1.16	40.33	21.87	49.67	34.92
	Total	314.7	717.2	297	459.8	511.2	363.2	428.08	422.5	260.56	215.12	292.94	362.93	88.43
Annual	Total	655.0	1143	599.5	767.4	962.4	611.4	787.1	727.3	528.0	489.1	572.8	820.4	350.5

Database and Methodology

The methodology scours through the possibilities of applying geoinformatics in mapping each disaster risk the District is prone, to evaluate the associated vulnerability, to visualise the multi-hazards scenario at village level and to formulate centralised decision support mechanism. For the creation of map layers, processing, and analysis of the results, tools from ArcGIS and Global Mapper has been extensively used in this study. The data has been compiled from various sources such as Open Series Map (OSM) sheets (1:50,000), 2011 Census of India portal, Open Street Map, Google Earth Imagery, NRSC Bhuvan portal, Department of Economics and Statistics Tamil Nadu (DoES TN), Indian Meteorological Department (IMD), and Karur District web portal.

The District flood disaster has been assessed based on the empirical model, run on the Shuttle Radar Topography Mission (SRTM) 90 m Digital Elevation Model (DEM), for flood rise in three different scenarios. An application of theoretical models for flood analysis is very expensive in both time and data. At the same time, empirical models are emphasised in this study, as they are relatively cheap in both data and time, as they produce the results right away. The drought has been assessed using the Normalized Difference Vegetation Index (NDVI) from the existing NRSC Bhuvan Drought data for the years 2011 to 2017. A long-term (1984-2013) drought conditions have been assessed through the Standard Precipitation Index (SPI). The insidious location of man-made industries, fireworks, dams/barricades, bridges and mines were identified with the help of GNSS. The epidemic disease (Dengue) data has been collected and mapped for 2015 and 2016. The overall vulnerability of each disaster is ranked according to the highest to lowest categories of hazards affecting every village, based on maximum likelihood and more than one type of disaster concentration. The overall methodology of the paper is the scope of the paper is to simplify the knowledge of disaster management for the administrative authorities, the geoscientist, and the citizens of the local communities, to have a basic understanding of the concepts and to prepare themselves to act proactively and cope up with before, during and after stages of a disaster (Figure 2). This paper has been prepared to respond to disasters with a sense of urgency in a planned way to minimise human, property, and environmental loss.

Standard Precipitation Index (SPI)

Standardized Precipitation Index is developed for the purpose of defining and monitoring drought conditions (McKee et al., 1993). It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interest using historical rainfall data. It can also be used to determine periods of anomalously wet events. The computation of SPI requires long term data on precipitation to determine the probability distribution function which is then transformed to a normal distribution with mean zero and standard deviation of one. Thus, the values of SPI are expressed in standard deviations, positive SPI indicating greater than median precipitation and negative values indicating less than median precipitation (Edwards and McKee, 1997). Fitting the normal distribution to the

rainfall data requires estimating α and β by using the normalization method suggested by Thom (1966). By dividing the difference between the normalised seasonal precipitation and its long-term seasonal mean by the standard deviation, SPI can be computed using the following expression (Khan et al. 2008):

$$SPI = X_{ij} - X_{im} / \sigma \quad (1)$$

where, X_{ij} is the rainfall recorded at the i^{th} rain gauge station and j^{th} season, X_{im} is the long-term seasonal mean and σ is its standard deviation. The SPI is equal to the z-score in statistics. Hence, SPI values are classified into extremely wet (>2.0), very wet (1.5 to 1.99), moderately wet (1.0 to 1.49), near normal (-0.99 to 0.99), moderately dry (-1.49 to 1.0), severely dry (-1.99 to 1.5), and extremely dry (<-2.0), as suggested by McKee et al. (1993).

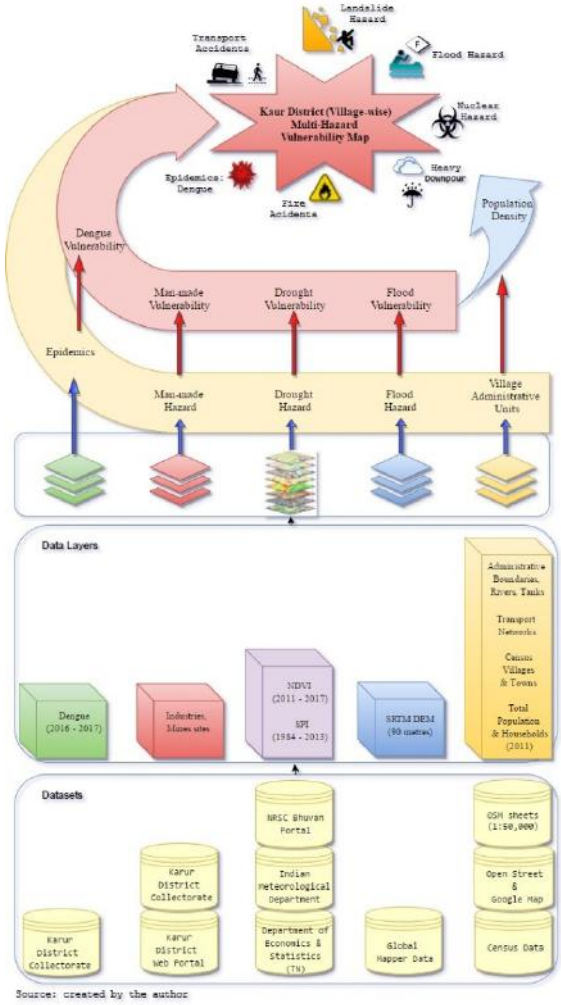

Fig. 2. Methodology of the Study (Bottom to Top Approach)

Results and Discussion

The results revealed that the District is more susceptible to droughts followed by floods, epidemics and man-made accidents.

Flood Hazard

The major rivers such as Cauvery, Amaravathi, Naganchiyar, Kudaganaru and Noyyal are contributing to the seasonal floods in the District (Table 4). Besides these major rivers, there are many jungle streams in the District, which carry the rainwater to the ponds/lakes. In the past, during the monsoon period, heavy water flow in Cauvery and its tributaries has affected the low-lying areas of the riverbanks. Due to this, the District has experienced severe flood havoc during the year 1977 and 2005 which caused a breach of banks and channel, erosion of bunds, damages of the road, sand cast of lands, human and cattle loss, crop damages etc. Nine low-lying villages nearby river bed were stranded by flood and nearly 27 villages were affected by the severe flood. The severe flood of 2005 is also noticed with the highest SPI value (1.85) (Table 5).

Besides the problem of flooding in the river plains, heavy intensity rains could cause local flooding in certain areas where the drainage is either naturally poor or the drains are choked due to various reasons such as careless discarding of litter in the drains and lack of maintenance. Much of the flooding problems in the towns owes to such causes. Figure 3 shows the flood years (2005, 2008, 2010 and 2015) through the deviation of actual rainfall from the normal.

Table 4. Seasonality of Hazards in the District

Disasters/Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flood										■	■	■
Drought	■	■	■	■	■	■	■	■				
Epidemic	■										■	■
Fire				■	■	■						
Industrial Disaster	■	■	■	■	■	■	■	■	■	■	■	■
Oil / Gas Leakage	■	■	■	■	■	■	■	■	■	■	■	■
Rail & Road Accident	■	■	■	■	■	■	■	■	■	■	■	■

The flood hazard map of the District depicts three possible scenarios of flood inundation with 1 m, 5 m, and 10 m rise in the water bodies (Figure 4). The 1 m rise in water is most common and highly vulnerable to the adjacent villages at every peak monsoons. The 5 m and 10 m rise would further affect adjacent interior villages connected with the chain of lakes, by submerging the whole villages situated along the water bodies. The very high flood hazard is traced in the vicinity of river Amaravathi and Cauvery confluence.

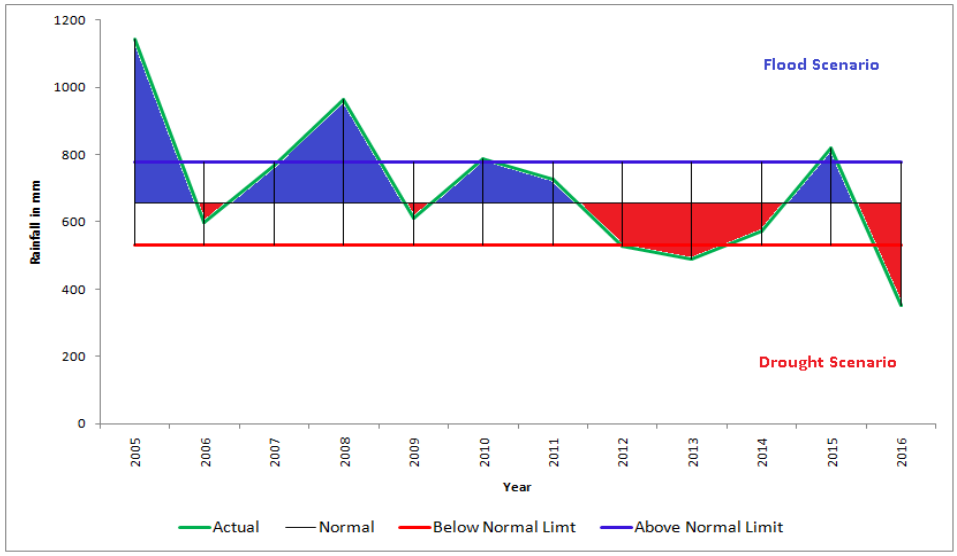

Fig. 3. Deviation of Actual Rainfall from Normal and Associated Scenarios (2005-2016)

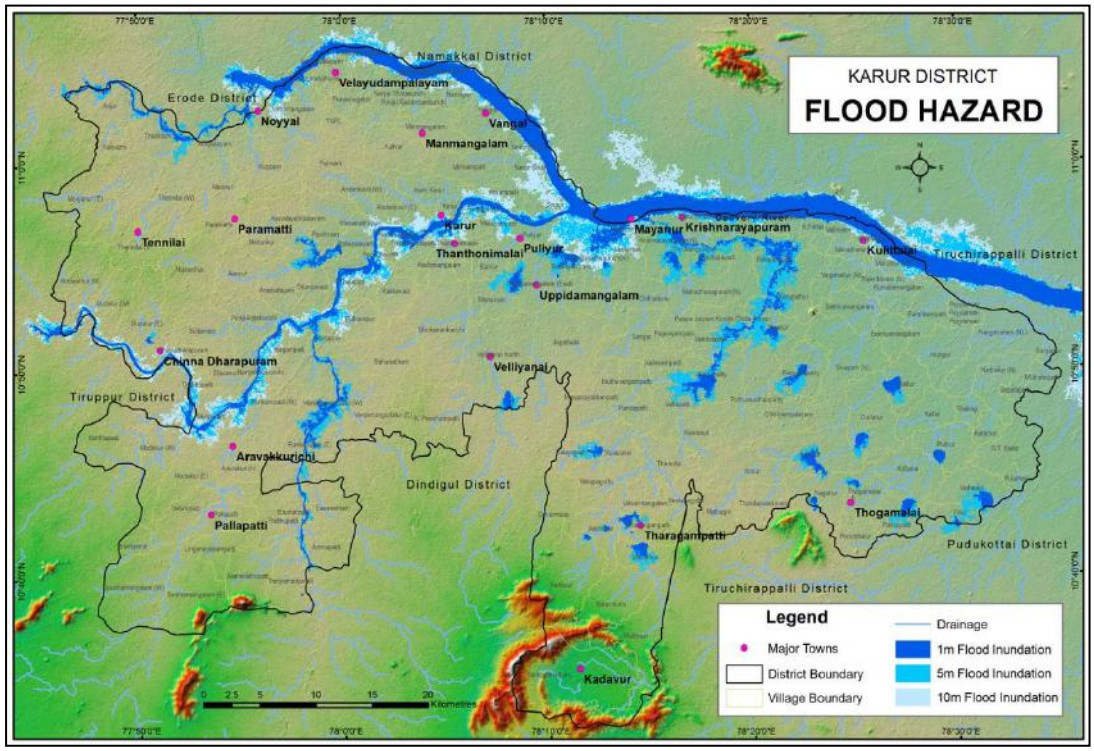

Fig. 4. Flood Inundation Model Scenarios at 1 m, 5 m and 10 m of Flood

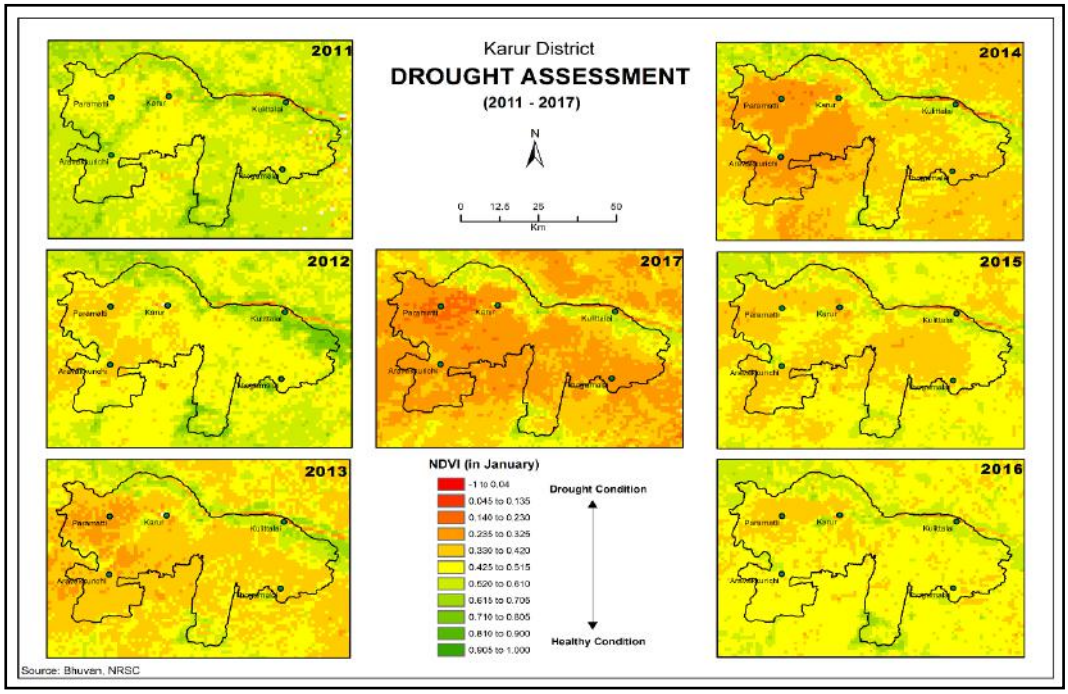

Fig. 5. Average Values of Normalised Difference Vegetation Index (NDVI) and Associated Conditions in Karur District in the Month of January from 2011 to 2017

Drought Hazard

Drought is a phenomenon that is either absence or deficiency of rainfall from its normal pattern in a region for an extended period of time leading to general suffering in the society. Karur District is normally witnessing droughts like conditions wherever the north-east monsoon fails. Since it is a slow-onset disaster, it is very difficult to demarcate the onset and the end of the drought (Rajendran, 2014). However, satellite-based NDVI enables anyone to monitor the drought conditions indirectly (Justice et al., 1985). Moreover, nowadays NDVI products are readily available in various portals including Bhuvan at different spatial and temporal scales. Figure 5 shows the assessment of drought in Karur District during 2011-2017. To avoid vegetation phenological variations during the period of study, the average values of January month is used in this study (Sellers, 1985). The assessment shows that the failure of monsoon during 2012 leads to initiation of stressed conditions, especially in the western part of the District. The consecutive negative deviations of rainfall during 2013-14 further aggravated the situation and lead to a drought situation. The positive deviation of rainfall in 2015 provides a sigh of relief from drought but temporarily. The negative deviation of rainfall again in 2016 and 2017 leads to a disastrous situation in 2017. Almost the entire District is affected by the drought and the severity is well noticed in the western part of the District. Though drought does not cause any physical damage, it affects seriously the agricultural production and drinking water supply.

The SPI is also calculated to understand the cyclic trend of drought in the District using 30-years rainfall data (1984-2013) of four stations. Table 5 shows that the District frequently experiences moderate drought conditions once in a three year (all light colour highlighted rows in the table). The extreme dry condition is observed in the year 2000 and 2013.

Man-made Hazards

Man-made hazards include industrial accidents, fire, explosions, CBR accidents, transport accidents seldom occur in the District, even though there are 4 large scales, 14 medium scale and 7,710 registered small scale industrial units functioning in the District to produce a wide range of industrial products. Figure 6 and Table 6 shows the locations and nature of industries and structures in the District.

Table 5. Rain Gauge Stations of Karur District with SPI Values (1984-2013)

Year	Karur	Mayanur	Kulithalai	K.Paramatti
1984	-0.21	0.36	0.25	-0.47
1985	-0.25	0.44	0.06	-0.43
1986	-0.25	0.31	-0.61	-0.47
1987	0.41	0.58	0.50	-0.42
1988	0.08	0.48	0.26	-0.38
1989	-0.06	0.52	0.13	-0.40
1990	0.31	0.35	-1.13	-0.45
1991	0.27	0.53	-0.56	-0.44
1992	-0.25	0.54	0.02	-0.48
1993	0.93	0.41	0.48	-0.44
1994	-0.90	0.36	0.26	-0.36
1995	-1.75	0.31	0.54	-0.48
1996	0.04	0.40	1.33	-0.38
1997	0.09	0.45	0.16	-0.36
1998	0.49	0.45	0.66	-0.40
1999	1.05	0.67	1.58	-0.34
2000	-2.61	0.18	-0.11	-0.41
2001	-0.28	0.56	0.63	-0.38
2002	0.23	0.28	0.58	-0.44
2003	0.29	0.31	0.49	-0.44
2004	0.17	0.56	0.94	-0.38
2005	1.86	0.74	1.18	-0.30
2006	0.02	0.52	-0.25	-0.47
2007	0.81	0.41	-0.37	-0.33
2008	0.86	0.70	0.20	-0.32
2009	-0.11	0.62	-0.87	-0.44
2010	1.26	0.74	-0.26	-0.41
2011	0.73	0.60	-0.48	-0.43
2012	0.02	0.04	-1.05	-0.50
2013	-3.06	-0.73	-4.24	-0.70

Table 6. Major Disaster Prone Industries / Structures in the District

Name of the Industry / Structures	Village / Taluks	Type
Tamil Nadu News Print & Papers Ltd.	Kagithapuram	Heavy Industry
Chettinad Cement Corpration., Ltd.	Puliyur	Heavy Industry
Deccan Sugars Pvt. Ltd.	Pugalur	Heavy Industry
E.I.D Parry Ltd.	Vandipalayam	Heavy Industry
. Cheran Cement Pvt. Ltd.	Thogamalai	Heavy Industry
Bharat Oil Refinery	Authur	Oil Refinery
Sri Krishna Fire Works	Thoranakalpatti	Fireworks
Bhaskar Fire Works	Uppidamangalam	Fireworks
Akshara Fire Works	Punnam	Fireworks
. Granite Queries	Paramatti and Thogamalai	Mining
. Barriage across Cauvery River	Mayanur	Dam
. Check Dam across Amaravathy River	Chettipalayam	Dam
. Check Dam across Amaravathy River	Anaipalayam	Dam
. Barriage across Amaravathy River	Kottapalayam	Dam

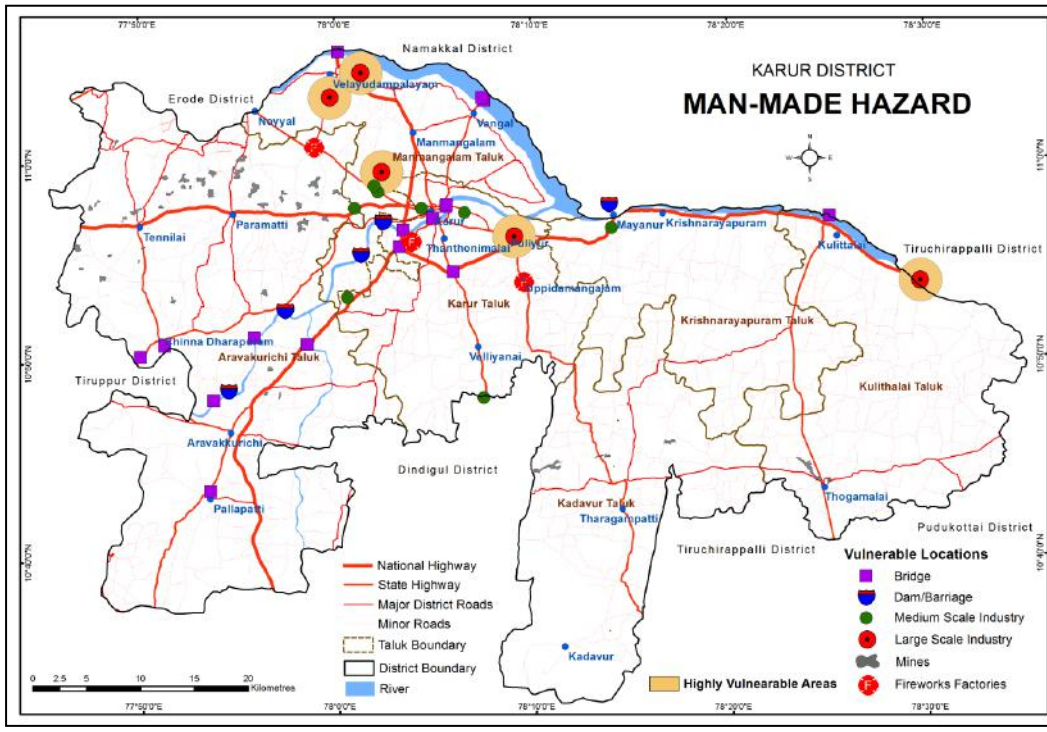

Fig. 6. Location of Heavy Industries, Fireworks, Bridges, Dams and Mining Areas

Vulnerability

The hazard maps (Figure 4, 5 and 6) and density of population is used as inputs to understand the vulnerability level of each village of the District, besides government historical records. The flood hazard map and density of population clearly portray that all

the riverine villages fall under higher flood vulnerability. The contiguous ponds and lakes in the rural villages of Krishnarayanapuram and Kadavur Taluks are also causing flood vulnerability (Figure 7). The impacts of drought slowly spread into the social fabric of the District in the form of reduced supply of drinking water, groundwater depletion, crop failures, poverty, rural-urban migration and social unrest. The irrigated areas of the District, especially villages situated along the river Cauvery, are affected by drought much later than the rainfed areas. These villages tend to function normally to a certain extent even when drought condition severely affects other parts of the District. This is mainly due to the annual release of water in the river Cauvery at least for a few months depending upon good rainfall in the catchment areas i.e. the Western Ghats. On the other hand, about 15 villages surrounding K.Paramatti (Western part of the District) fall under higher drought vulnerability where irrigation facilities are absence and groundwater level also very low (Figure 8 and 9).

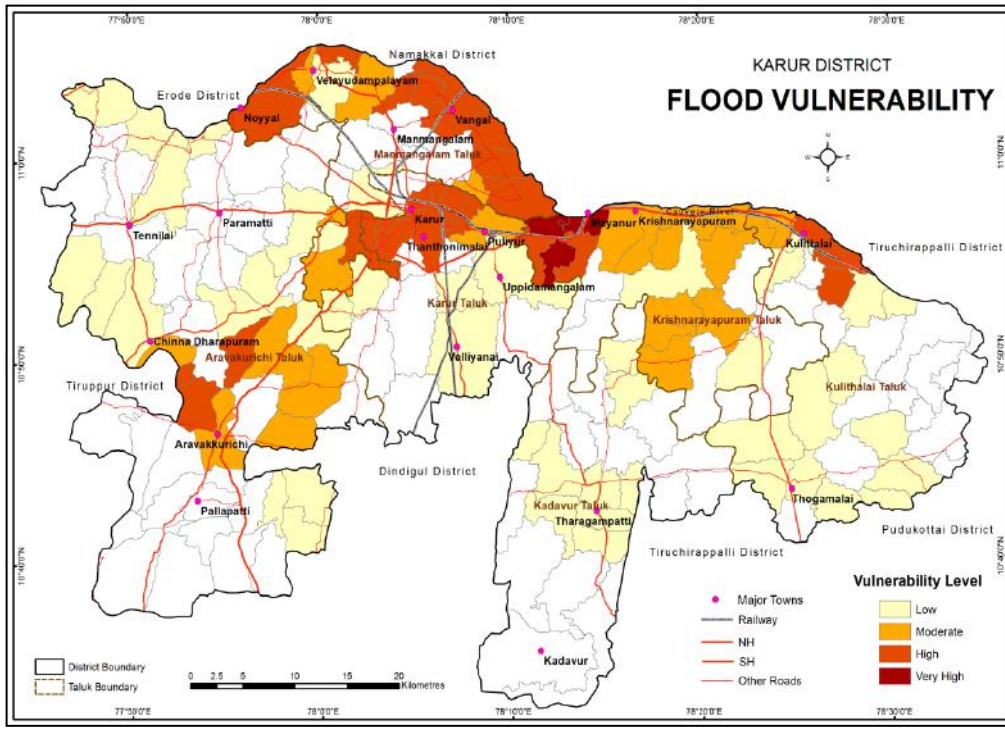

Fig. 7. Village-wise Flood Vulnerability Level in the District

The outburst of dengue is normally noticed in urban centres (Kabilan et al., 2005). Based on dengue cases reported during 2016-2017, the blocks of the District are classed into vulnerable classes. The very high vulnerability found in Karur municipality, followed by Thogaimalai and Aravakurchi blocks. The local health officials correlated the cases of dengue with poor drainage in urban centres and water stagnant in the dug pits of mining areas (Figure 10). The abandoned mining sites in the District (Figure 11) act as a breeding ground for dengue-borne mosquitoes.

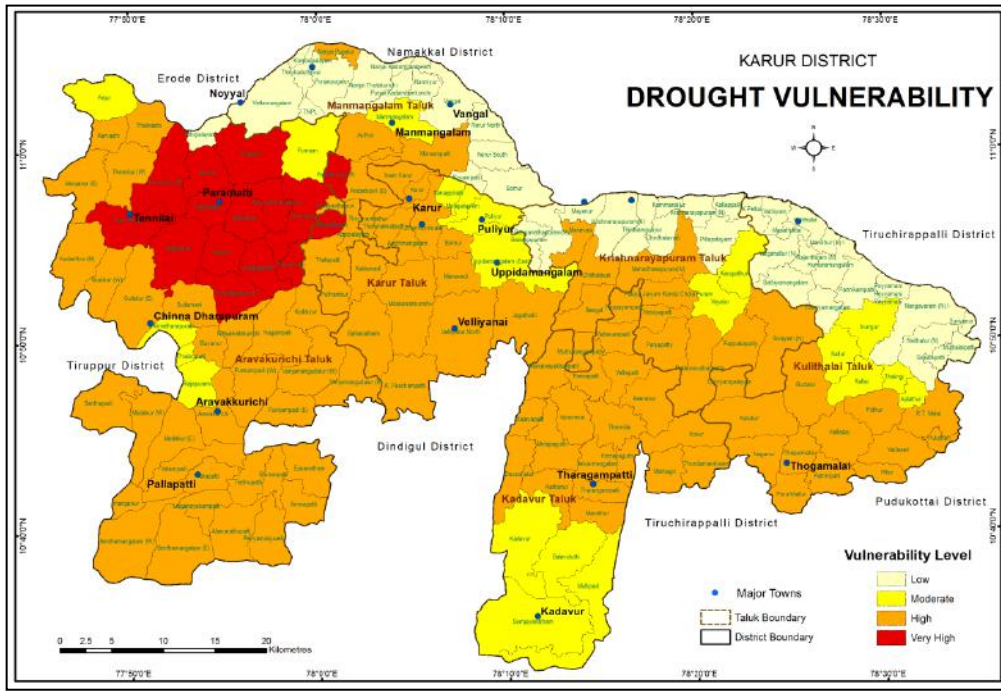

Fig. 8. Village-wise Drought Vulnerability Level in the District

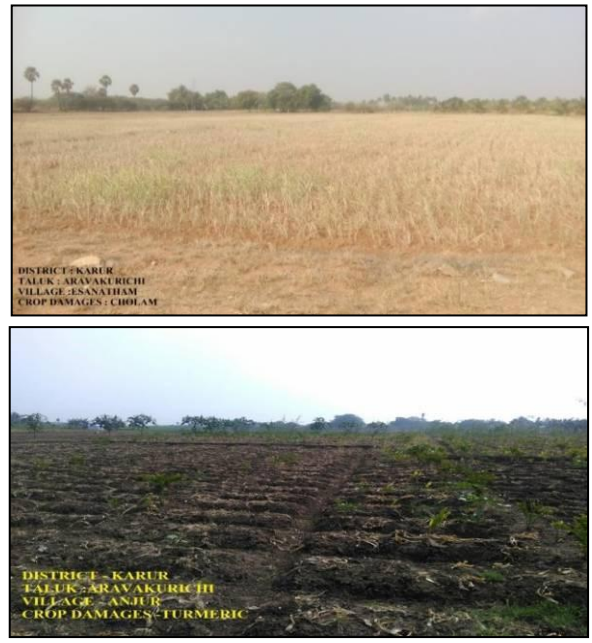

Figure 9. Photographs were Taken from Drought-Affected Villages in K.Paramati Taluk - 2017

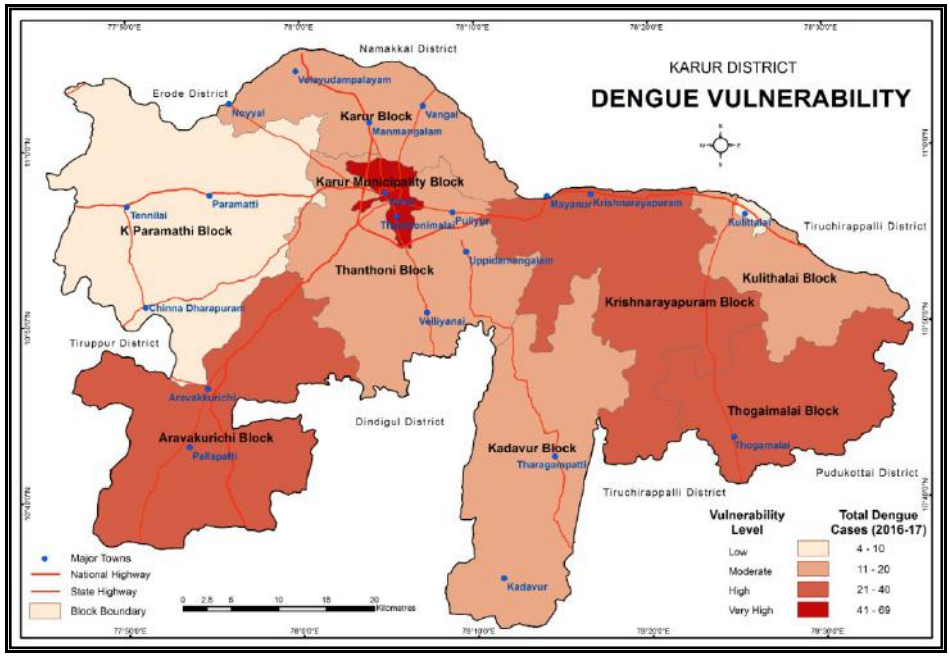

Fig. 10. Block-wise Dengue Vulnerability Level

Based on locations of vulnerable activities and structures collected through GNSS, vulnerable villages are identified with the help of GIS-based spatial analysis. A buffer analysis with variable width is used to categorise the vulnerability level. The man-made vulnerability is very high in the capital region of the District (Figure 12).

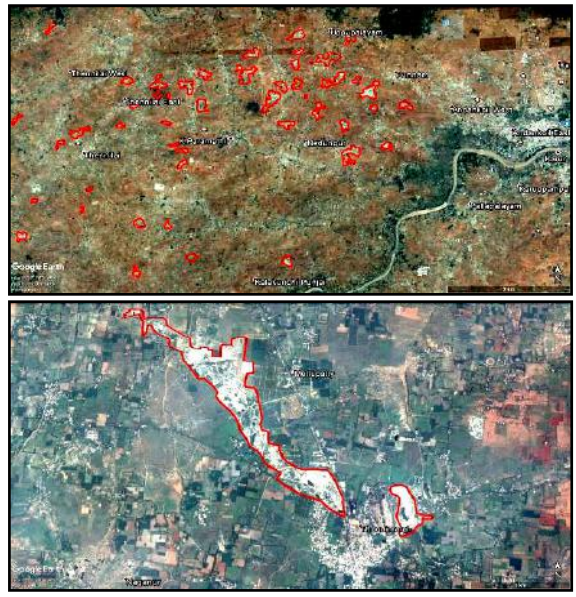

Fig. 11. Abandoned Mines Sites in Aravakurichi (Left) and Thogaimalai Taluks (Right) Captured Using Google Images

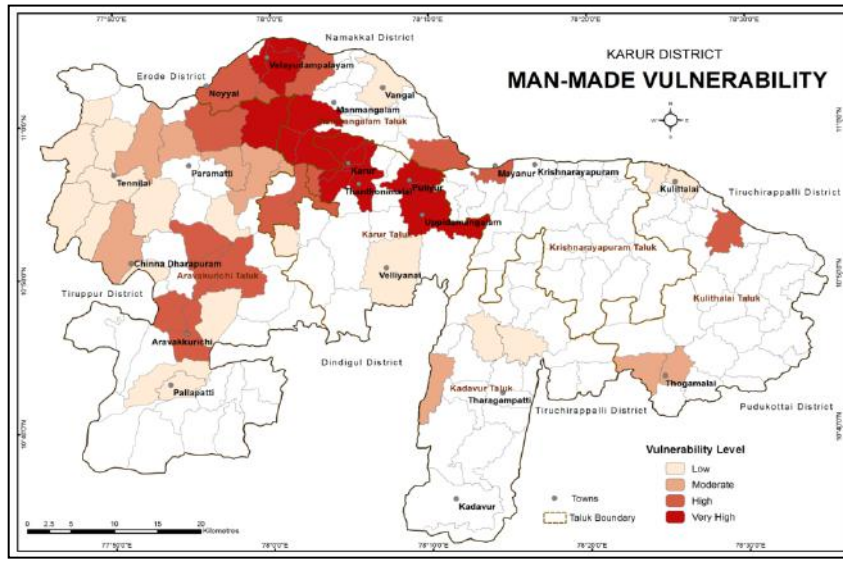

Fig. 12. Village-wise Man-made Vulnerability Level

Multi-Hazard Vulnerability

The multi-hazard vulnerability is assessed using GIS operations on the basis of a combination of more than one type of hazard a village is prone to. The class of very high vulnerability is assigned to a village which is marked with very high vulnerability under three or more hazards. The vulnerable level categorising with at least two disasters a village is vulnerable. The high, moderate and low vulnerability level respectively depicts the case of two, one and no prominent hazards in a village. The classes of vulnerability are further normalised with the help of population characteristics and history of disasters. The very high multi-hazard vulnerable level resides in the heart of the Karur District i.e. Karur town and adjoining 11 villages (Figure 13).

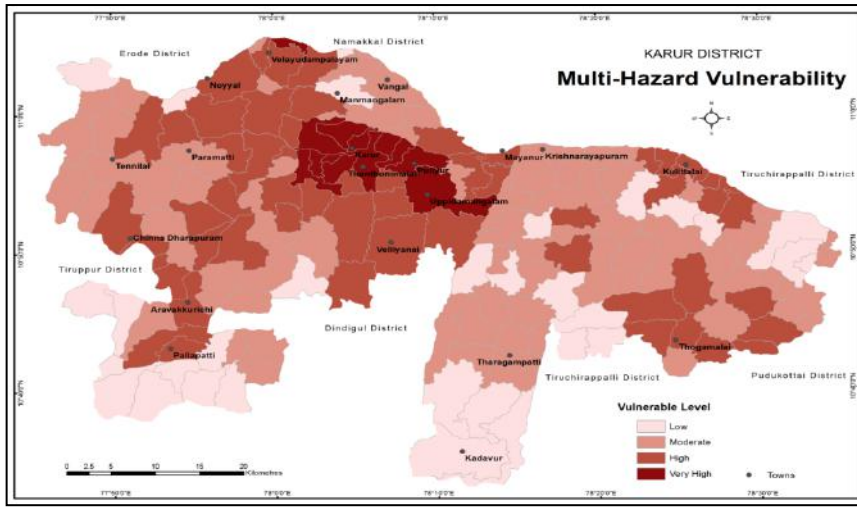

Fig. 13. Village-wise Multi-Hazard Vulnerability

Conclusions

The integrated multi-hazard vulnerability map derived through systematic integration of remote sensing, GIS and GNSS illustrate the clear picture of vulnerable villages that poses a threat to the subjected population. The results of the study would be very helpful in the preparation of effective disaster management plan and to develop a plan that integrates disaster reduction activities in the development works of the District. Further, the individual hazard and vulnerability assessment would help the local planners to develop short and long term planning measures. Hence, the use of geoinformatics becomes a formidable tool and provides a spatial catalyst for identifying, analysing, evaluating and formulating a better disaster management plan.

Acknowledgements

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WEB BASED GIS APPLICATION FOR DROUGHT RISK ASSESSMENT IN SALEM DISTRICT, TAMIL NADU

Sakthivel M., Gaikwad Vishal Vilas and Panhalkar Bilal Dastagir

Department of Geography, University of Madras, Chennai - 600 025
E-mail: nitinvg3@gmail.com

Abstract

Landsat8 satellite image of 2016, 2017 and 2018 was downloaded from the website: https://earthexplorer.usgs.gov. Satellite image was used for generating varies types of indices which are Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI), Vegetation Health Index (VHI), Temperature Condition Index (TCI), and also used for Land use and Land cover (LULC), Land Surface Temperature (LST). 1998 to 2018 daily rainfall datasets were acquired from State Ground & Surface Water Resources Data Centre, Taramani. Rainfall data was used for generating Standardized Precipitation Index (SPI), Rainfall Anomaly Index (RAI). All above layers (VHI, TCI & LULC) are further processed and analysed in overlay and ranking is given to evaluate agricultural drought area. All the layers will overlay to find the final integrated output of agricultural drought. Same process used for evaluating meteorological drought for that SPI and RAI layers are used. The main target of developing a web based GIS interactive map for assessment of the agricultural and meteorological drought area.

Keywords: Web based GIS, Drought indices, LU/LC, LST

Introduction

Drought in simple terms is the dryness due to deficient rainfall or shortage of water for an extended period -a season, a year or several years over a particular region. It can be defined according to meteorological, hydrological and agricultural criteria. Drought is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard. Drought is a slow-onset, creeping natural hazard that is a normal part of climate for virtually all regions of the world; it results in serious economic, social, and environmental impacts. Drought onset and end are often difficult to determine, as is its severity. There is no consensus over the threshold of the deficit or the minimum duration of the lack of precipitation that makes a dry spell an official drought. The term drought hinges on the societal expectations and public perception that available water is too meagre to sustain normal activities. The impacts of drought are largely non-structural and spread over a larger geographical area than are damages from other natural hazards. The non-structural characteristic of drought impacts has certainly hindered the development of accurate, reliable, and timely estimates of severity and, ultimately, the formulation of drought preparedness plans by most governments. The impacts of drought, like those of other hazards, can be reduced through mitigation and

preparedness. Drought preparedness planning should be considered an essential component of integrated water resources management. Increasing society's capacity to cope more effectively with the extremes of climate and water resources variability (i.e., floods and droughts) is a critical aspect of integrated water resources management. Drought preparedness planning will also provide substantial benefit in preparing for potential changes in climate. Historically, more emphasis has been given to flood management than drought management. With increasing pressure on water and other natural resources because of increasing and shifting populations (i.e., regional and rural to urban), it is imperative for all nations to improve their capacity to manage water supplies during water-short years (Chandrasekar, 2016). The objectives is to study is the agricultural drought using multi-date remote sensing data, the meteorological drought using rainfall and temperature data for the year 2016, 2017 and 2018 and to further identify areas facing high drought risk by combining satellite data and other thematic information.

Study Area

Salem is situated on the North and East Hemisphere located between 11^0 14' and 12^0 53' North latitude and between 77^0 44' and 78^0.50' East longitudes. It covers the geographical area of 5245 sq.km. It is the fifth largest district in Tamil Nadu. It is located about 160 kilometres North East of Coimbatore, 186 kms South East of Bangalore and about 340 kilometres South West of Chennai. The District is surrounded by Dharmapuri and Karnataka state in the North, Erode in West, Vilupuram and Perambalur in East and Namakkal and Tiruchirappalli in South.

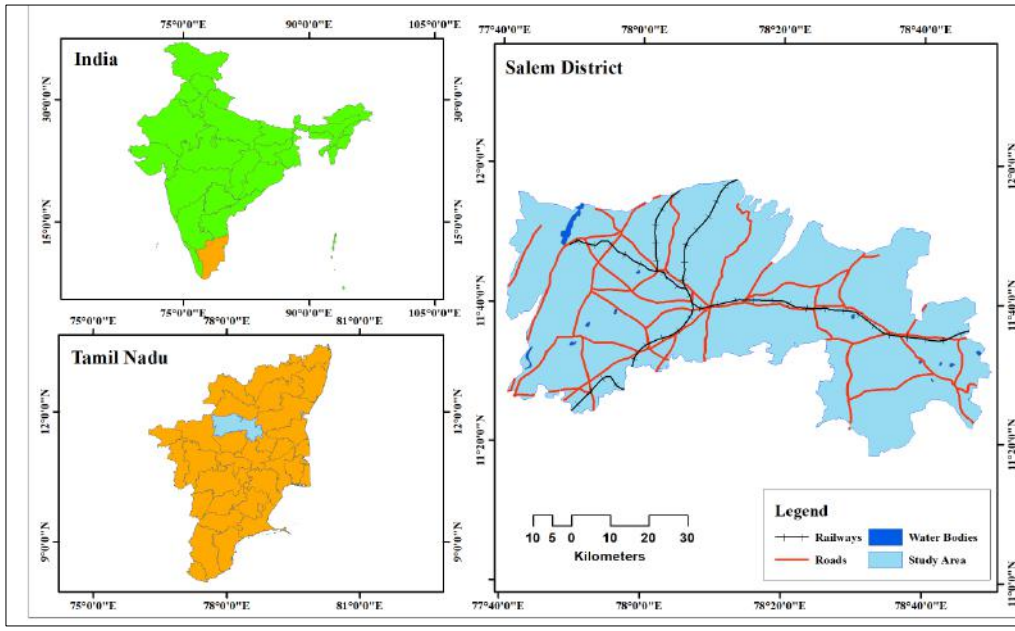

Fig. 1. Location of Salem District

Database and Methodology

Table 1. Dataset for Drought Assessment

Sl. No	Data	Source	Scale / Resolution
1	Rainfall 1998 to 2018	State Ground & Surface Water Resources Data Center, Taramani	
2	Landsat 8 (OLI/TIRS) Operational Land Imager/ Thermal Infrared Sensor (2016, 2017 and 2018)	https://earthexplorer.usgs.gov	30 metres

Land Surface Temperature

Conversion of Top of Atmosphere (TOA) Radiance:

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers (DN) can be converted to TOA spectral radiance.

$$L\lambda = \{(Lmax - Lmin) / (QCalMax - QCalMin)\} * (QCal - QCalMin) + Lmin$$

where,

Lλ = TOA spectral radiance
LMax = The spectral radiance that is scaled to QCalMax
LMin = The spectral radiance that is scaled to QCalMin
QCalMax =The maximum quantized calibrated pixel value in DN
QCalMin = The minimum quantized calibrated pixel value in DN
Qcal = Quantized and calibrated standard product pixel values (DN)

Conversion of Top of Atmosphere (TOA) Brightness Temperature:

Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant values in metadata file.

$$BT = K2 / \ln (k1 / L\lambda + 1) - 272.15$$

where,

BT = Top of atmosphere brightness temperature (°C)
Lλ = TOA spectral radiance (Watts/(m2 * sr * μm))
K1 = K1 Constant Band (No.)
K2 = K2 Constant Band (No.)

Normalized Differential Vegetation Index (NDVI):

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which calculated using Near Infra-red and Red bands.

$$NDVI = (NIR - RED) / (NIR + RED)$$

where,

RED = DN values from the RED band
NIR = DN values from Near-Infrared band

Land Surface Emissivity (LSE)

Land surface emissivity (LSE) is an important surface parameter and can be derived from the emitted radiance measured from space. Besides radiometric calibration and cloud detection, two main problems need to be resolved to obtain LSE values from space measurements. These problems are often referred to as land surface temperature (LST) and emissivity separation from radiance at ground level and as atmospheric corrections in the literature. Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

PV = [(NDVI – NDVI min) / (NDVI max + NDVI min)]^2

where,

PV = Proportion of Vegetation
NDVI = DN values from NDVI Image
NDVI min = Minimum DN aloes from NDVI Image NDVI max = Maximum DN values from NDVI Image

E = 0.004 * PV + 0.986

where,

E = Land Surface Emissivity
PV = Proportion of Vegetation

Land Surface Temperature (LST)

The Land Surface Temperature (LST) is the irradiative skin temperature of the land surface, as measured in the direction of the remote sensor. It is estimated from Top-of-Atmosphere brightness temperatures from the infrared spectral channels of a constellation of geostationary satellites. LST is a mixture of vegetation and bare soil temperatures which respond rapidly to changes in incoming solar radiation due to cloud cover and aerosol load modifications and variation of illumination. In turn, the LST influences the partition of energy between ground and vegetation, and determines the surface air temperature.

LST = (BT / 1) + W * (BT / 14380) * ln (E)

where,

BT = Top of atmosphere brightness temperature (°C)
W = Wavelength of emitted radiance
E = Land Surface Emissivity

Agricultural Drought Indices

Temperature Condition Index

The Temperature Condition Index (TCI) was developed to capture different responses of vegetation to in-situ temperature as additional information. This can be achieved by employing thermal channels for drought monitoring. The TCI was calculated using the following equation.

$$\boldsymbol{TCI = \frac{(LSTmax - LST)}{(LSTmax + LSTmin)} X\ 100}$$

where,

TCI is Temperature Condition Index;
LST is the LST value of current month;
LSTmin and LSTmax denote the minimum and maximum LST values, respectively.

Vegetation Condition Index

The VCI was obtained from Normalized Difference Vegetation Index (NDVI) to monitor vegetation condition. The VCI data were derived by following equation.

$$\boldsymbol{VCI = \frac{NDVI - NDVImin}{(NDVI - NDVImax)} X\ 100}$$

where,

VCI = Vegetation Condition Index;
NDVI = represents NDVI value of current month;
NDVImin and NDVImax denote the minimum and maximum NDVI values, respectively, throughout the period of observation.

Vegetation Health Index

Combined VCI and TCI data was then employed to calculate VHI, a vegetation drought index that incorporates overall vegetation health and its severity to indicate agricultural drought extent at any time of the year. The VHI was calculated to assess both vegetation stress and temperature to evaluate drought severity. The VHI can be expressed by following equation.

$$\mathbf{VHI = 0.5\ X\ VCI + 0.5\ X\ TCI}$$

where,

VHI is Vegetation Health Index,
VCI is Vegetation Condition Index,
TCI is Temperature Condition Index.

Meteorological Drought Indices

Standardized Precipitation Index (SPI)

Standardized Precipitation Index (SPI) expresses the actual rainfall as a standardized departure with respect to rainfall probability distribution function. The computation of SPI requires long term data on precipitation to determine the probability distribution function which is then transformed to a normal distribution with mean zero and standard deviation of one. Thus, the values of SPI are expressed in standard deviations, positive SPI indicating greater than median precipitation and negative values indicating less than median precipitation (Edwards and McKee, 1997).

$$\mathbf{SPI} = \mathbf{Pi} - \overline{\mathbf{P}}/\mathbf{Sd}$$

where,

SPI is Standardized Precipitation Index
Pi = Annual precipitation in each station,
$\overline{\mathrm{P}}$ = Average precipitation in each station,
Sd = Standard deviation of precipitation in each station.

Rainfall Anomaly Index

From the precipitation data, the Annual Rainfall Anomaly Index (RAI) was calculated to analyze the frequency and intensity of the dry and rainy years in the studied area. In addition, the monthly RAI as calculated for specific years of the historical series aiming to analyze the distribution of rainfall in the years of greatest anomaly.RAI, developed and firstly used by Rooy (1965) and adapted by Freitas (2005), constitutes the following equations:

$$\mathbf{RAI} = \mathbf{3}\ \frac{\mathbf{N}-\overline{\mathbf{N}}}{\overline{\mathbf{M}}-\overline{\mathbf{N}}}\ \textbf{, for positive anomalies}$$

$$\mathbf{RAI} = -\mathbf{3}\ \frac{\mathbf{N}-\overline{\mathbf{N}}}{\overline{\mathbf{X}}-\overline{\mathbf{N}}}\textbf{, for negative anomalies}$$

where,

RAI is Rainfall Anomaly Index
N = current monthly/yearly rainfall, in order words, of the month/year when RAI will be generated (mm);
$\overline{\mathrm{N}}$ = monthly/yearly average rainfall of the historical series (mm);
$\overline{\mathrm{M}}$= average of the ten highest monthly/yearly precipitations of the historical series (mm);
$\overline{\mathrm{X}}$= average of the ten lowest monthly/ yearly precipitations of the historical series (mm);
and positive anomalies have their values above average and negative anomalies have their values below average.

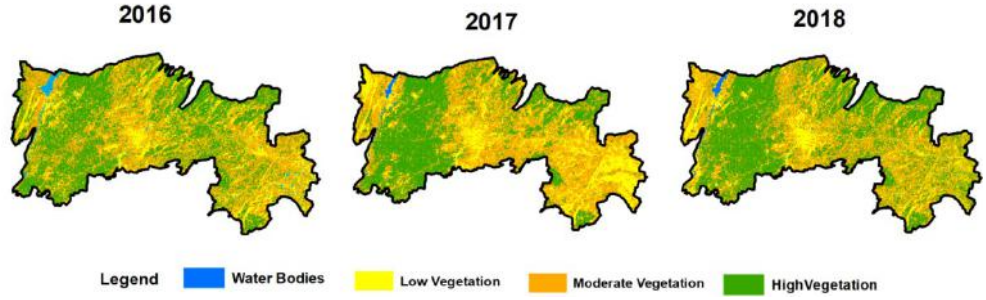

Fig. 2. NDVI of Salem District during 2016, 2017 and 2018

Results and Discussion

NDVI

NDVI images have been generated by using NDVI = (NIR – RED) / (NIR + RED) formula for 2016, 2017 and 2018 years as a measure of vegetation abundance, for land sat 8 band 4 (Red), Band 5 (NIR) used. NDVI map generated for calculation of land surface emissivity (LSE). Above map show the vegetation cover in Salem district in year 2016, 2017 and 2018. In 2017 south-east of Salem district is low vegetation, water bodies also reduce comparatively 2016 and 2018.

Landuse / Land Cover

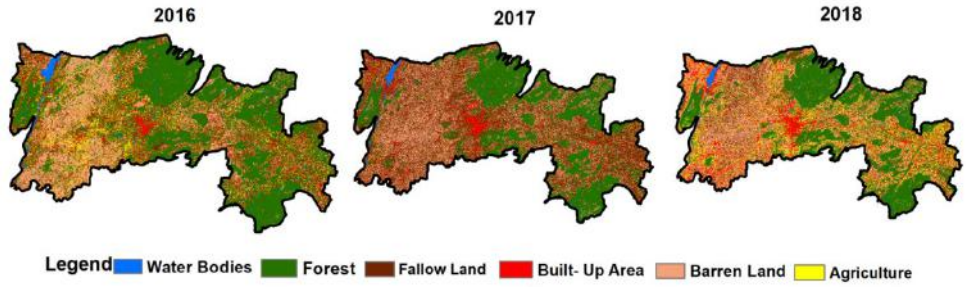

Fig. 3. Landuse / Land Cover of Salem District during 2016, 2017 and 2018

Table 2. LU/LC of Salem District

Years	2016		2017		2018	
Classes	**Area (sq.km)**	**Area (%)**	**Area (sq.km)**	**Area (%)**	**Area (sq.km)**	**Area (%)**
Water Bodies	64	1	61	1	54	1
Forest	2,368	46	1,603	31	2,013	39
Agriculture	461	9	232	5	689	13
Fallow Land	719	14	1,543	30	448	9
Barren Land	1,095	21	1,151	22	1,339	26
Built-up Area	446	9	562	11	611	12
Total	**5,153**	**100**	**5,153**	**100**	**5,153**	**100**

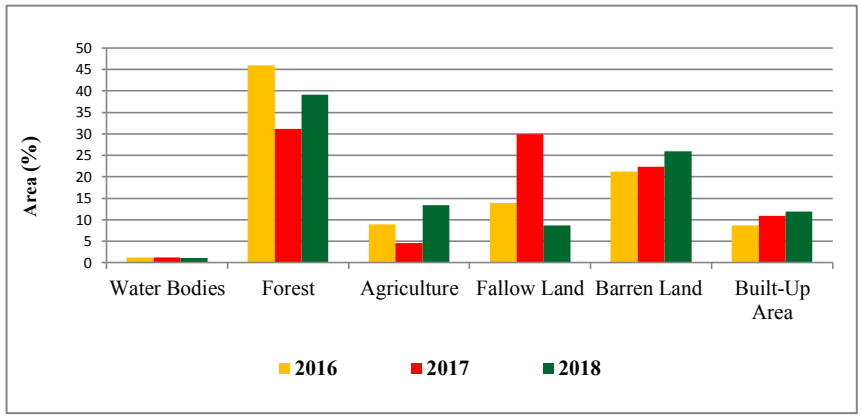

Fig. 4. LU/LC of Salem District

The landuse / land cover maps of the year 2016, 2017 and 2018 and the results shows the percentage of area under different land use classes as obtained from the unsupervised classification of images. It was observed that the built up area has significantly increased in the core and also in area away from the centre. In 2016 built up area is 9 % (446 sq.km) is increased by 2% which is 11% (562 sq.km) in 2017 and in 2018 is increased by 1 % which is 12% (611 sq.km). Forest and agriculture area has decreased in year of 2017 comparatively 2016, which is 16% and 4% respectively. Fallow land and barren land increased by 16 % and 1% respectively.

Land Surface Temperature

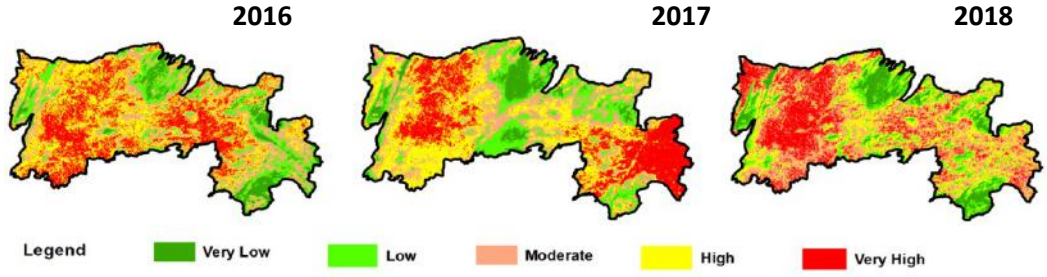

Fig. 5. Land Surface Temperature of Salem District during 2016, 2017, 2018

Table 3. Land Surface Temperature Statistic

LST of Salem District (Area in sq.km)			
Class Name	**2016**	**2017**	**2018**
Very Low	359	339	480
Low	809	911	753
Moderate	1,128	1,149	1,594
High	1,641	1,172	1,214
Very High	1,212	1,578	1,102

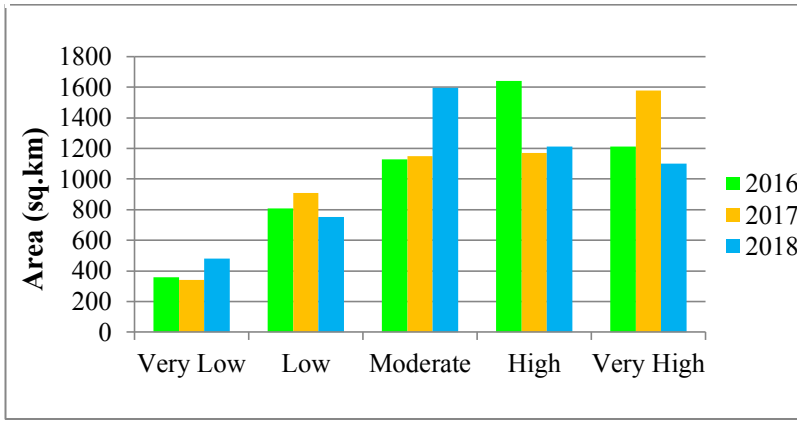

Fig. 6. LST of Salem District

Above figure show the spatial distribution of day time summer LST in the study area in year 2016, 2017 and 2018. Bar graph shows the yearly changes in land surface temperature. In 2017 the area under the very high LST class is increased and the area of very low LST class is decreased comparatively 2016.

Agricultural Drought Indices

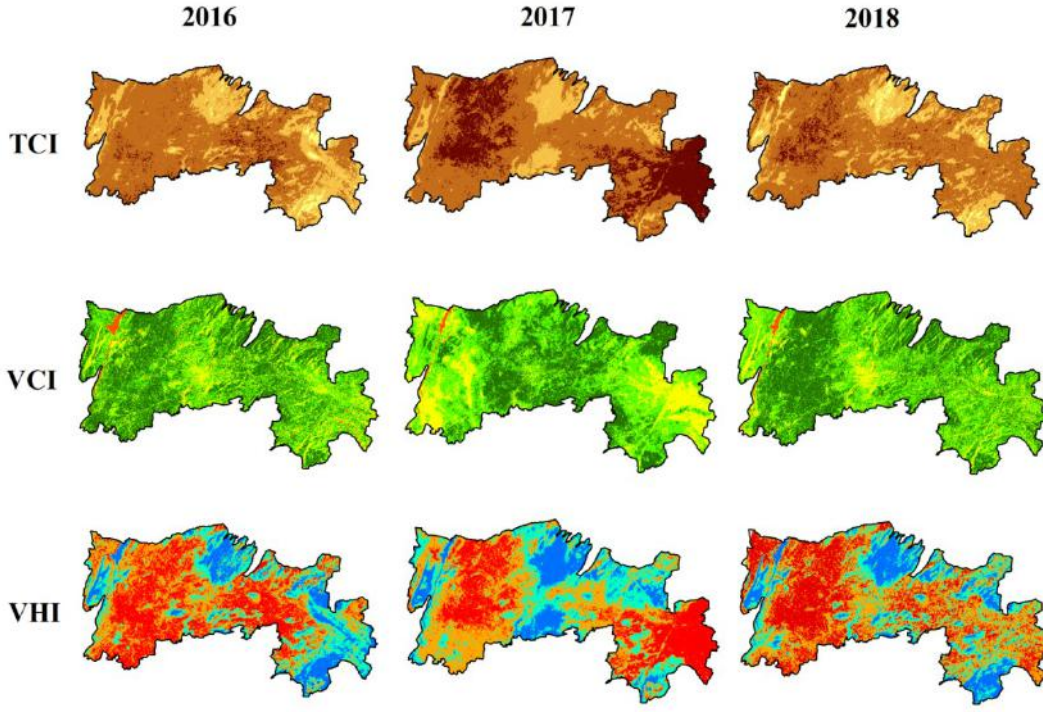

Fig. 7. Agricultural Indices (TCI, VCI and VHI) of Salem District during 2016, 2017 and 2018

Table 4. VCI, TCI and VHI Classifications and Colour Schemes for Agricultural Drought

Drought	Values	TCI	VCI	VHI
Extreme	<10			
Severe	10-20			
Moderate	20-30			
Mild	30-40			

The TCI layer and VCI layer generated by using LST and NDVI layers respectively. Vegetation Health Index (VHI) generated by using TCI and VCI layers. TCI, VCI and VHI layers are categorised into four classes 1-10 values shows the extreme drought, 10-20 and 20-30 values shows moderate drought and severe drought respectively and 30-40 values shows mild drought condition.

Agricultural Drought

Salem district are classified into five agricultural drought severity classes which are extreme, severe, moderate, mild, and no drought. Figure 8 shows severe drought is covered in middle part of the Salem district in 2016 year. According to 2017 map 2,539 sq.km geographical area of Salem District affect by severe drought condition. In 2018 agricultural drought is covered by 2,496 sq.km area by moderate drought. 2017 year is showing severe drought comparatively 2016 and 2018.

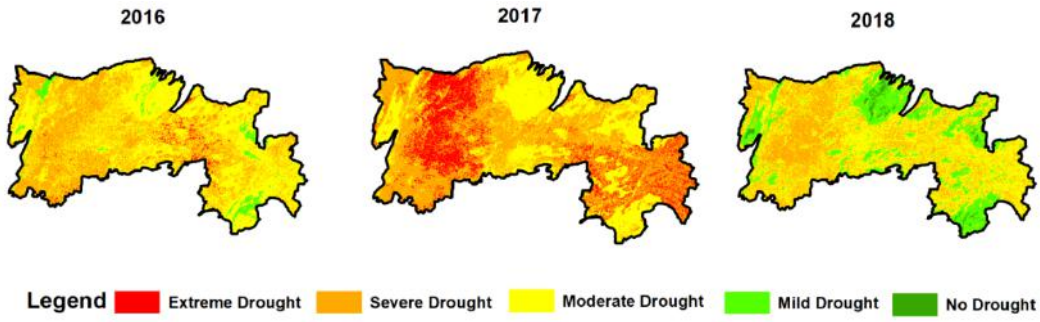

Fig. 8. Agricultural Drought of Salem District during 2016, 2017 and 2018

Table 5. Agricultural Drought of Salem District

			(Area in sq.km)
Classes	**2016**	**2017**	**2018**
Extreme Drought	90.00	880.00	0.00
Severe Drought	1,887.00	2,539.00	1,494.00
Moderate Drought	2,979.00	1,734.00	2,496.00
Mild Drought	194.00	0.17	1,075.00
No Drought	0.00	0.00	77.00

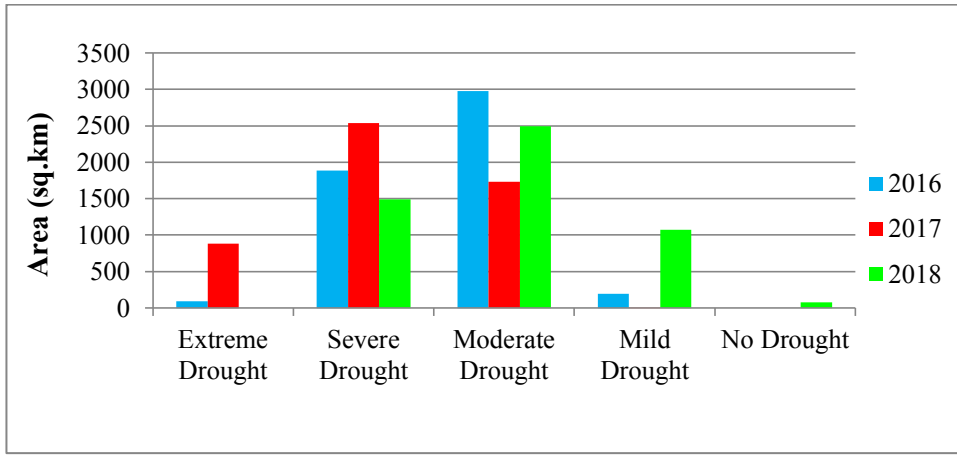

Fig. 9. Agricultural Drought of Salem District

Integrated the layers of VHI and LU/LC layers to find the agricultural drought area. VHI and LULC layers are further processed and analysed in overlay and ranking is given to evaluate agricultural drought area. All the layers will overlay to find the final integrated output of agricultural drought. Below map shows the agricultural drought condition of Salem district in 2016, 2017 and 2018. In 2017 map red colour shows the extreme drought condition which cover 880 sq.km area of total area of Salem district.

Meteorological Drought Indices

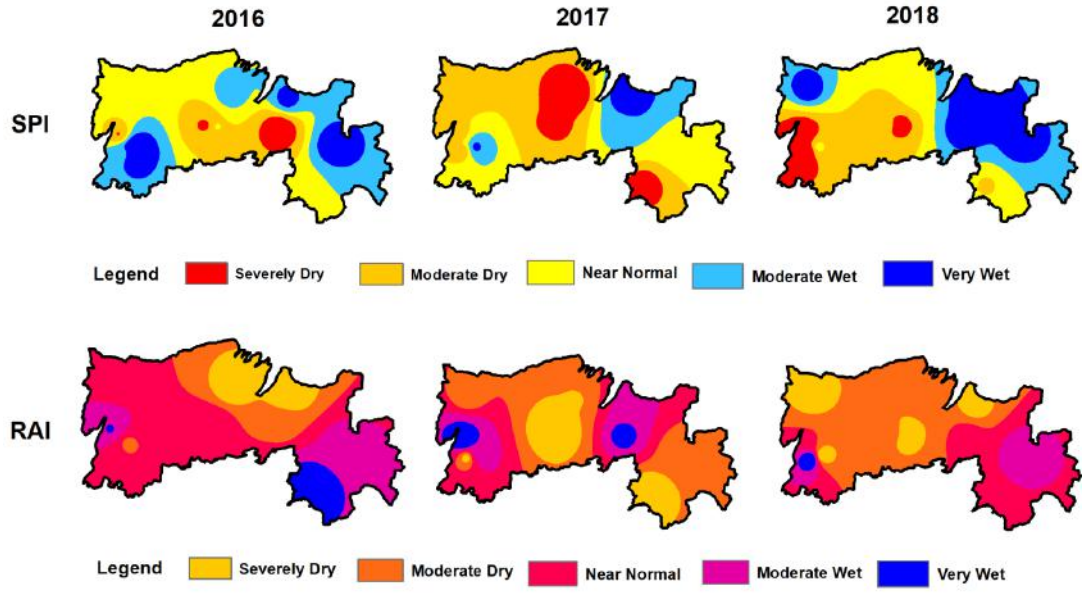

Fig. 10. Meteorological Drought Indices (SPI and RAI) of Salem District

The 1998 to 2018 rainfall data used for generating SPI and RAI layers. SPI and RAI layers show the meteorological drought condition. Both SPI and RAI maps divided into five classes, which are severe dry, moderate dry, near normal, moderate wet and very wet.

Meteorological Drought

Table 6. Meteorological Drought of Salem District

Meteorological Drought of Salem District (Area in sq.km)			
Classes	**2016**	**2017**	**2018**
Very Severe Drought	203	699	263
Severe Drought	825	1,914	1,450
Moderate Drought	2,383	1,633	1,493
Low Drought	1,470	688	1,245
Very Low Drought	267	213	697

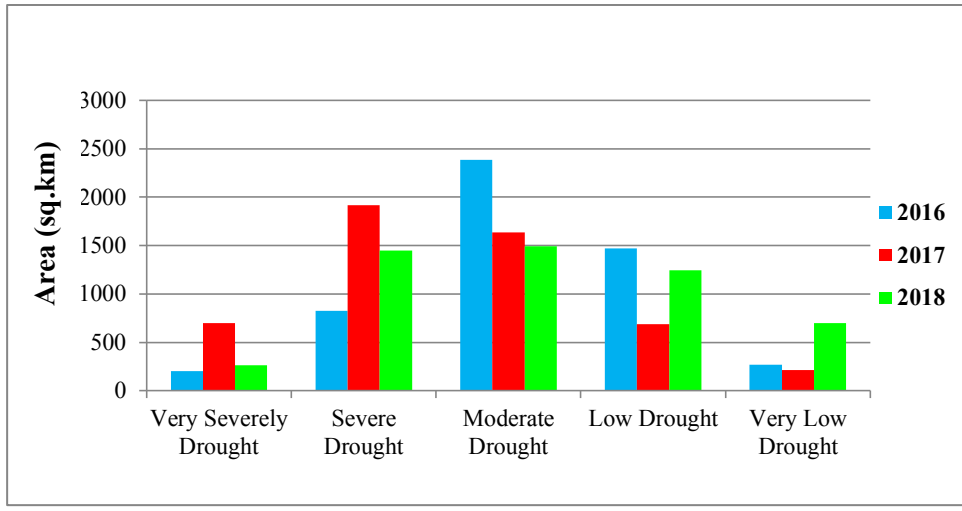

Fig. 11. Meteorological Drought of Salem District

Above bar graph shows the area of meteorological drought of Salem district in sq.km. Blue colour bar represents the year of 2016, Red and Green colour bar represent year of 2017 and 2018 respectively. In 2017 very severe drought and severe drought classes showing the high drought condition which cover the 699 sq.km and 1914sq.km area respectively.

The maps shown below depict the meteorological drought condition of Salem District in 2016, 2017 and 2018. The SPI and RAI layers will overlay to find the final integrated output of meteorological drought. Red colour shows the severe drought condition and blue colour shows low drought condition of Salem District.

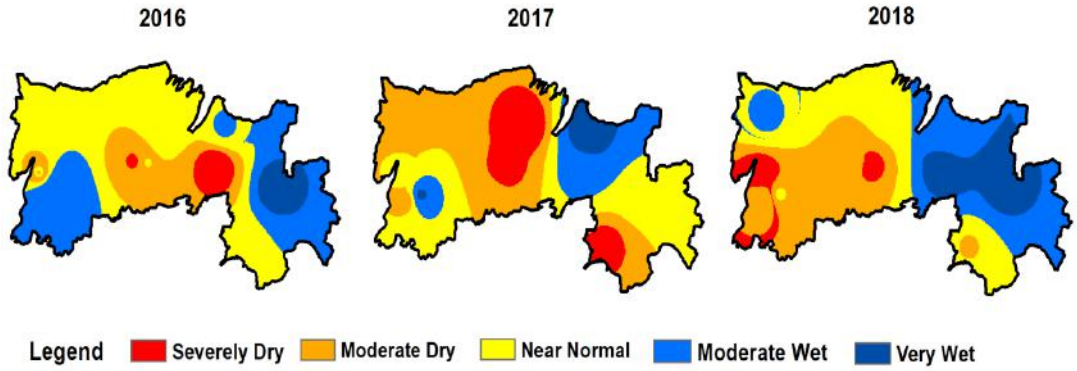

Fig. 12. Meteorological Drought of Salem District

Web GIS Components

For creating the web page ArcGIS Server Manager used as a web server and for web services, visualization of maps ArcGIS viewer for flex software used. On the top side of the web based GIS portal there is a tool bar which are an important tools used for map handling. Also those tools are used to information about layers, legend, coordinates, attribute, search, draw and the whole information about Google base maps. One bar is located on the left side of web page that used for fit to display, zoom in, zoom out, pan etc.

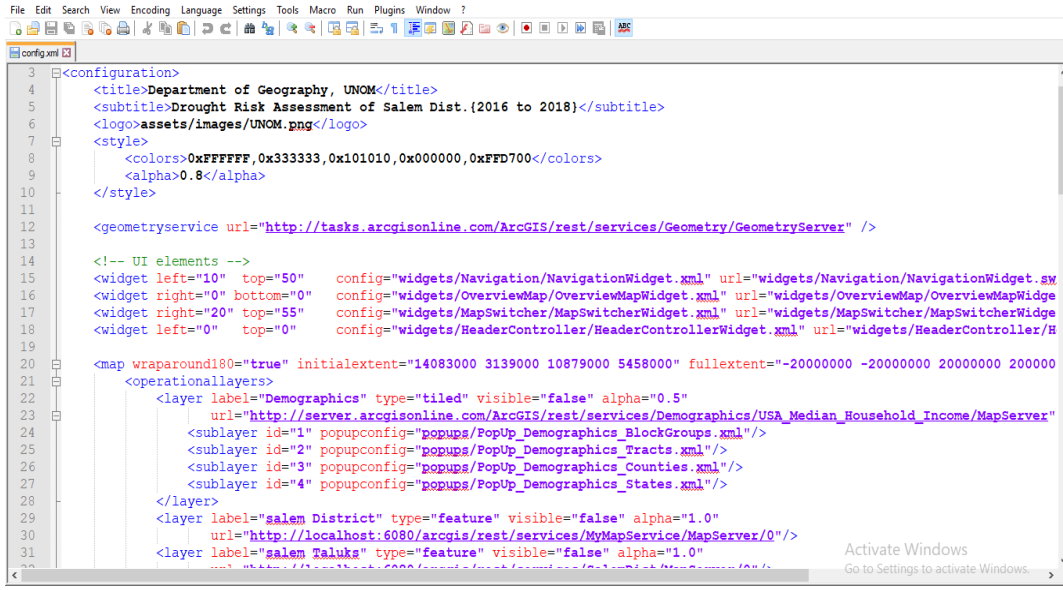

Fig. 13. Programming of Web Page

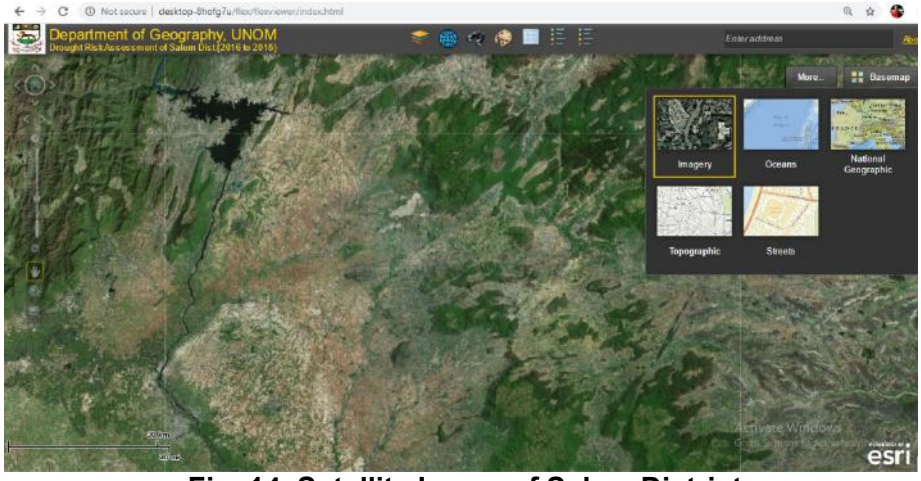

Fig. 14. Satellite Image of Salem District

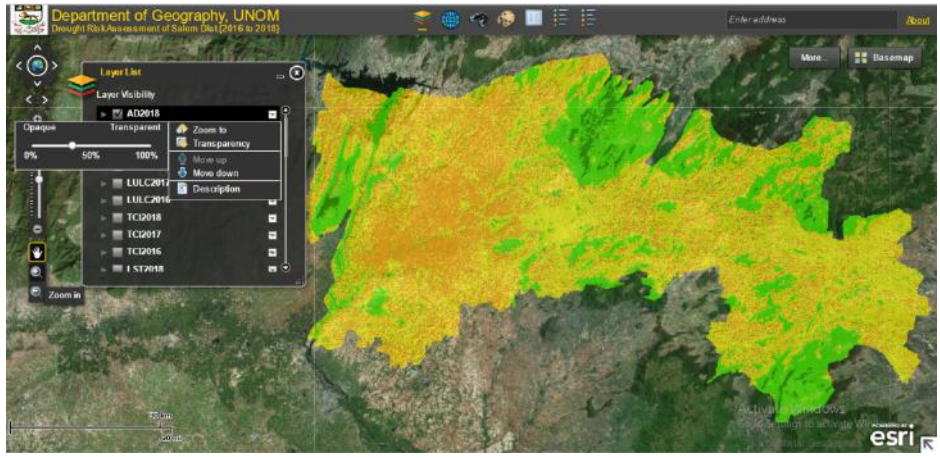

Fig. 15. Web Based Agricultural Drought

Fig. 16. Features of Web Page - Legend, Attribute Table, Layer List and Chart

Conclusions

This study identify the spatio-temporal changes of agricultural drought and meteorological drought of Salem district using satellite data (Landsat 8) and meteorological data (Rainfall) based on Vegetation Health Index (VHI), Land Use Land Cover (LU/LC), Standardised Precipitation Index (SPI), Rainfall Anomaly Index (RAI). We found that this index can be successfully used for identify the spatio-temporal changes of both droughts of Salem district in 2016, 2017 and 2018. It can also explain drought severity classes in the study areas through composite analysis of both vegetation healths by vegetation condition and temperature condition of vegetation for agricultural drought and standardised precipitation index, rainfall anomaly index for meteorological drought. Figure 8 and Figure 12 shows the agricultural drought and meteorological drought of Salem District respectively. 2017 year shows severe drought condition comparatively 2016 and 2018, all this assessment, visualisation and comparison of layers are done through using web page.

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ETHNIC ENCLAVES AND LABOUR MARKET AT KHAIRA HASAN VILLAGE OF CHITTORA BLOCK IN BAHRAICH DISTRICT OF UTTAR PRADESH

Falak Butool

Department of Geography, National P.G. College, Lucknow - 226 001
E-mail: falakbutool@gmail.com

Abstract

The role of ethnicity in labour market outcomes has long engaged the attention of researchers interested in social inequality. It is generally found that immigrant people all over the world face certain restriction on the work due to their immigrant status. Often they live in geographical concentrations or ghettos. In India some social groups like scheduled caste and Muslims are living in geographical concentration and mostly doing fixed and low ranked jobs because they are occupying the position of 'others' in the prevalent Brahmanical ideological system of India and both of them are mostly land less. From the results it is clear that the minority enclave does not hold for Scheduled caste but it does so for Muslims up to certain extent. Among Muslims the minority enclave is the result of their push out from the regular salaried jobs and also because of the lack of access to land in rural areas like Khaira Hasan village of Chittora block of Bahraich district.

Keywords: Ethinic Enclaves, Labour Market, Khaira Hasan Village, Chittora Block, Bahraich District, Uttar Pradesh

Introduction

The principal source of this variation is the angular inclination of the sun. This angular inclination has resulted in the variation of the sun rays received on different part of the earth which in turn is responsible for the variation in the atmospheric phenomena like wind, rain fall and ocean current and so on. This variation in atmospheric phenomena is meant to enrich the human kind with abundant and more varied supply of resources. One of the important outcomes of this variation is the origin of different races. People further divided in different groups on the basis multiple physical and socio-economic characteristics. Since then strong group started exploiting the weaker group. Our country India, one of the biodiversity rich regions is also not untouched by this kind of exploitation.

No country in the world has a greater diversity of a group life than our motherland, India. India's 1.2 billion population sustain a bewildering variety of religion, languages, culture, social life, music, colours, traditions, attitude, habits and beliefs and so on. The people of India speak many languages each with a distinct script and dialect. However, individuals also hold their own significance. During the debates of the Constituted

Assembly, the architect of India's constitution, the indomitable, Dr. B.R. Ambedkar emphatically declared that the 'individual' not the 'group' was the basis on which India's constitution was designed. In fact, as an 'untouchable dalit' Ambedkar has suffered greatly in the hands of caste communities and was fearful of the oppressions that India's caste based group was capable of unleashing. His masterpiece 'Annihilation of Caste' is often called Ambedkar's Utopia - his impracticable, unfeasible dream. As in his work he has talked about the absolute equality which was just like rolling a boulder up a cliff (Anand et al., 2013).

There is an abundant scholarly literature available about caste in India that spans disciplines from History to Sociology, from Anthropology to Economics. Some-times the distinct names of these castes within India and are associated with a certain regional or geographic base. Castes are nothing but endogamous descent groups having hierarchical dimension. According to Rig Veda, which is one of the earliest literatures of Hindus, there were four Verna in the society. They were Brahmins, Kshatriyas, Vashyas and Shudras. Shudras lied at the lowest rung of the caste system and were described as 'servants of others' (Butool, 2011:3). This classification of the society was basically functional and occupational in nature and character. However, it was the feudal character of the society more than religious aspiration which mostly resulted in subjugation of scheduled caste in India (Mohammad, 1987:17). The stickiness of scheduled caste people with their traditional unclean occupation is responsible for their sluggish socio-economic growth. If they will be able to develop ethnic enclave then their social and economic status will surely be improved.

The literal meaning of ethnic enclave is "A neighbourhood or larger territory whose population is largely ethnically distinguished from the surrounding area and its inhabitants" (Castree et al., 2013). In sociology, an ethnic enclave is a geographic area with high ethnic concentration, characteristic cultural identity, and economic activity (Abrahamson, 1996). This term is usually used to refer to either a residential area or a workspace with a high concentration of ethnic firms. (Portes and Jensen, 1992). While participation in the enclave economy may assist in achieving upward mobility through increased availability of employment opportunities in the enclave labor market (Edin et al., 2003). Ethnic enclaves are rich in informal activities, as the entrepreneurial services making the core of the enclave's founding were historically informal ventures. Informality proves favorable for immigrant entrepreneurships or the entrepreneurship of other socially restricted groups like scheduled caste and Muslims in India. Additionally, the scope of employment for them is greatly widened by the availability of informal jobs in the enclave economic sector.

However, such studies on the development of ethnic enclave of underprivileged classes or groups are meager. Therefore, in the present study the development of ethnic enclave of scheduled caste population and underdeveloped religious minority i.e., Muslims of India is dealt at a village level. The selected village is Khaira Hasan village of Bahraich district of Uttar Pradesh in India. Thus these kinds of study will grove the geographical literature about the meager availability of studies on the development of ethnic enclave of

underprivileged social groups of India. This study will surely be helpful in improving the socio-economic status of this downtrodden segment section of the Indian society.

The main objectives of the study are to study the educational levels scheduled caste population and Muslim population in Khaira Hasan Village of Chittora block of Bahraich District, study the types of employment among the scheduled caste population and Muslim population of village Khaira Hasan of Chittora block in Bahraich District and to find out the relationship between educational levels and type of occupation of scheduled caste population and Muslim population of in Khaira Hasan village of Chittora block of Bahraich District.

Study Area

Khaira Hasan is a scheduled caste dominated village located in the northern part of Chittora block of Bahraich District. The village is economically and politically isolated from the nearest major commercial centre i.e., Allahabad and it is satellite village of a small town (Chichri). The household of the village are mostly engaged in subsistence farming and local wage labour as their primary source of income. The population of scheduled caste in the selected village is 55 percent while Muslims are 30 percent and rest of the 5 per cent are Hindu OBC's with no upper class Hindu family in the village.

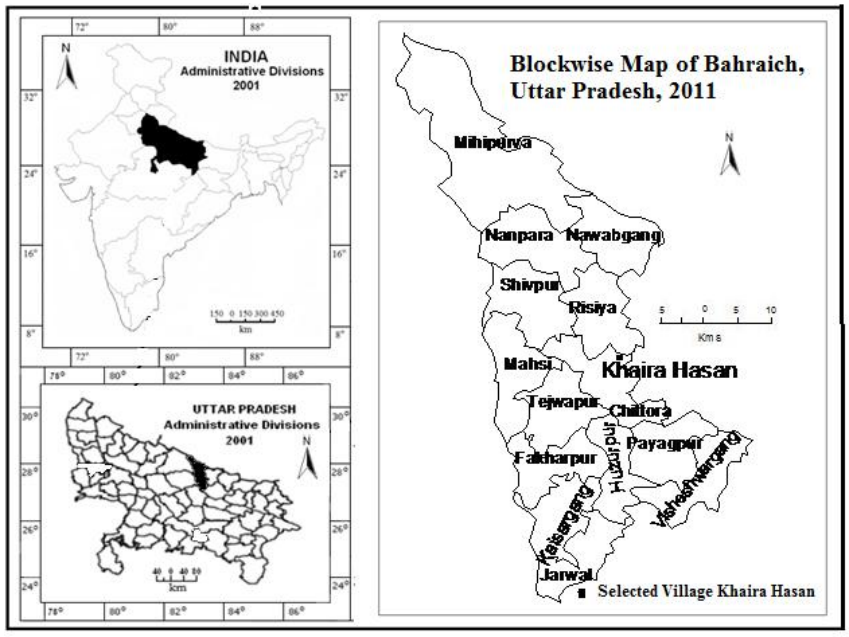

Fig.1. Location of Blocks in Bahraich, Uttar Pradesh

Database and Methodology

The present study is based on primary data generated by comprehensive survey of scheduled caste and Muslim population in the *Khaira Hasan* village of Chittora block of

Bahraich District carried out during June 2017. This rural survey consisted of all the 25 per cent households of scheduled caste population and Muslim Population in the Khaira Hasan village. The data regarding the educational characteristics and occupational characteristic of scheduled caste population and Muslim Population is obtained. The workers are grouped into 6 categories. The category I includes self-employed farmer (Cultivators), II includes (Shop Keepers and Skilled Workers, III claims Agricultural Labourer and Construction Labourers) IV records Regular Salaried Workers (Domestic Servant working on in workers in hotels and shops) V includes Lower Order Government Jobs (Sweepers and Peon) VI Higher Order Government Jobs includes (teachers and clerks). The educational levels are categorised into uneducated, primary educated and post primary educated.

Results and Discussion

Exclusion, Discrimination and Minority Enclave in India

In India, exclusion revolves around the societal institutions that exclude, discriminate, isolate and deprive some groups on the basis of identities such as caste, ethnicity, religion and gender. Among them, caste identity is one of the peculiar grounds of most of the inequality and discrimination. This caste system is actually a system of social and economic governance enshrined in Rig Veda of Hindu society.

According to the Hindu literature unequal economic rights are assigned to the people belonging to different groups leading to the forced exclusion. The most unfortunate sufferer of this type of exclusion or discrimination is scheduled caste. Apart from it Muslims, the largest minority community in the country, are also facing the problem of forced exclusion. They constitute 13.4 per cent (Census of India, 2011) of the population, are seriously lagging behind in terms of most of the human development indicators. While the perception of deprivation is widespread among Muslims, there has been no systematic effort since independence to analyse the condition of religious minorities in the country (Sachar Committee Report, 2006). Sachar Committee report was probably the first attempt to analyse the socio-economic condition of in India using large scale empirical data. Today, globally Muslims show the lowest literacy rate. Muslims being the socio-economically very backward are not benefitted by most of the reservation policies in India. Even the scheduled caste people who are practicing Islam or following Christianity are excluded from these benefits (Thorat and Newman, 2012).

Now the question arises ‘Are Scheduled caste and Muslims comparable?’ Indian academicians are often making the comparison between Scheduled caste and Muslims. The two groups grew out of very different historical circumstances-one the product of an age old ideology of caste and the other the product of waves of conversion and invasion, so complex that it is impossible to separate who was converted and when there are other differences as well that play out in the present. The most important of these stems from Scheduled caste as beneficiaries of a system of reserved quotas in public education and employment that allows them to access to the salaried labour market (since the major part

of this salaried market is in the public sector). A minor difference is that while there are large conclaves of Muslims in urban areas, Scheduled castes reside mostly in rural areas. Finally, Muslims have strong elite and social networks that have allowed them to secure space in trading occupations, while Dalit networks, although strong politically, are weak in terms of access to assets and markets. Yet, we argue that as sociologically conceptual categories, Scheduled caste and Muslims have strong similarities that make them comparable entities for this analysis (Das, 2012).

First, perhaps the greatest social similarity between them is that there is an elaborate dominant religious ideology that excludes them. The Brahmanical ideology that confers the status of the 'others' to these group plays out also in the type of occupations they pursue. Second, while most social groups in India have historically and hierarchically determined occupations, the important similarity among Muslims and Scheduled caste is that they are mostly poor and landless (Das, 2012).

The minority enclaves hypothesis rests on the assumption that those who are excluded from or disadvantaged in formal job sector will set up alternative 'minority labour markets' based and (non-farm) self-employment. In rural India, when we say formal employment we mean teachers, clerks, public sector medical providers, security personnel and office attendants, mostly in the public sector-jobs that come with security, pension, and several important perquisites that come confer social status. While non-form self-employed occupations are not necessarily high status and are highly heterogeneous, they are next best alternative to formal jobs. An important mediating factor to pull in of formal jobs is the effect of job quotas or affirmative action of Scheduled caste (Pande, 2003).

Therefore, Scheduled caste in rural areas may be self-employed in a variety of low-end service trades like small confectionary shop, grocery shop, Tea stall, masonry, carpentry, cycle repairing but moving out of these trades or expanding them may present significant barriers, as they are locked into a web of social relations based on these trades. The effect of poverty and perhaps lack of networks and other entrepreneurial wherewithal is felt most strongly by scheduled caste who cannot enter self-employment due to variety of social and economic reasons. (Thorat et al., 2012). For scheduled caste, Low availability of credit, being typed into caste- specific menial occupations, combined with the social pressure to stay in those occupations means that they do not have access to 'enclave labour market' even if they are not educated. So while the salaried job market absorbs some educated scheduled caste, clearly there are not enough of those jobs to absorb the growing pool of educated Scheduled caste (Das, 2012).

From the Table 1 it is clear that 35 per cent scheduled caste population is working population. Among the workers 13 per cent are working as casual labourers out of which 12 per cent are uneducated and 1 per cent is primary educated. The other important occupational category for scheduled caste workers is cultivators (9 per cent) out of which 6 per cent workers are uneducated and 2 per cent workers are primary educated and 1 per cent workers are post primary educated. From the table it is also clear that only 3.5 per cent workers are self-employed. Among them 2 per cent people are uneducated 1 per cent are

primary educated and 0.5 per cent are post primary educated. These self-employed people are having their grocery and confectionary shops in the village or they are having their own rice mill or flour mill in the village. Only 5.5 per cent scheduled caste workers are regular salaried workers either working in the ghalla mandi or working as domestic servant in the city area. Rest of 3 per cent scheduled caste workers are in the lower order government sector and 1 per cent workers are in higher order government jobs and they all are post primary educated.

Table 1. Relationship of Educational Levels of Scheduled Caste Population and Muslim Population with the Nature of their Employment, in Khaira Hasan Village, Chittora Block, Bahraich District, 2017

Population Group with their Educational Levels	Nature of Employment						
	Self-employed Farmer (I)	Non-Farm Self-employed (II)	Casual Laborers (III)	Regular Salaried Workers	In Lower Order Government Sector (IV)	In Higher Order Government Sector (V)	Not in the Work Force (VI)
Scheduled caste population (not educated)	6	2	12	5	0	0	40
Scheduled caste population (Primary educated)	2	1	1	0.5	0	0	21
Scheduled caste population (Post Primary educated)	1	0.5	0	0	3	1	4
Muslim population (not educated)	6	7	7	2	0	0	42
Muslim population (Primary educated)	1	3	1	1.5	0	0	22
Muslim population (Post Primary educated)	0.5	2	0	1	0	0	4

Source: Based on Calculation of the Collected Data by the Researcher from Field Survey (I Cultivator, II Shop Keepers and Skilled Workers, III Agricultural Labourer and Construction Labourers IV Domestic Servant working as Workers in Hotels and Shops, V Sweepers and Peon, VI Teachers and Clerks)

For Muslims the occupational structure is changed and the percentage of working population is 3 per cent lesser than the scheduled caste working population. Among Muslims only 32 per cent people are working. Through in depth analysis of the table it is found that 7.5 per cent of the total Muslim workers are engaged in agricultural sector as cultivators. Among them 6 per cent workers are uneducated, 1 per cent workers are primary educated and 0.5 are only post primary educated. The largest group of Muslim workers (12 Per cent) are engaged in nonfarm self-employment sector. Among them 7 per cent workers are uneducated 3 per cent workers are primary educated and 2 per cent are post primary educated. These workers are having small confectionary shop, grocery shop, tea stall, rice mill, flour mill in the village or working as carpenter, electrician, barber, tailor etc.

The second largest occupational group among the Muslim workers is the group of casual labourers. Among these labourers 7 per cent are uneducated and 1 per cent is primary literates. Rest of the 4.5 percent workers are working as regular salaried workers.

Among them 2 per cent workers are uneducated, 1.5 per cent workers are primary educated and 1 percent workers are post primary educated. This 1 percent post primary educated Muslims are working abroad as skilled labourer in Saudi Arabia. No workers among the Muslims are found in the government sector either at the lower order or higher order government sector.

Thus, it can be inferred from the above discussion that Muslim men seem to fit the minority enclave hypothesis to an extent, as the largest occupational group among the Muslim population of Khaira Hasan is non-agricultural self-employed workers. These people are either having their own small grocery or confectionary shops, flour or rice mill or working as skilled labourers like carpenter, electrician, tailor, barber, Painter, mason etc. They do not get regular salaried government jobs clearly visible from the collected data (Table 1) and up to certain extent they are pulled into self- employment. Hence, they can to be self-employed in to non- farm occupation and can create their own ethnic enclave. A good example of it is Chock area of Lucknow where Muslims live and operate their main business of embroidery in geographical cluster. However, scheduled caste people are no more involved in menial jobs but majority of them are involved in agricultural pursuits. Some educated people among them have availed the benefit of reserve quartos in employment sector and got the job in lower and higher order government jobs.

Conclusions

The results from this analysis demonstrate that the minority enclave does not hold for scheduled caste but it does for Muslims. Among Muslims the minority enclave is the result of their push out from the regular salaried government jobs and also because of the lack of access to land in rural areas. This has necessitated them to set up enclaves. Field studies and qualitative data also point that scheduled caste are mostly working as agricultural labourers some as cultivators and few of them are also absorbed in government jobs both lower order and higher order jobs as shown in the table 1. From the results, it is clear that education seems to have counterintuitive effect on allocation to employment type for scheduled caste population up to certain extent as they have fixed quotas in the formal employment sector. In the absence of acceptable employment opportunities, educated Muslim minority men would rather opt out of the labour force if they can afford to, or else, undertake low status employment. The return to education in the form of entry into the preferred employment-regular salaried jobs- is lower for this group.

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URBAN INFRASTRUCTURE AND SERVICE DELIVERY IN INDIA

Lakshmi Sivaramakrishnan

Department of Geography, Jadavpur University, Kolkata - 700 032
E-mail: lakshmi.bu@gmail.com

Abstract

Infrastructure is the physical facilities through which services can be provided to the public. Infrastructure development is essential for sustaining growth and good quality infrastructure affects the quality of life and livability. India's economic development is dependent on its urban areas as it is the key positive factor to overall development. The urban sector contributed 62 to 63 percent of the GDP in 2011 and is expected to contribute 75 percent by 2021. So good infrastructure, and its efficient delivery is of prime importance. However, there is a huge and wide gap between the demand and supply of essential urban services and infrastructure in Indian cities. India is urbanizing fast and the cities and towns will be at the centre of India's development trajectory. Ensuring high quality public services for the urban areas of India is an end in itself, but it will also facilitate the full realization of India's economic potential. Cities are the engines of national growth and development, so managing them will be India's priority. For this improving the urban infrastructure and particularly the service delivery is very important. The present paper will delve into the state of urban infrastructure in India and the quality and efficiency of delivery of these services to the public. The focus of the paper will be on water supply, sanitation and solid waste management. It will also focus on how reforming the governance can help in improving the delivery of the services and access to it, particularly for the urban poor.

Keywords: Infrastructure, Access, Service Delivery, Governance

Introduction

Urban infrastructure refers to the physical structure present in the cities and towns through services are delivered to the people. Infrastructure development is essential for sustaining growth and good quality infrastructure affects the quality of life and livability. India's economic development is dependent on its urban areas as it is the key positive factor to overall development. The urban sector contributed 62 to 63 percent of the GDP in 2011 and is expected to contribute 75 percent by 2021 (GOI, 2005). So good infrastructure, and its efficient delivery is of prime importance. Rapid expansion of urban areas has aggravated the shortage of infrastructure in Indian cities and has also limited the quality of service delivery of these facilities. India is urbanizing fast and the cities and towns will be at the centre of India's development trajectory. Ensuring high quality public services for the urban areas of India is an end in itself, but it will also facilitate the full realisation of India's

economic potential. Cities are the engines of national growth and development so managing them will be India's priority. For this improving the urban infrastructure and particularly the service delivery is very important.

India's urban population is growing rapidly from 17.28 percent in 1951 to 37.7 in 2011 and is expected to be 50.6 percent by 2050 (UN, 2010). At this rate, provision of urban services to the growing urban population will be a challenge to the administration and governance. The haphazard and unplanned urban development in India is also a retarding factor in the development of urban infrastructure. Moreover, most Indian cities have a large floating population who use these urban services so there is always a wide gap between the supply and demand.

Importance of Urban Infrastructure

Indian cities will be the locus and engine of economic growth in the coming years, and the realization of an ambitious goal of 9%–10% growth in GDP depend fundamentally on making Indian cities much more livable, inclusive, bankable, and competitive. Lack of adequate and quality infrastructure is proving to be a binding constraint in sustaining, deepening and expanding India's economic growth and global competitiveness. The various urban development projects taken by Government of India with emphasis on inclusive growth for urban poor would mean that urban infrastructure has to be strengthened and service delivery be improved and streamlined. Indian cities particularly the million and mega cities face a myriad of problems like increased population, slums, deterioration in the physical environment and quality of life, scarcity of water, poor sanitation, increase in the number of the vehicles, inadequate road and parking spaces, lack of public transportation, and solid waste management. These will stand in the way of global investments or in attracting investors or it can offer huge opportunities to companies engaged in such public amenity projects. The investments on these public amenities offer a strong growth potential. It has been rightly stated that wealth of nations is actually the wealth of its cities, and the roots of the ailments that plague nations can be traced to the state of their cities (Jacob, 1984). So the importance of urban infrastructure in any economy becomes clear and is required for economic growth. The dismantling the highly restrictive trade policy regime was begun in 1991 brought about structural changes in the economy associated with reduced dependence of the population on agriculture and increased migration from low-productivity agriculture to high-productivity sectors of industry and services in search of employment. The high productivity sectors are often concentrated in urban areas so it is expected that urban population will surge in future. In case of India the decline in agricultural employment has been moderate while growth in Industrial sector has not been impressive, but the service sector has shown a sharp increase in employment particularly in highly skilled services like IT sector , telecom etc. Construction in urban areas has increased and this leads to demand for unskilled labour augmenting the rural urban migration. So pressure on urban areas is going to increase and the infrastructure which is bursting its seams needs to be improved.

Status of Urban Basic Services in India

The three basic components of basic services which have immense imperatives on the health and environment are drinking water, sanitation, sewage and waste management. Inadequate availability of safe drinking water and sanitation can have serious consequences on the health of the population. Globally, diarrhoeal diseases are the second leading cause for children death under 5 (UNICEF, 2010), and 25 per cent of global diarrhoeal deaths occur in India (WHO, 2009). Around 88 per cent of diarrhoeal deaths can be attributed to inadequate sanitation hygiene and water (UNICEF, 2010). The greatest environmental concern is the pollution of water in urban India mainly by faulty sewerage and unhygienic conditions in urban areas.

Indian cities today are larger, with more diverse population, and are growing rapidly. They require technical skills to manage the delivery of urban services as well as provide a socio-economic environment in which the industry and services sectors can become globally competitive (GOI, 2011). The basic necessities of urban infrastructure are drinking water, sewage and solid waste management as these are directly related to the quality of life of the urban residents. However, most cities in India present a grim picture with regard to availability of basic services.

Availability of good drinking water and access to it is a basic need of human beings, but unfortunately urban India faces severe crisis with respect to drinking water. Table 1 show the average access to drinking water in India in the different size class cities and it is clear that access is higher in the larger cities and poor in the small towns. Nearly 70 per cent households have access to tap water, out of which 62 per cent have access to treated tap water. Thus, nearly 40 per cent of urban population do not have access to safe drinking water.

Table 1. City / Town - Average Access to Drinking Water (2008)

City / Town with Population Class	Average Access to Drinking Water in Percentage
Class I cities (1,00,000 and above)	73
Class II cities (50,000–99,999)	63
Class III cities (20,000–49,999)	61
Other cities/towns (<20,000)	58

Source: 11th Five-Year Plan, 2007-2012

Some of the prominent features of water supply in the cities of India are inadequate coverage, intermittent supplies, low pressure, and poor quality. With rapid increase in urban population and continuing expansion of city limits, the challenge of delivering water in Indian cities is growing rapidly. It is clear from Table 1 that access to drinking water is very poor and even the class I cities do not have100 percent access. Availability of drinking water in Urban India is also not very satisfactory.

An analysis of the census of India data shows that only 71.2 percent of the households have drinking within the premises and 20.7 percent near their premises and 8.1 percent have to travel longer distance for drinking water there has been marginal increase in the availability. The change in the two census years is also very nominal (Figure 1). The source of drinking water also varies from treated tap water to hand pumps. According to the 2011 Census of India only 49.38 percent of the household have access to treated tap water within their premises. The rest have to depend on other sources of water like well, pump, river water, ponds, open wells etc, which are mostly untreated.

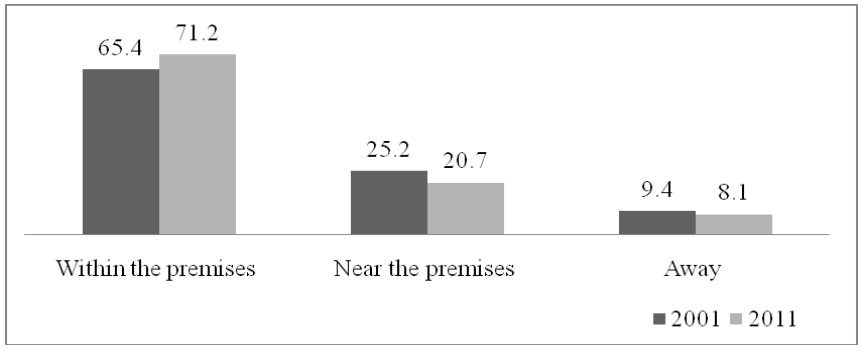

Fig. 1. Availability of Drinking Water in Urban India (2001-2011)
Source: Census of India 2001and 2011

Access to Safe Drinking Water

One of the major hurdles of drinking water in urban areas of India is the access to safe drinking water. From Table 2 shows, the access to safe drinking water in the different states of India and it can be seen that most of the states more that 90 percent of the households have access to safe drinking water (Figure 2 and 3). The most striking feature here is the fact that Kerala which is considered to be one of the developed states of India has very low percentage of households in urban areas with access to safe drinking water. The picture however changes if we consider the availability of safe drinking water within the premises of urban households'. Excepting the state of Punjab, which has 92 percent households with access to drinking within its premises; all other states have only 50 to 70 percent of the households with drinking water facilities within their premises. This implies that the urban population has to depend on water outside its premises with may be common stand posts or tube wells, pond or other sources. In addition to a large percentage of households not having access to pipe water supply, a large proportion of urban households do not have access to water within the house. According to Census 2011, 21 percent of the households have the water near their premises and 8 percent have to travelabout 100 metres to fetch water (Figure 4). This percentage is higher among poor urban households where nearly 12 percent of the households have to travel 100 metres to fetch water.

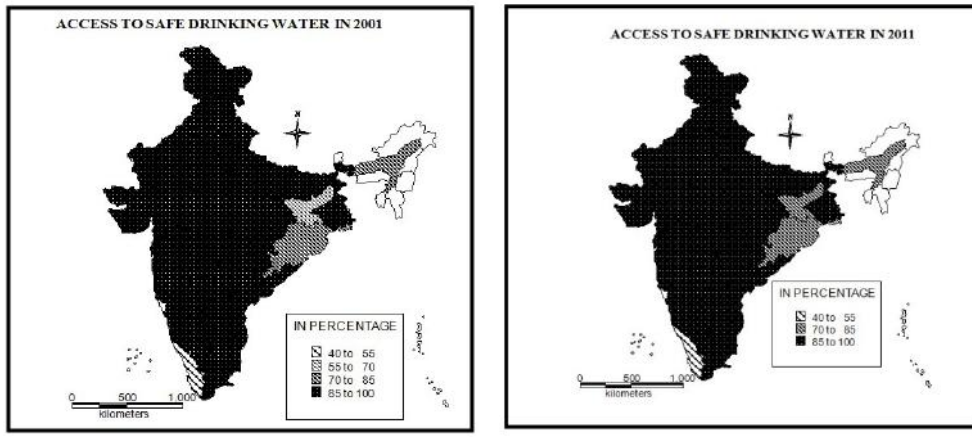

Fig. 2. Access to Safe Drinking Water

Supply Norms and the Reality

The norms for water supply suggested by the Ministry of Urban Development, Government of India is given in Table 3, while the Central Public Health and Environmental Engineering Organization (CPHEEO) has recommended 135 lpcd for cities provided with piped water supply where sewerage system is existing, and 150 lpcd for Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/ contemplated and 70 lpcd for towns provided with piped water supply but without sewerage system. But the reality is something different.

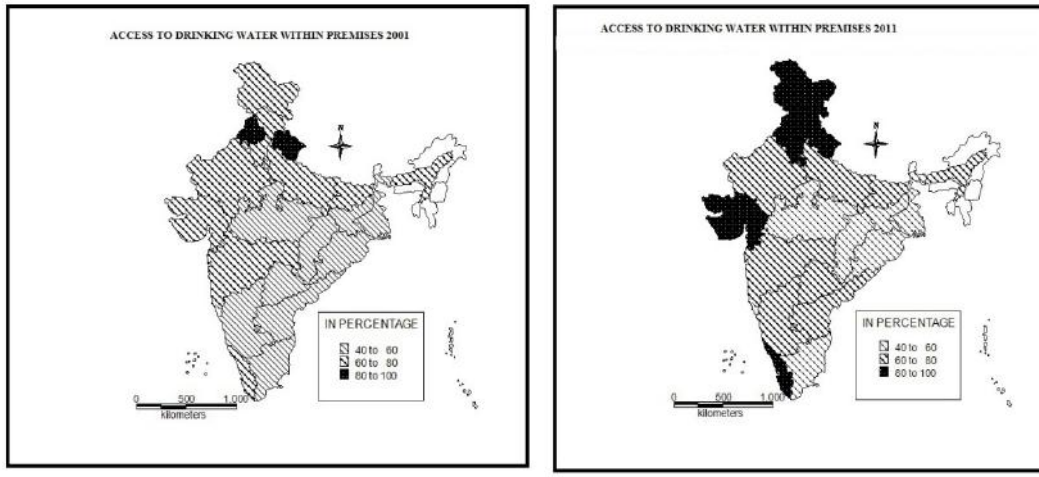

Fig. 3. Access to Safe Drinking Water within Premises

The average per capita water consumption in domestic households Indian cities is about 92 lpcd. The highest consumption is in Kolkata (116 lpcd), followed by Hyderabad (96 lpcd), Ahmadabad (95 lpcd), Mumbai (90 lpcd), Madurai (88 lpcd), Delhi (78 lpcd), and Kanpur (77 lpcd) (Shaban and Sharma, 2007). Considering the supply norms of 24 hours

supply only two Indian cities have continuous supply i.e. Thiruvanthapuram and Kota and majority of the Indian cities on an average supply water for 3.3 hours.

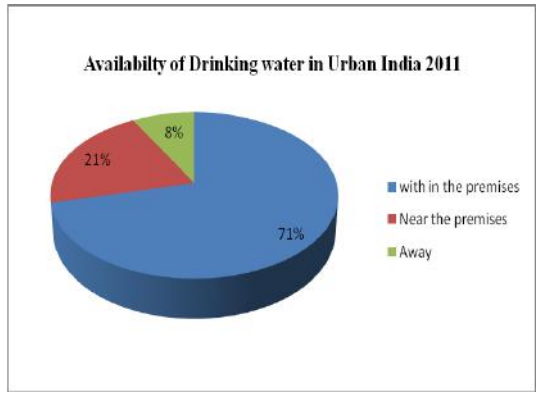

Fig. 4. Distance from Source of Water

Table 2: Urban Households with Access to Safe Drinking Water (in percentage)

Name of State	Households with Access to Safe Drinking Water		Households with Access to Safe Drinking Water within premises	
	2001	2011	2001	2011
India	90.1	91.4	65.4	71.2
Jammu & Kashmir	95.7	96.1	74.7	84.8
Himachal Pradesh	97.1	97.8	73.3	84.7
Punjab	98.9	98.9	92.1	92.7
Uttarakhand	97.8	98.6	82.1	88.7
Haryana	97.3	96.7	76.0	83.9
Rajasthan	93.5	94.3	75.8	78.2
Uttar Pradesh	97.1	97.8	77.0	78.8
Bihar	91.3	94.7	70.5	75.5
Assam	70.3	78.2	63.2	78.8
West Bengal	92.3	93.9	53.4	56.2
Jharkhand	68.2	78.5	57.2	59.1
Odisha	72.3	79.7	52.1	56.9
Chhattisgarh	88.8	93.9	49.3	49.7
Madhya Pradesh	88.5	92.1	55.2	55.4
Gujarat	95.4	97.0	73.5	83.7
Maharashtra	95.4	95.7	73.3	79.3
Andhra Pradesh	90.1	94.5	57.2	67.9
Karnataka	92.1	92.2	56.6	70.9
Kerala	42.9	39.5	78.9	83.3
Tamil Nadu	85.9	92.9	48.3	54.0

Source: Census of India 2001 and 2011

Table 3 Minimum Physical Standards for Water Supply

Service	Population/Area Target	Service Level Target
Water Supply	100% Population to be Covered	• Piped water supply with sewerage: 150/135 lpcd. • Piped water supply without sewerage: 70 lpcd. • Public stand posts in the low-income settlements with a minimum supply of 40 lpcd.

Source: NIUA, 2007

Dependence on Multiple Sources

Due to inadequacy in supply of water and poor service standards urban household have to depend on a range of option for water. Traditionally Indian cities depended on surface water sources but with increasing demand in most cities ground water is beingexploited scrupulously. Urban households access groundwater through three primary means: a) public supply by urban local bodies or other parastatal agencies, which may be completely or partially dependent on groundwater, b) private supply from shallow wells or bore wells within or near premises of use, and c) semiformal and informal trading of groundwater (Narain, 2012). This groundwater dependence has several consequences, the most prominent one being depletion of urban aquifers.

Sewerage and Sanitation in Urban India

The situation with respect to sewerage and sanitation in India is very acute. Majority of the urban areas do not have a proper sewerage system and underground drainage system is seen only in the metropolitan cities. In a survey carried out in 300 cities, only 100 cities had sewerage systems (NIUA, 2005). The number of cities with sewerage has increased slightly, according to Census 2011.

Table no. 4 shows the number of cities with sewerage connection. Only 42 cities in India have almost full sewerage connection for its residents and 68 percent of the cities have lee 10 percent coverage. This clearly portrays the dismal condition of sewerage in India. The sewerage systems, where they exist, are plagued by multiple problems. The sewers in most Indian cities are badly maintained: frequent blockages, siltation, missing manhole covers, gulley pits. There is hardly any preventive maintenance with repairs being made only in the case of crises (WSP-TARU, 2008).

Improper disposal of solid waste also tends to block sewer lines. Sometimes, storm water enters the sewerage network, leading to inflow in excess of the capacity of the system, and hence sewer lines cannot function. In many Indian cities, sewers do not take wastewater to treatment plants, and instead discharge untreated wastes into surface water bodies.

Table 4. Cities with Sewerage Connection

Percentage of Households Connected to Sewerage System	Number of Cities
More than 90	42
75-90	115
50-75	224
25-50	411
10-25	1,675
5-10	1,801
Less than 5	3,658
Total	7,926

Source: Census of India, 2011

The problem of sanitation is more acute in urban areas particularly in the slums. Good sanitation according to JMP (Joint Monitoring Programme), UNICEF and WHO (2010), includes, flush toilet, piped sewer system, septic tank, flush / pour flush to pit latrine, Ventilated Improved Pit-latrine (VIP), pit latrine with slab, composting toilet etc. In India data on availability of toilets is available in the census reports and according to the 2011 census report, around 81 per cent of urban households have access to toilet facilities within the household premises, 6 per cent access public toilets, and 12 per cent are forced to resort to open defecation. If we consider the slum population then only 66 percent of the households have access to toilet facility within their premises, but in most cases in the slums these toilets are shared by three to four households.

The above analysis of availability and access to basic urban services particularly safe drinking water and sanitation clearly reveals that universal access is not available with respect to these facilities. Mere availability does not assure access to all sections of the urban population. The environmental concerns posed by the urban water supply and sanitation are two-fold .There is inadequate attention being paid to the protection of water sources, and there are hardly any efforts to move towards conjoint management of water. The more severe concern is pollution of both surface and groundwater caused by a lack of treatment of wastewater.(IIHS, 2014).

Solid Waste in Urban India

The rapid growth of urban population together with rural migration and floating population in urban areas has increased the quantity of waste generated in the urban areas. It is a common feature to see waste littered in all parts of our cities and towns. Proper municipal solid waste (MSW) disposal systems to address the burgeoning amount of wastes are absent. The current solid waste management services are inefficient, incur heavy expenditure and are so low as to be a potential threat to the public health and environmental quality.

Improper solid waste management deteriorates public health, causes environmental pollution, and affects the quality of life of the people. The recent effects of globalization and life style changes among the urban population have also changed the type of solid waste generated. Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the ever growing problem of solid waste management. The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011, fuelled by changing lifestyles and increased purchasing power of urban Indians. Urban population growth and increase in per capita waste generation have resulted in a 50 percent increase in the waste generated by Indian cities within only a decade since 2001. The waste generated varies by the population size of the urban settlement. Cities with 100,000 plus population contribute 72.5 percent of the waste generated in the country as compared to other 3955 urban centers that produce only 17.5 per cent of the total waste (Table 5).

Table 5. Waste Generated in Class I Cities of India

Type of Cities	Number of Cities	Tones Per Day	Percentage of Total Garbage
Mega Cities	07	21,100	18.35
Metro Cities	28	19,643	17.08
Class I Towns	388	42,635	37.07
Total	**423**	**83,378**	**72.50**

Source: MOUD, 2005

Therefore, from the above analysis it is clear that urban infrastructure in Indian cities is severely lacking and the situation gets more aggravated with 25.7 per cent of the total urban population still living below the poverty line. According to Census of India (2011), that 17.4 per cent of all urban households, live in slums. So improving the service delivery system is very essential to improve the environmental condition in urban areas particularly the slums. This can be done by strengthening the urban governance. This can be done by bringing about some service delivery reforms like corporatization of urban services like drinking water and waste management, Public private partnerships in providing better services to urban citizens. Along with this, there should be some administrative and fiscal reforms whereby the Urban Local Bodies can take some decisions for improvement of services.

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MIGRATION OF BANGLADESHI PEOPLE TO DHUPGURI BLOCK OF JALAPIGURI DISTRICT, WEST BENGAL

Tushar Sarkar and Nuruzzaman Kasemi

Department of Geography, Raiganj University, Raiganj - 733 134
E-mail: tusharsarkargeo@gmail.com, nkasemi@gmail.com

Abstract

Partition of India only on religious line and the subsequent events in Bangladesh uprooted millions of people from their ancestral homeland which in turn resulted considerable episodic inflow of Bangladeshi people to West Bengal. The study along with examining trend and spatial distribution of Bangladeshi people also highlights the reasons for the specific migration to Dhupguri block from 1947 onwards. The findings of the study indicate that the specific inflow to Jalpaiguri District has been an episodic phenomenon and people preferred to settle down close to the border of Bangladesh. Fear psychosis and religious marginalization of the Hindus were found as the main reasons for the migration of the surveyed households to Dhupguri block. In most of the cases, they followed their relatives, friends and familiars in Dhupguri block thus social networking theory is found to be more relevant in this specific migration.

Keywords: Episodic inflow, Fear psychosis, Religious marginalisation and Social ties

Introduction

Migration, one of the most significant of all human behaviours has been going on from the very antiquity of human civilization all over the world (Frisbie, 1975). The sudden imaginary line drawn in 1947 to separate the nation, uprooted millions of people from their ancestral land and they were in the move to be in a place of physical safety and economic stability (Sengupta and Chaterjee, 2012). West Bengal has been receiving a large scale in-migrants from what is present day Bangladesh more so after 1947 (Banerjee et al, 1999). On the other way round this considerable inflow of migrants influenced the demography, social, economic and political conditions of the state (Datta, 2004; Pramanik, 2005). Migration from Bangladesh to West Bengal has been a matter of gradual episodic phenomena and this could be attributed to security issues of the Hindus after the partition of the country followed by economic aspects in recent times (Nath, 2003; Samaddar, 1999). West Bengal alone accounts for about 86 per cent of total Bangladeshi people in India (Kumar, 2005). Jalpaiguri District located in the northern part of West Bengal has been the main recipient district of Bangladeshi people in North Bengal (Sarkar, 2010). As of now, most of the scholars of the related field have worked to document the volume and pattern of the Bangladeshi migration to southern parts of West Bengal. Scholars have somehow missed empirical studies on the concerned migration to Jalpaiguri District; though the district received a considerable inflow throughout as far as receiving of Bangladeshi people is

concerned. Hence, the present study focuses on assessing the trend and drivers of the specific migration of Bangladeshi people to Dhupguri block of Jalpaiguri District of North Bengal along with examining the underlying reasons behind the area as a destination. The study along with acquiring fundamental insight of the different inflows of Bangladeshi people to the study area, would also like to contribute something to the scholarly debates on the determinants of this particular cross-border movement. The objectives are to study the trend of inflow of the people from what is present day Bangladesh in Jalpaiguri District and to examine the underlying reasons for in migration and selecting Dhupguri block as a destination.

Study Area

Jalpaiguri District, situated in the northern part in the state of West Bengal, India, share an international border with Bhutan and Bangladesh in the north and south respectively. The district extends over an area of about 3044 Km^2. Its territory is located between the latitudes of 26^0 16' N to 27^0 00' N and longitudes of 88^0 25' E to 89^0 53' E (Figure 1). The district has about 40 colonies of Bangladeshi people, stretches over its different parts. Dhupguri block an administrative division of Jalpaiguri District lies on the eastern extremity of the district. The Block has five squatter colonies and occupied by the Bangladeshi people, migrated in different times to Dhupguri block (Figure 1). Since cross-border movement remained a sensitive issue, hence Dhupguri block was selected only after rapport building with the respondents.

Database and Methodology

Data on international in-migrants from Bangladesh to Jalpaiguri District were collected from District Census Handbook Jalpaiguri District, 1951 and migration Table 'D' series, Census of India, 2001. Refugee Relief and Rehabilitation department of Jalpaiguri District has been consulted to study the block wise spatial distribution of people from what is present day Bangladesh in Jalpaiguri District. As what is present-day Bangladesh has been known in three different names after the partition of country in 1947 i.e. East Bengal (1947-1956), East Pakistan (1956-1971) and Bangladesh (1971 onwards), hence only Bangladesh name is used in the study in order to keep the confusion away.

Since cross-border migration remained a sensitive issue, hence migrated people felt uncomfortable to share information about their migration. These migrated people especially close to the border of Bangladesh i.e. from Rajganj and Jalpaiguri block hesitated more to share information. Hence, these two blocks could not be taken as a research site though they are the prominent blocks in Jalpaiguri District as far as receiving of Bangladeshi people is concerned. Dhupguri block, the third highest, in terms of presence of Bangladeshi households in Jalpaiguri District is located relatively far away from Bangladesh border as compared to Rajganj and Jalpaiguri blocks. Rapport could only be built with the migrated people of Dhupguri block. Hence, Dhupguri block is selected in order to find out the compatible outcomes of the objectives taken in the present research work.

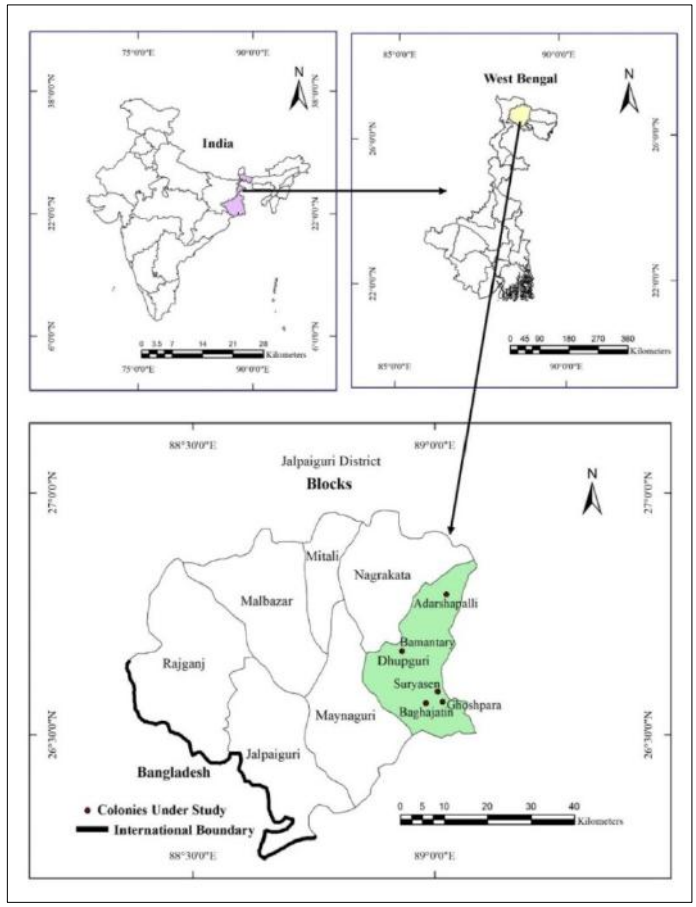

Fig. 1. Study Area

The core of the study is based on primary data. Primary data were collected from a sample survey of the migrant households in the colonies of Dhupguri block in June-November, 2017. Primary survey has been conducted for household survey and in-depth interview with the people from Bangladesh. Household surveys have been conducted in 410 households (33 %) from the 5 migrant colonies of Dhupguri block following a random sampling method with a semi-structured questionnaire. Stress have been given to conduct the surveys with the head of the households. In case of his absence, the next important member of the households were consulted. Data on drivers, trend and Dhupguri block as a destination of the households have been covered by the survey.

In-depth interviews have been conducted to cross check the reasons for the out migration from Bangladesh as it has learnt during the pilot survey that sometimes migrated people from Bangladesh intentionally introduce themselves as religious victims from Bangladesh in order to keep the political complications away. 50 in-depth interviews, 10 at each colony were conducted to learn the underlying reasons for the migration from Bangladesh.

Interviews were conducted with an unstructured questionnaire in the age group of 45 and above. Purposive sampling technique was employed to select the respondents. Respondents were drawn from prominent elders, community leaders, teachers and government officials and care was taken to cover same proportion of respondents from these aforementioned group. Opinions of the each respondent were taken in all the 7 aspects, classified by the researcher in the study about the reasons for migration. These opinion in each category were summed up and divided by 50, for all the 7 reasons to find out the average. Opinions of the respondents were converted into percentage, tabulations were done and analysis has been made to draw the conclusion. Care was taken during the entire study to check the validity of the information collected.

Results and Discussion

Trend of Migration from Bangladesh to Jalpaiguri District

Partition of India only on religious line is one of the cruellest partition in the history of mankind (Datta, 2004). On account of the partition of the country in1947, communal tensions flared up in both the side of Bengal and the subsequent events in Bangladesh uprooted millions of people especially the Hindus from their ancestral land (Dasgputa, 2000). West Bengal appeared as like a tepid destination to these uprooted people owing to same Bengali culture, geographical proximity and emotional attachment with the Bengali people of West Bengal (Samaddar, 1999; Sarkar, 2018). West Bengal received a drastic inflow when the Pakistan army tried to dissolve the *Mukti Bahini* of Bangladesh and rule over them. During that time about 7 million people fled from Bangladesh and taken shelter especially in the bordering districts of West Bengal (Weiner, 1993). Migration of the Bangladeshis is still going on in many forms to parts of West Bengal even after the independence of the country in 1971 (Datta, 2004; Nath, 2003; Pramanik, 2005).

West Bengal borders Bangladesh by 9 districts. Of them, Jalpaiguri District, situated in the northern part of West Bengal share a direct international border with Bangladesh by two of its community development block namely Rajganj and Jalpaiguri. Dhupguri block, also lies close to the periphery of Bangladesh. Divisional town of Jalpaiguri has been remained a somewhat preferred destination place for the specific inflow. Presence of considerable number of tea gardens, relatively well-developed road transportation, facility of Darjeeling mail, which earlier used to run across the mainland of Bangladesh, absence of big river and rivulets in Bangladesh side to Jalpaiguri District drew the attention of the migrants which in turn facilitates the movement to Jalpaiguri District (Sikdar, 2005).

Partition of the country resulted loss of five police stations to erstwhile East Bengal from Jalpaiguri District. Jalpaiguri District has been receiving major inflow of migrants from East Bengal even before the partition in1947, more specifically following the of *Noakhali* riot of 1946 in East Bengal (Bhowmik, 2015). Quite unsteady prevailing after the partition in

1947 and religious marginalization of the Hindus in Bangladesh led many Hindus to migrate Jalpaiguri District. As a result, the district received an episodic increasing inflow of 13522 persons in 1947 to 47025 persons in the subsequent year of 1950 (Table 1).

Table 1. In-migration to Jalpaiguri District from Erstwhile East Bengal (1946-1950)

Year	Persons
1946	1,630
1947	13,552
1948	18,149
1949	15,452
1950	47,025

Source: District Census Handbook, Jalpaiguri, 1951

It is evident from Table 2 that during 1946-1950, migration from Bangladesh to Jalpaiguri District has essentially taken place from the districts of Bangladesh lying just opposite side of the border of Jalpaiguri District (Fig. 2). People predominantly came from Rangpur, Dinajpur, and Mymensingh district of Bangladesh (Table 2). It could be said that 'Distance-Decay Model' of Ravenstien was quite relevant in the migration during 1946-1950 (Figure 2, Table 2).

On the other hand, Dhaka district of Bangladesh lying relatively far away from Jalpaiguri District, also shared a sizable portion of 16.71 per cent of migrants during 1946-1950 to Jalpaiguri District (Table 2). Apart from Dhaka district, Faridpur (4.66%) and Pabna district (4.19%) also shared a discernible portion to Jalpaiguri District during 1946-1950 (Table 2). Migration from these far lying District (Figure 2) could be attributed to social networking among the migrants from Bangladesh.

It is evident from Table 3 that in-migration in Jalpaiguri District has essentially taken place from Bangladesh during 1951-2001. Bangladesh (up to 1971 East Pakistan) alone outstripped other foreign countries by a large extent in terms of presence of foreigners in Jalpaiguri District that the district enumerated with more than 80 per cent of Bangladeshi in-migrants during 1951-2001 (Table 3). After 1961, Jalpaiguri District witnessed an episodic increasing inflow of migrants from Bangladesh (Table 3). Liberation war of Bangladesh (1971), assassination of *Bangabandhu* Sekh Mujibar Rahaman, (1975), repercussion of *Ayodhya* events (1991) in Bangladesh etc. led millions of people to West Bengal (Datta, 2004). The Data of Government of India shows that during 1972-1993 a total of 41.25 lakh people arrived from Bangladesh and out of them, 8.36 lakh overstayed in India (Banerjee et al 1999). Kumar (2011) argues that approximately 12 million have moved in an undocumented way to various state of India in post-1971 period. On the other hand, Kumar (2005) argues that 86 per cent of migrated people from Bangladesh settled down in West Bengal. Jalpaiguri District might have registered a considerable inflow of migrants from Bangladesh during the above mentioned period which in turn added an additional extent to the presence of Bangladeshi people in Jalpaiguri District in recent years.

Table 2. In-migration to Jalpaiguri District from Districts of Erstwhile East Bengal (1946-1950)

Districts	Number of Persons					% of Migrants from Different Districts
	1946	1947	1948	1949	1950	
Kusthia	21	269	244	88	183	0.84
Jessore	17	526	405	161	321	1.49
Khulna	3	344	184	98	193	0.86
Rajsahi	10	278	268	234	413	1.26
Dinajpur	48	742	1167	3272	12211	18.20
Rangpur	541	2190	2854	3621	15805	26.11
Bogra	10	268	257	176	468	1.23
Pabna	75	834	1200	575	1328	4.19
Dacca	321	3095	4071	2659	5862	16.71
Mymensingh	264	1861	4283	3093	7009	17.23
Faridpur	73	1074	1232	722	1364	4.66
Bakharganj	34	554	571	194	596	2.03
Tipperah	63	413	600	221	401	1.77
Noakhali	67	476	523	139	397	1.67
Chitagong	24	495	186	139	305	1.20
Syhlet	59	133	104	60	169	0.55
Total	1630	13552	18149	15452	47025	100

Source: District Census Handbook, Jalpaiguri, 1951

Table 3. In-Migrants from Erstwhile East Bengal (Bangladesh) to Jalpaiguri District (1951-2001)

Year	Total In-migrants from Bangladesh	% Share to District's Total In-Migrants
1951	132358	84.44
1961	218431	83.44
1981	279186	93.13
1991	249424	94.55
2001	230574	94.56

Source: Census of India, 1961; 2001

Spatial Distribution of the Bangladeshi People in Jalpaiguri District

Jalpaiguri District has been registering people from Bangladesh since a long time (Sarkar, 2018). Urban, suburban and rural areas of Jalpaiguri District have been filled up by the victims of several riots, conflicts and quite political unrest prevailing in Bangladesh (Sikdar, 2005). Jalpaiguri District has about 40 colonies, stretching over its 5 block. These colonies have been occupied by the people migrated to the district from Bangladesh during different times. These colonies are government or semi-government sponsored, self-initiated and squatter in nature.

People from Bangladesh preferred to settle themselves in those blocks (Rajganj and Jalpaiguri) of Jalpaiguri District which share border with Bangladesh (Fig.1). These two

blocks are accounting for 56.64 and 24.93 per cent of the total migrants of Jalpaiguri District respectively (Table 4). Besides this, the presence of Jalpaiguri city might have attracted the attention of Bangladeshi people. Bhowmik (2015) argues that people from Bangladesh prefer to settle in and surrounding areas of Jalpaiguri city. This may be because of getting a job and other facilities. On the other hand, government tried to resettle the proletariat people from Bangladesh in the unused lands close to Jalpaiguri city (Sikdar, 2005). This could be another reason behind Jalpaiguri city oriented distribution of Bangladeshi people in the district.

Table 4. Block-wise Distribution of Migrants from Bangladesh in Jalpaiguri District, 2011

Block	Number of Household	% Share to District Total
Rajganj	9492	56.64
Jalpaiguri	4933	29.43
Dhupguri	1245	7.42
Mal	942	5.62
Mainaguri	145	0.86
Total	16757	100

Source: Refugee Relief and Rehabilitation Department, Jalpaiguri, 2011

At Rajganj block Suryasen, Netajinagar and Bhakitnagr are the prominent colonies as far as number of Bangladeshi household is concerned (Table 5). The quite high concentration of the concerned people in the colonies of Rajganj block could be attributed to short distance with the Bangladesh border, presence of sufficient agricultural land and other facilities as compared to other colonies in the block or even in Jalpaiguri District. In case of Jalpaiguri block, Indira Gandhi, Subhas Unnayan and Pilkhana are the three important colonies (Table 5) as far as number of Bangladeshi household is concerned. Presence of Jalpaiguri city and social networking among the migrants themselves played a crucial role in resettling them in Jalpaiguri block.

Adarshapalli colony alone outstripped other colonies in Dhupguri block regarding the number of Bangladeshi household. This colony alone accounts for 750 households out of the total 1245 household in Dhupguri block (Table 5). Migration to Dhupguri block has essentially taken place following social-networking among the migrants (Sarkar, 2018). Beside this, presence of 21 tea gardens in and around Banarhat city also might have pulled the concerned people to Adarshapalli colony. Adarshapalli colony is followed by Ghoshpara, Suryasen and Baghajatin colony regarding the number of households in Dhupguri block (Table 5). Diversified opportunities in economically productive activities, locational advantage and the urban character of these colonies of Dhupguri block drew the attention of the people from Bangladesh (Sarkar, 2018). On the other hand, rural Bamantary (90) colony has the least number of migrant households from Bangladesh settled in Dhupguri block (Table 5). Bamantary colony has been predominantly residing by the *Namasudra* agriculturalist people from Bangladesh. This is due to agriculture-oriented economy of Bamantary colony that *Namasudras* migrated to the colony.

On the other hand, in Mal block, Mal colony and Netaji Udbastu are the prominent ones regarding number of Bangladeshi households (Table 5). Mal block has about 850 migrant households from Bangladesh. This could be attributed to work opportunities in the tea gardens of the block. Mainaguri block has only one colony namely Panbari, accounts for a mere 145 households. Because of relatively less economic opportunity and other facilities as compared to the above mentioned four blocks, people from other side of the border did not prefer to settle themselves in Mainaguri Block.

On the other hand, Nagrakata and Mitali block in Jalpaiguri District has no such colonies. The reasons behind such distribution could not be properly known. These may be because of relatively far distance of these blocks from the Bangladesh border (Fig. 2) and absence of their own relatives and familiars.

Table 5. Block Wise Major Colonies of Bangladeshi People in Jalpaiguri District

Blocks	Name of the colony	Number of Household
Rajganj	Suryasen	1150
	Netajinagar	850
	Bhakitinagar	800
	Bankimnagar	790
	Niranjannagar	510
Jalpaiguri	Indira Gandhi	650
	Subhas Unnayan	550
	Pilkhana	500
	Baghajatin	350
	Mahamaya	280
Dhupguri	Adarshapalli	750
	Ghoshpara	145
	Suryasen	135
	Baghajatin	125
	Bamantary	90
Mal	Mal colony	500
	Netaji Udbastu	200
	Ramkrishna	112
	Teachers colony	30
Maynaguri	Panbari	145

Source: Refugee Relief and Rehabilitation Department, Jalpaiguri, 2011

Reasons for Migration from Bangladesh

Migration from Bangladesh to West Bengal has been remained a controversial issue as Bangladesh was a part of undivided Bengal till 1947 (Dutta, 2013). Partition was at the root of all evils (Datta, 2004; Samaddar, 1999). The partition of the country only on religious line ended up with communal tensions on both the side. As a result, a considerable number of people from Bangladesh were somehow had to leave their homes and hearth to join and rebuild their lives in parts of West Bengal, where they faced with dwindling public sympathy and institutional apathy (Chatterji, 2007).

Fear psychosis has been found the leading factors as far as reasons for the migration of the Bangladeshi people in Dhupguri block is concerned (Table 6). After the partition, worry about their family and future in the Muslim majority country led the Hindus towards a nation, they believed their own i.e. India. Most of the head of the households are of the opinion that their decision of migration has stood positive when the security issues comes under consideration.

Religious marginalization of the Hindus also played a significant role for the specific migration from Bangladesh which almost accounts for 24 per cent of the surveyed households in Dhupguri block (Table 6). The surveyed victims of religious marginalization affected substantially that they had to leave their ancestral homeland behind and move for a place which they psychologically believed to their own. The major Chunk of the religious victims in Dhupguri block got influenced by the repercussions of the *Hazratbal* riot (1964) and *Barbi* Mosque event (1992) in Bangladesh.

Table6. Reasons for Migration from Bangladesh to Dhupguri Block (Based on Household Survey)

Reasons	% of Households
Fear Psychosis	39.42
Religious Marginalization	23.84
Political Unrest	18
Economic Issues	11.44
Social Ties	5.60
Natural Calamities	0.97
Others	0.73

Source: Field Survey 2017

Remaining part of the religious victim, migrated to Dhupguri block following different minor riots and religious conflicts in Bangladesh. 89 per cent of the surveyed head of the households, influenced by religious issues in Bangladesh, are of the opinion that leaving their ancestral country was needed in securing their *Samman* (honour), *Pran* (life) and *Dhan* (wealth).

Political unsteady prevailing in Bangladesh influenced a considerable section of 18 per cent of surveyed households in Dhupguri block (Table 6). It has learnt during the course of field interactions that after the assassination of *Bangabandhu* Sekh Mujibar Rahaman, Zia's military rule and the election result of 1991, 2001 the political environment in Bangladesh got quite unsteady. Consequently, a sizable section of them crossed the border. It has returned by more than 76 per cent of the households that economically they were quite efficient in Bangladesh. This could also be evident from Table 6 that economic aspects played a relatively less significant role in leaving their ancestral country which accounts for only 11.44 per cent of the surveyed households in Dhupguri block.

Presence of friends and familiars in West Bengal also pulled a small part of the households (5.60%) from Bangladesh (Table 6). Out of these 5.60 per cent of migrant households, 62 per cent wanted to be in a place, close to their own people. While another

17 per cent of the concern migrant households settled themselves under the shade of their relatives as they were somehow dependent upon them. About 0.97 per cent of the households migrated on account of quite frequent natural calamities like flood, cyclones in Bangladesh (Table 6). It has found that 54 percent of victim of natural calamities were affected by the devastating flood of 1988 in Bangladesh. A mere 0.73 per cent of the households believed that they would get better opportunities in health, education and a social environment in West Bengal compared to their last place of residence in Bangladesh.

The results of the in-depth interviews show a quite disparities as far as reasons for the specific migration of the surveyed households is concerned. Table 7 shows that 52 per cent of the respondents put fear psychosis as the reason for migration from Bangladesh, which have been accounted with 39.42 per cent in household survey (Table 6).

Table7. Opinions of the Respondents Regarding the Reasons for Migration from Bangladesh to Dhupguri Block (Based on In-depth Interview)

Reasons	% of Respondents
Fear Psychosis	52
Religious Marginalization	18
Economic issues	12
Less opportunities in Health, education and social environment	8
Political unrest environment	5
Social Ties	4
Natural Calamities	1

Source: Field Survey 2017

Religious marginalization was found a relatively less important determining factor for the specific migration in the results of in-depth interview as compared to household survey. It was accounted with 18 per cent (Table 7) in in-depth interview where the same accounted for 23.84 per cent (Table 6) in household survey. It has learnt that migrated people from Bangladesh often intentionally introduce themselves as religious victims in order to keep the political complications away, though in actuality they have migrated due to other reasons. Respondents of in-depth interview found chances of better education and health opportunities in West as compared to their ancestral homeland as an important attracting factor for the specific migrants and consequently which pulled some amount of them from Bangladesh. In case of Dhupguri block about 8 per cent of the respondents opined for less opportunities in education and health in Bangladesh as a reason for the specific migration (Table 7); where it was found a mere 0.73 per cent in household survey (Table 6). Besides this, in in-depth interview, quite political unsteady prevailing in Bangladesh was found a relatively less important determining factor in leaving their ancestral country compared to household survey. Here it is accounted with 5 per cent (Table 7) and the same was accounted with 18 per cent in household survey (Table 6). While, in case of social ties and natural calamities as a reason for the specific migration, the percentage found to be almost same in both the survey.

Despite a discernible variation in the results of household survey and in-depth interview, the results of both the survey advocate that fear psychosis and religious marginalization of the Hindus were the main reasons behind the specific migration of the surveyed households to Dhupguri block. Along with this less opportunities in economic activities, health and education led a small section of the surveyed households from Bangladesh to Dhupguri block.

In-migration to Dhupguri Block

Dhupguri block registered an episodic inflow of Bangladeshi people throughout the time (Table 8). It is evident from Table 8 that Dhupguri block received major inflow of migrants (43.80%) from Bangladesh during 1967-1977. It has found that 81 per cent of the concern migrant households of 1967-1977 decade, crossed the border during the liberation war of Bangladesh in 1971. Another 16 per cent of migrant households of the same decade, moved after assassination of *Bangabandhu* Sekh Mujibar Rahaman in 1975. This decade is followed by 1957-1967 (27.25%). It has learnt during the course of field interactions that about 62 per cent migrant households of the concerned decade were moved in and around 1964 following the repercussions of Hazratbal riot in Bangladesh. Remaining section of the concern decade moved to the study area in a scatter way. During 1947-1957 the place registered a small part of 12.16 per cent of migrant households (Table 8). It has found that 41 per cent of them left their ancestral country during 1947-1948 on account of partition of the country in 1947. Another 37 per cent of the study households of the decade, moved during 1952-1953 following the passport proposal by the Pakistan government in 1952. It has learnt that passport proposal appeared to them as like a now or never kind of situation to move to India.

Table 8 shows a considerable decrease after 1977 in the specific Migration to Dhupguri block. It has found that during 1977-1987, people moved to the area throughout the entire decade in a scatter way. On the other hand, during 1987-1997, major chunk of the migrant households came to the study area following the repercussions of '*Ayodhya*' event (1992) in Bangladesh. After 1997, migration to the colonies of Dhupguri block from Bangladesh has decreased substantially that a mere 1.46 per cent of the surveyed households moved during this time.

Table 8. Decade-wise, Share of Migrants from Bangladesh to Dhupguri Block

Decade	% of Households
1947-1957	12.16
1957-1967	27.25
1967-1977	43.80
1977-1987	10.46
1987-1997	4.87
After 1997	1.46

Source: Field Survey 2017

Dhupguri Block as a Destination: Reasons

The social networking among the migrant themselves has facilitated the process of

migration from Bangladesh to West Bengal (Behera, 2011; Ansary and Das, 2016). In case of migration, to Dhupguri block also, social networking among the migrants were found quite strong (Table 9). It is evident from Table 8 that major chunk (37.21%) of the surveyed households came to Dhupguri block following their blood relatives. Only a few households migrated to the study area in the first flow. Thereafter, they had informed their relatives, friends and familiars about the places and thus migration taken place to Dhupguri block in an accelerated manner. Another considerable section of 19.25 per cent of surveyed households followed their friends and familiars to Dhupguri block (Table 9).

Comparatively better economic opportunities in Dhupguri block drew the attention of 18.32 per cent of the surveyed households (Table 9). This is mainly because, Dhupguri town has been working like a nodal trade centre in Jalpaiguri District since a long time (Sarkar, 2018). It has found that about 53 per cent of the economic migrants are from districts lying just opposite side of the border of Bangladesh like Rangpur, Lalmonirhat, Mymensingh etc. Remaining part of the economic migrants are from relatively far lying districts of Bangladesh mainly from Pabna and Dinajpur (Figure. 2).

Table 9. Reasons for Selecting Dhupguri Block as a Destination by the Bangladeshi Migrants

Reasons	% of Household
Presence of Blood Relatives	37.21
Friends & Village Acquaintances	19.25
Economic issues	18.32
Low-cost land in the Colonies	12.28
Cordial Behaviour of the Residents of Dhupguri	5.99
Other	6.95

Source: Field Survey 2017

It has further known that land were distributed in a low cost and sometimes in free of cost in the colonies by the local political bodies for the resettlement of these proletariat people from Bangladesh. Thus the availability of low-cost land in the colonies of Dhupguri block attracted a small section of 12.28 per cent of surveyed household. Along with these the cooperation of the local people towards the Bangladeshi people also somehow motivated 5.99 per cent of the surveyed households to Dhupguri block (Table 9). It has learnt that local people helped them in a considerable way by providing them food and other valuables to survive initially. Another 6.95 per cent of the surveyed households believed that they would get comparatively better health, education opportunities and good social environment (Table 9) in Dhupguri block especially households from districts like Rangpur, Lalmonirhat, Mymensingh and Nilphamari (Figure 2).

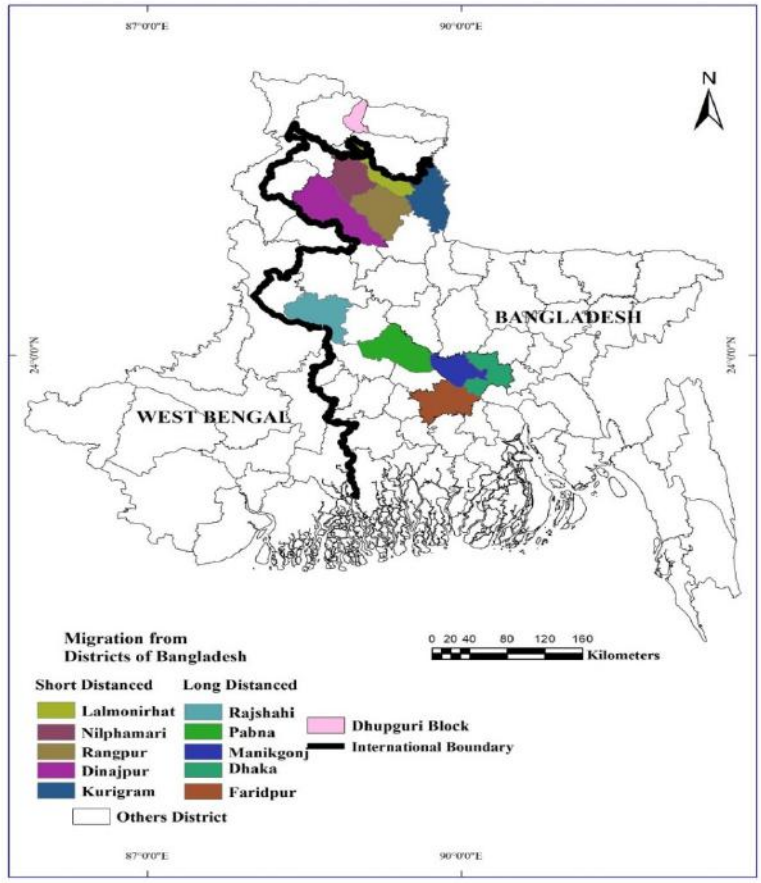

Fig. 2. In-Migration to Dhupguri Block from Bangladesh

Conclusions

The findings of the study pertaining to examining trend of migration to Jalpaiguri District lead to the conclusion that Jalpaiguri District has been registering the specific migration since the time of partition in 1947. During liberation war of Bangladesh, the place registered a rather drastic inflow. The findings show that people from Bangladesh preferred to settle themselves close to the border of Bangladesh. Dhupguri block registered an episodic inflow from what is present day Bangladesh owing to same Bengali culture and being located in the periphery of Bangladesh border. Fear psychosis and religious marginalization have been the main reasons in leaving their ancestral country of Bangladesh of the surveyed households. However, economic issues also played a significant role for the specific migration and most of them are short distance travelled migrants from Rangpur, Lalmonirhat, Nilphamari districts of Bangladesh. The surveyed households mainly followed their blood relatives, friends and familiars in their resettlement to Dhupguri block. It indicates that social-networking among them was pretty strong. Diversified economic opportunities and low-cost land in the colonies of Dhupguri block also attracted a sizable section of the households in Dhupguri block.

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DEPLOYMENT OF SOLAR ENERGY PLANTS IN STONY WASTELAND AREA - A CASE STUDY OF BARA TAHSIL, ALLAHABAD DISTRICT

Deeksha Mishra and Singh B.N.

Department of Geography, University of Allahabad, Allahabad - 211 002
E-mail: dmishra583@gmail.com

Abstract

Solar energy is being championed as a potentially significant new job opportunity, efficient use of wasteland and rural growths and also a means of addressing environmental and energy security concerns. Sentinel-2 satellite imagery (10 m, 20 m) and Cartosat-2 DEM (2.5 m) data are the major data sources for extracting thematic layers. In the present study, the suitable region for installation of the solar power plant is identified through the AHP method in combination with cost distance function by considering existing infrastructure in Bara tahsil of Allahabad district. Major expected impact of a solar power plant on the local economy and supposed key challenges in the study area is also discussed. Research finding indicates that the rocky and stony wasteland area with even terrain has a capacity of 5703.3 MW in 126.74 km^2 area. However solar power plant unit in wasteland area is not going to create a lot of skilled job opportunities for the local population, but rather some infrastructure development, water resource conservation, wasteland management and energy revenue generation.

Keywords: Solar energy, Sentinel-2, Cartosat-2 DEM, Site suitability, Solar power plant

Introduction

The continuous combustion of limited stocked and non-renewable fossil fuels for energy consumption and the negative impact on the environment i.e. global warming has forced many countries to adopt more renewable energy alternatives. The Sun, which produces more than 2500 terawatts (TW) energy, can be tapped through the solar power plant. It is one of the environment-friendly and renewable alternatives for sustaining energy consumption and energy independence in respect of fluctuating price and environmental cost of fossil fuels (Georgiou and Skarlatos, 2016). A solar power plant offers a grid-connected photovoltaic system consists of solar panel, inverters, a power conditioning units and grid connection equipment (Kumar and Sudhakar, 2015). Photovoltaic panels are made of semiconductors that directly converts solar energy into electricity. Generated energy is distributed to electrify remote villages of the region. Thus, a solar power plant provides safe, efficient, reliable and environment-friendly renewable energy for a long time.

India also focused on promoting and developing solar energy with an ambitious target of achieving 175 GW solar capacity by 2022 under Paris COP 21 climate summit. The current installed capacity of India is 26 GW on 30th Sept 2018 (Ministry of New and Renewable Energy, 2018). Hence, it is imperative to identify the suitable regions for installation of the solar power plant to fulfilling the national commitment by considering local, financial, environmental and legal conditions as well. In respect of this, the Analytical hierarchy process (AHP) incorporation with GIS environment is efficient and flexible decision making tool for the identification and selection of suitable region (Kontos et al., 2005, Carrion et al., 2008; Tegou et al., 2010, Georgiou and Skarlatos, 2016). Analytical hierarchy process (AHP) under multi-criteria decision making (MCDM) provides an effective method for dealing with complex decision making, reducing biases and subjectivity (Saaty, 2008, Perzina and Jaroslave, 2013, Tisza, 2014).

The Uttar Pradesh has 22300 MW potential solar energy and targeting 10700 MW capacity by 2022 under the solar power plant policy (2014) with a mandatory restriction that all the solar power plant should be established in the wasteland area for efficient use of this vast lands. Hence, in the present study, an attempt is made to explore the potential and suitable region for deployment of a solar power plant incorporation with the existing infrastructure of the study area. An economic impact of a solar power plant on the local economy is also discussed here, since the study area; Bara tahsil, is one of the most backward regions in Allahabad District, because of its vast rocky and stony wasteland area.

Study Area

Bara tahsil consists of two development blocks Jasra and Shankargarh with 29 nyaya panchayats viz., Sidhtikar, Ghurpur, Lotarh, Jasra, Asarwai, Gauhani, Parsara, Tikarikalan, Nivi, Kanti, Bashara Uperhar, Bhatpura, Lohra, Amgodar, Manpur, Golhaiya, Surwal Sahini, Shanakrgarh, Jorwat Nauriha Uperhar, Amgodar, Golhaiya, Shanakrgarh, Jorwat, Bashara Uperhar, Nauriha Uperhar Surwal Sahini and Lohra (figure 1). It represents a transition zone between the plain of the Yamuna and uplands of the Vindhyan region, located in the south west of Allahabad district of Uttar Pradesh of India. It lies between the $25^0$2'30''- $25^0$22'30'' N latitude and $81^0$31'- $81^0$50' E longitude with a total extent of 729.45 km^2.

The plains of Yamuna and Tons have low elevation (-7-33 m) than the North-western part of Bara tahsil which is occupied by rocks of Kaimur group, have the highest elevation ranging from 46 m to 129 m. The study area has tropical monsoon type of climate characterized by cool dry and invigorating winter and scorching and dusty summer. The population statistics of study region disclose that 51.22 % population of tahsil Bara is supported by development block of Jasra in spite of having only 25.11 % area of the tahsil of Bara rather than development block of Shankargarh which covers 47.82 % area of the tahsil of Bara (Mishra and Singh, 2017).

Database and Methodology

- **a)** L1C product of Sentinel-2 (Year-2017, tiles; T44RNN and T44RNP, Blue, Green, Red, NIR and SWIR 1 and SWIR 2 band (BGRNSS bands) composed satellite image dated 2016-2017, resolution- 10 m and 20 m), downloaded from https://earthexplorer.usgs.gov.
- **b)** Cartosat 2 DEM data (Year-2014, Resolution- 2.5 m) downloaded from nrsc.gov.in.
- **c)** 1:50,000 scaled toposheet of Survey of India.
- **d)** Google Earth imagery.
- **e)** ArcGIS v 10.2.2 and ERDAS IMAGINE v 2014 is used for image processing and analysis.

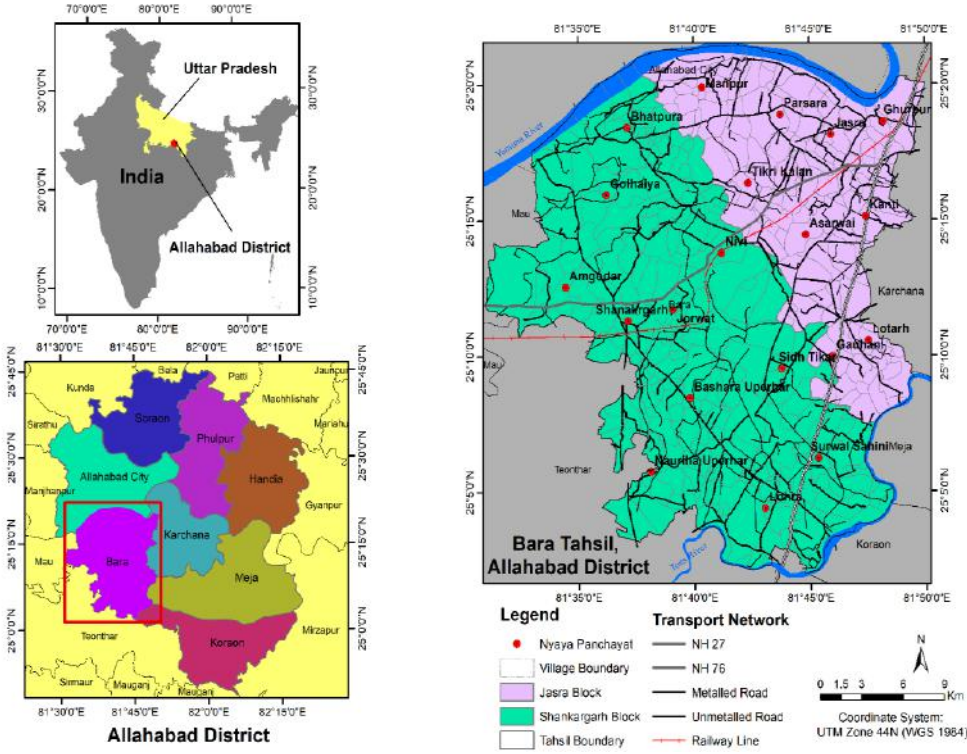

Fig. 1. Location of Study Area

Details of the Methodology is Discussed in the Following Section :

Preparation of Database

Solar radiation layer showing the total amount of incoming solar radiation within a year in unit of kWh/m^2 is generated from Cartosat DEM-2 Data. LULC map is prepared by transforming GRNSS stacked (green, red, NIR, SWIR1 and SWIR 2) Sentinel-2 image (dated 23 Feb. 2017) into the principal component image. First, four PCs representing 99.85 % information used as input for maximum likelihood classifier and further this

image is classified into 87 classes representing 5 type of LULC; cropland, fallow land, rocky and stony wasteland, water bodies, sandy area. Manually digitized AOI of the built-up area is generated from the Google earth. Signature of tree cover and scrubs is identified through analysis of multi-temporal NDVI stacked images (Oct. 2016-May 2017) having constant NDVI value (0.3-0.7) and Isodata classifier is performed on the Sentinel 2 image dated 14 May 2017 having blue, green red, NIR, and SWIR 1 band combination, when no crops were found on the field. Both tree cover and scrubs and built-up layer are overlaid on the classified image to get the pure land cover classes (Mishra, 2017). Transmission line and Road network are digitized from SOI toposheet and Google earth imagery respectively.

Establishment and Justification of Constraint / Unconstraint Factors

The constraint and unconstraint factors for the establishment of a solar power plant are presented in table 1. These factors are designed according to Solar power policy of UP Government-2014 and draft-2017, the ongoing court case of stone query and its adverse impact on society and environment, Prayagraj thermal power plant, and other technical parameters. These constraints / unconstraints factors are extracted from LULC map, slope map, aspect map, and transport and power transmission line proximity maps. A binary GIS file is created for each factor using the reclassifying tool, with cells falling within a constrained area assigned '0' and the rest of the assigned '1'.

Table 1 Constraint/Unconstraint Factors for Establishment of Solar Power Plant

Constraint Factors; SPP must not be within		**Reasons**
F1.	50 m from major road	Road encroachment
F2.	200 m from reserved forest area	Forest protection
F3.	Croplnad and fallowland area	Cropland protection from land lease
F4.	200 m from waterbody	Water resource protection
Unconstraint Factors; SPP must be within		
F5.	2000 m from major road	Transport Cost saving
F6.	In the wasteland area	Wasteland reclamation
F7.	1500 m from transmission line	Construction saving
F8.	Solar radiance more than 1550 kw	Technical
F9.	Slope surface with 0-15^0 degree topography	Technical
F10.	Solar aspect of South, SE, SW	Technical

The Solar Power Plant policy of Uttar Pradesh Govt. and draft policy clearly indicates that all the solar power plant should be established in the wasteland area for suitable use of these extensive inhabited lands, so F6 is according to solar legislation. The solar power plant should be away from nearby water-body, reserve forest, and cropland area to avoid its encroachment in these lands and to promote sustainable development in the region. During field visits and satellite analysis, it has been observed that Prayagraj thermal power plant has encroached about 3000 ha cropland area through the land lease. This encroached cropland area was only livelihood option for the local population. Also, the wetland area of this region has encroached for settlement expansion, consequently encourages water stress in the region. Hence, F2, F3 and F4 are set by the researcher

to avoid encroachment in water-body, cropland and forest area. F8, F9 and F10 are set by experts to exploit the best performance of solar panel in electricity generation. F1, F5 and F7 are set by policy-makers to lessen down construction cost through saving in road transportation and power-line transmission cost.

Standardised Layer Generation through Cost Distance Function

Installation of the solar power plant or any other industrial unit depends upon cost functions, investment cost will be increased if distances from road network and transmission line are increased as a financial investment will be required for additional road construction and transmission line establishment. Also, investment cost is more in a slight sloppy surface of wasteland area for fixation of rod angles to support a solar panel in the desired direction. Hence, all the factors are normalized using the cost distance tool of arc-gis, where each binary file are converted into standardized layers. These standardized layers have suitability index of scale ranges from 1 to 10, with 10 representing most desired site because of low cost and 1 representing most undesired site due to high cost, hence less preference is given to 1 value sites.

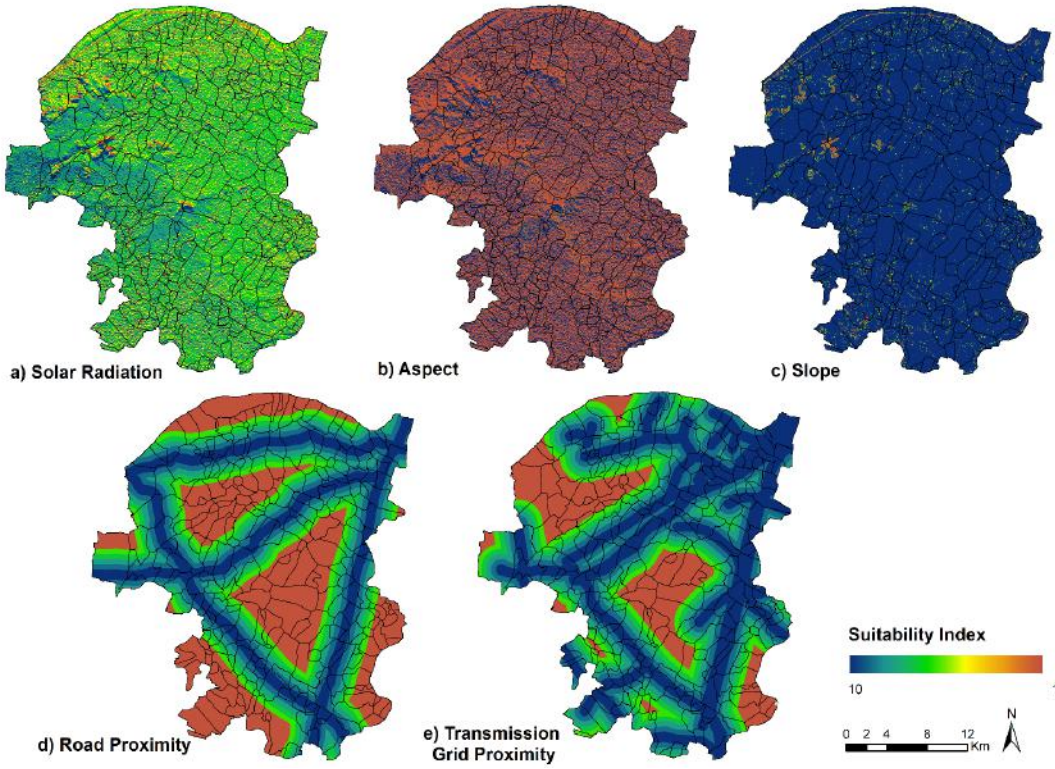

Fig. 2. Standardized Layers determined through Technical Factors and Cost Distance Function

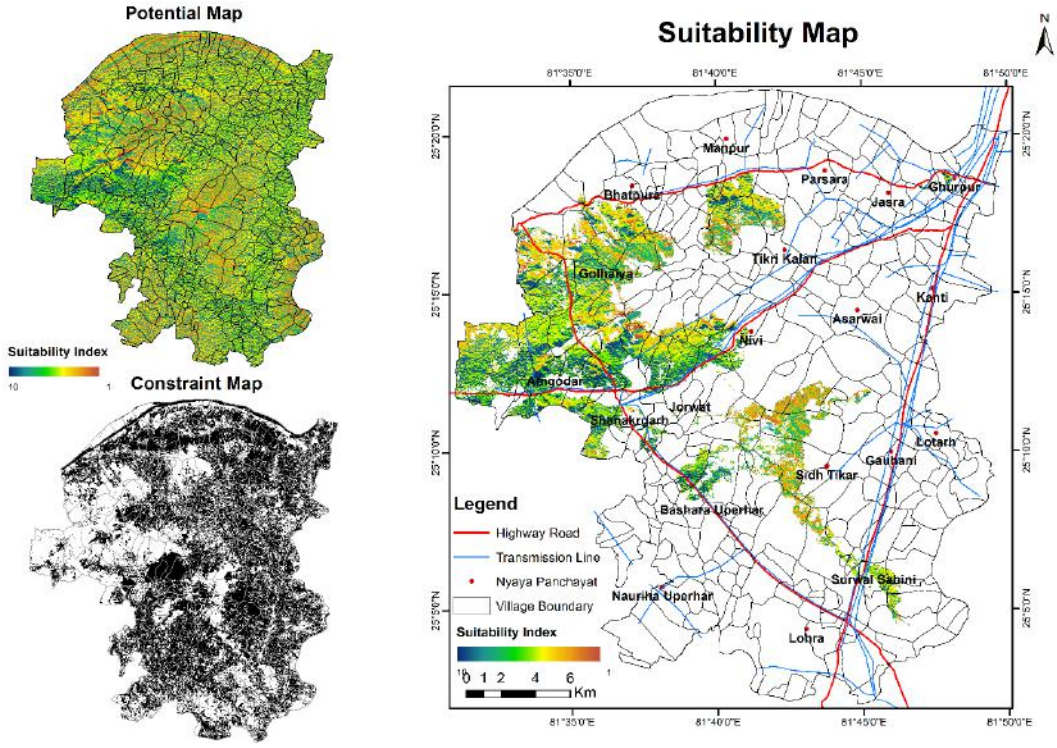

Fig. 3. Potential, Constraint and Suitability Map of Study Area for Installation of Solar Power Plant

Assignment of Weights through Saaty`s AHP Method

All the generated and standardized layers i.e. slope; aspect; transmission line; road network and solar radiation layer represent 5 parameters which are considered for installation of the solar power plant. The pairwise rank comparison matrix (PCRM) is generated in the Microsoft Excel sheet by assigning ranks to all these 5 parameters according to their relative importance using the 9 point rating scale of Saaty. In the Saaty`s 9 point rating scale, a score of 1 represents equal importance between two parameters and a score of 9 indicates the extreme importance of one parameter compared to the other one (Saaty, 1980) (table 2). Further, a weighted score for each parameter is derived from DAME add-in tool of excel sheet (table 2). The value of the consistency index (CI) was 0.0059. CI of 0.10 or less is acceptable to continue the AHP analysis and to check the consistency of the decisions i.e. given weight. Thereafter raster calculator of spatial analyst tool is used to integrate all the standardized layers according to their corresponding parameters. Thus potential region for the solar power plant is extracted by integrating five parameter layers i.e. global solar radiation, slope, aspect, road proximity, and transmission line proximity.

Table 2 Pairwise Comparison Matrix & their Corresponding Weight						
Criteria	Transmission Line	Highway Road	Aspect	Slope	Solar Radiation	Weight
Transmission Line	1	1/2	1/3	1/4	1/9	0.052223
Highway Road	2	1	1/2	1/3	1/4	0.093482
Aspect	3	2	1	1/2	1/3	0.153408
Slope	4	3	2	1	1/2	0.252696
Solar Radiation	9	4	3	2	1	0.448191
CI = 0.0059 < 0.1						

Identification of Suitable Region

The Suitability analysis involves overlaying of different GIS data according to study objectives and integration of these layers with exclusionary layers for planning restrictions. Further, the intersection method is used to find out the most suitable region for installation of the solar power plant, thereby GIS layer showing the potential region of solar energy production is combined with constraint factor layer i.e. omitting area of water body, reserve forest, cropland, built-up, stone quarry region and including only areas of wasteland.

Result and Discussion

Suitable Areas

The map of the potential region of solar energy production shows whole study region has excellent conditions for exploiting solar energy due to its geographical position and climatic conditions and hence expected to fulfill the national and state commitment of solar energy policy. It has insolation value of 1194 -1859 hours of the sunshine and 498.16 – 703.73 kWh/m^2/day of solar radiation. However, if considering constraint factors and unconstraint factors, approximately 17 percent (126.74 km^2) area of the study region is falls under the most suitable region for installation of the Solar power plant. Thus, the total capacity of the study region is 5703.3 MW if 1 km area has installed capacity of 46 MW. This area is characterized by a very low population density with scattered settlement in small places, often isolated. This suitable region is distributed in the villages of Janwan, Bankipur, Surwal Sahini, etc. (Figure 4).

Expected Impact on Economic Landscape

1) If solar power plant can ensure legally to share their profit with landowners through share participation, then it will enable landowners to earn a fixed amount of income from their unused, abandoned or uncultivated land.
2) The establishment of the solar power plant can increase the tax base of the region which can be utilized for infrastructure development, social service provisions and wasteland reclamation for agriculture activities, etc.
3) The solar power plant generates electricity in a renewable way, which is helpful to reduce carbon emission and to combat climate change in the long term.

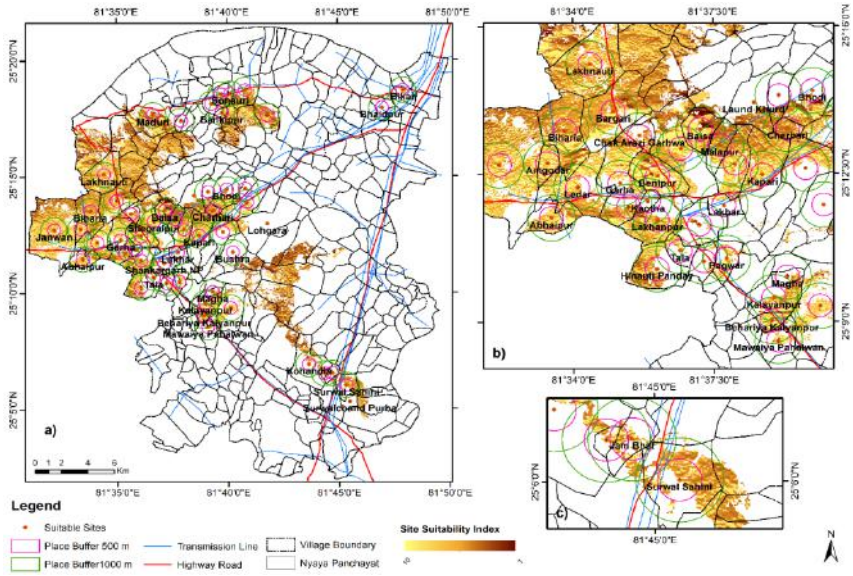

Fig. 4. Suitable Sites of Solar Power Plant in the Study Area

4) Solar energy will provide energy efficiency through its use in solar pumps, cold storage, warehouse, glass and ceramic industries, which enables energy independence in village areas.
5) Establishment of the solar power plant will promote the road connectivity in the region, which further enhances the business activity in the region.
6) The excess power also can be transmitted to nearby city area, which will create energy revenues.
7) The solar power plant will be a game changer like the (Prayagraj thermal power plant) in the development of wasteland area through efficient use of the wasteland, road construction, 24x7 hour energy supplying and lots of skilled and unskilled job creation. Thus, the installation of a solar power plant in the study area will open a huge scope for the development of small scaled industries, agro-based industries, and other business activities. All these development will further create huge job opportunity in the village.
8) The wasteland area has limited groundwater storage due to low permeability that is the result of the solid and consolidated rocky structure of sandstone and quartzite. Moreover, this region also being exposed to the impact of climate change. Evaporation of surface water and vegetation transpiration is increased with increasing temperature, which can be seen through the dried water-bodies and pale grassland in the summer season. Consequently, precipitation amount, variability and intensity are changed which will directly impact the flux and storage of water in the reservoir; lake, ponds, canals, soil and groundwater. Greater rainfall variability can be seen through low groundwater level and saline intrusion in aquifers in summer. Hence, water resources conservation and management (rainwater harvesting, water use efficiency in irrigation, water metering, etc.) will be promoted by the solar power plant on a large-scale while combating with water scarcity.

9) Nowadays, in the region, electricity is generated at Prayagraj thermal power plant and it causes a lot of damage to the environment. So if the study region has a capacity of solar energy then it should be tapped instead of going for imported coal. Moreover, the use of solar energy will reduce CO_2 emission which will be helpful in climate change mitigation.
10) Tribal population of Shankargarh region, whose large part involved in stone querying and wage work activities, is still struggling to fulfill their basic needs; food, clothes, education, house and medicine. Installation of the solar power plant can be able to remove absolute poverty of the region in coherence with the right government policies through changing the economic opportunity of the region.
11) The energy produced at this station can be provided at nearby city area and in public transportation. If metro rail corporation develops a metro railway line in the district of Allahabad then generated energy can be used to operate the metro station and to run a metro train which will further enhance development here.

Key Challenges

Even though Bara tehsil offers good solar radiation and land required for plant installation it also supposed to key challenges; (1) the wasteland and long fallow-land area of study region offer best land requirement for solar power plant establishment. A solar power plant having 10 MW electricity production capacity requires at least more than 0.21 km^2 of land with even terrain and the total wasteland area of Bara tehsil is 20.11 % (145.83 km^2) to total geographical area. Hence, this area can attract a large part of investment related to solar energy deployment; (2) 750 MW enabled solar power plant will be established at an investment of Rs 45,000 million and spread in an area of nearly 16 km^2. (3) Solar panels mounted at the solar power plant are required to clean twice in a month for a better power yield generation. Hence, water resource management becomes significant in the wasteland area which already facing the problem of water scarcity during the peak summer season. (4) The solar power plant will require better road connectivity for the accessibility of the plant and for smooth, timely and cheaper movement of solar power plant workers. Besides the villages connected to NH 27, wasteland area of Bara tehsil still facing poor and uneven road connectivity which hampers smooth movement and accessibility in the region.

Conclusion

Thus, in the present study, the important parameters in raster form are standardized and integrated into raster calculator according to their corresponding weight, which are derived from the AHP method of Saaty. Further, suitable regions are extracted through the intersection of potential and constraint factor layer. However, standardization criteria and weight to each criterion are flexible, which can be changed and adapted according to economic and technical viability or according to social and environmental concerns, whichever gets more preferences in the collaborative decision of government`s policymakers, investors, and local villagers. However, the result reveals that the study region has appropriate insolation conditions (498.16–703.73 KWh/m^2/day) along with vast

wasteland area (145.83 km^2) for deployment of a photovoltaic plant. The deployment of the solar power plant will create an opportunity for infrastructure development and employment generation at the local level. The geographic tie with Jasra block characterized with groundwater rich floodplain could enable installation of the solar power plant in wasteland area of Shankargarh block.

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ELECTORAL DELIMITATION AND GEOGRAPHY OF REPRESENTATION IN RESERVED CONSTITUENCIES OF RAJASTHAN : A STUDY IN SOCIAL GIS

Seema Jalan

Department of Geography, Mohan Lal Sukhadia University, Udaipur - 313 001
E-mail: seemajalan1@gmail.com

Abstract

Political empowerment is often conceived as an effective road to the socio-economic development of backward sections of population. The present paper evaluates the electoral boundaries of SC/ST reserved assembly constituencies of 10 districts of north east Rajasthan for their conformity to spatial pattern of distribution of SC/ST population in the region in light of constitutional mandates and guidelines of delimitation. The study demonstrates a robust methodology based on GIS for preparation and evaluation of electoral delimitation plans. GIS capabilities of dynamic mapping, map overlay and spatial statistics have been effectively used to assess the degree to which electoral boundaries of reserved constituencies encompass the SC/ST concentration regions. It has been found that location of reserved constituency boundaries significantly deviates from spatial pattern of distribution of SC/ST population in the region which has deprived a large segments of these population groups from due representation in the legislature. Existing lacunae in the delimitation process have also been identified.

Keywords: GIS, Electoral delimitation, Reserved constituencies, Spatial statistics, Assembly elections

Introduction

Delimitation literally means the act or process of fixing boundaries of territorial constituencies in a democratic State for purpose of electing representatives with reference to a unit of election - the national parliament, the State legislature or the local self-governing bodies. In single member pluralistic representative systems like India, the geography of welfare in a region is largely determined by the government's policies and priorities. Since the complexion of the government or *geography of representation* is a direct derivative of party preference of voters, the policies undertaken by the governments are often ones which are most suited to the particular ends of groups in power. The nature of the government – the spatial bases of support to the ruling party – is the chief determinant in the 'where' part of the central question 'who gets what and where' (Dikshit, 1995).

High quality redistricting plans provide representation to the broadest array of demographic groups possible (Webster, 2013). Several studies have held that in India

caste and religion are the most important determinants of party support (Chibber, 1999). Hence it is absolutely necessary that constituency boundaries are so drawn that all population groups, particularly the backward sections of the society, get adequate representation in the legislature. Underlining the extreme sensitivity of the task of electoral delimitation Singh (2000) cautions that enclosing within or dividing people across constituency framework without understanding the human geography of the area can divide up people who may in effect lose their voice in the legislature.

Electoral studies have been a grossly neglected sphere in Indian political geography during the past two decades. The objective of 'geography of voting' and 'areal' approach has consistently dominated the countable few studies that have been undertaken viz. Dikshit & Sharma (1993), Sharma & Chand (2004), Gurjar & Jalan (2002) and Jalan (2006) (for detailed review of hitherto trends in Indian electoral studies see Jalan, 2009). Pioneering studies towards evaluation of electoral boundaries in India have been made by Sharma (2003) and Jalan (2015).

The Philosophy and Process of Delimitation of Reserved Constituencies in India

Political empowerment is conceived as an effective road to the socio-economic development of backward sections of population. The Constitution of India has recognizes the potential import of adequate electoral representation for these historically underprivileged and deprived population groups in Articles 330 and 332, and has ensured adequate representation for Scheduled Castes (SC) and Scheduled Tribes (ST) in governing bodies through reservation of seats in the House of the People (allocated to States/ Union Territories) and State Legislative Assemblies respectively in conformity with their proportion to total population of the State/ Union Territory.

Subsections (c) and (d) of Section 9 (1) of the Delimitation Act, 2002 (Delimitation Commission of India, 2008[1]) prescribe the manner in which the reserved seats are to be geographically distributed across the State. Subsection (c) of the said act provides for distribution of seats reserved for SCs "in different parts of the State and located, as far as practicable, in those areas where the proportion of their population to the total is comparatively large". Subsection (d) lays down that "constituencies in which seats are reserved for STs shall, so far as practicable, be located in areas where the proportion to the total is the largest". The phrase 'so far as practicable' accounts for the constraints of equal population, geographical compactness, natural barriers, administrative contiguity and cohesiveness, facilities of communication and public convenience common to delineation of reserved as well as unreserved assembly constituencies (ACs) (Delimitation Commission of India, 2008[2]). The objective here is to provide effective representation to largest possible strength of SC/ST population.

Detailed process of allocation of SC/ST seats has been prescribed in Section VII of the *Guidelines and Methodology* formulated by the Delimitation Commission (Delimitation Commission of India, 2008[3]). In order to fulfil the requirements of Section 9 (1) (d), first all the ACs in the State have been delimited, and subsequently those constituencies where the

percentage of the ST population to the total population of the constituencies is the largest are reserved, in descending order, equal to the requisite number of ST constituencies. To comply with the provisions of Section 9 (1) (c), the number of seats to be reserved for SCs has been worked out separately for each district as the same proportion to the total number of SC reserved ACs in the Legislative Assembly of the State as the proportion of SC population in the district to the total SC population in the State. SC seats are reserved in those constituencies in the district in which the percentage of SC population to total population is the largest, in descending order equal to the number of SC seats in the district. Nevertheless, wherever three or more SC ACs were contiguous to each other or with the adjoining district, one of those was dereserved and the AC with the next higher percentage of SC population has been reserved for SCs. In Rajasthan, the lowest administrative unit to be kept undivided during delimitation is Patwar Circle (PC).

Research Problem: Representation vs. Effective Representation

The boundaries of electoral constituencies in India are periodically redrawn on the basis of last published census figures by an independent non-political statutory body –the Delimitation Commission- which executes this task in accordance with the prescribed constitutional guidelines. The main objective of periodic delimitation exercise is to rationalise the population structure as well as composition of electoral constituencies by delineating equi-populous constituencies.

In India, and alongside in Rajasthan, the parliamentary and AC boundaries have been recently revised under the Delimitation Act, 2002 on the basis of population of 2001 Census. The recommendations of the Commission have become effective since 19th February, 2008.

Merely establishment of guidelines does not necessarily guarantee fairness in the process of redistricting (Busteed, 1975). Similarly equality of population totals between constituencies does not necessarily imply equal opportunity of representation to all population groups comprised therein. A close scrutiny of the revisions and changes in the boundaries of assembly segments of Rajasthan made under Delimitation Act, 2002 indicates that administrative considerations have often taken precedence over other more significant criteria during the process of deciding the location of boundaries.

Apparently, the methodology adopted for delimitation of reserved constituencies is mathematically robust to the extent of allocating SC/ST seats in proportion to their respective share in total population and to constituencies having largest population of respective population groups. Ironically, the actual implementation of guidelines overlooks *effectiveness of representation* and lack provisions to ensure that maximum possible masses of SC/ST population get political representation and that the location of reserved constituency boundaries practically conforms to spatial patterns of their concentration.

In view of the momentous role that political representation plays in socio-economic empowerment of the underprivileged and marginalized segments of population, the present

paper scrutinizes the delimitation of SC and ST constituencies of ten districts located in north eastern part of Rajasthan State made under the Delimitation Act, 2002 for their conformity to spatial distribution of SC/ST population in the region in light of prescribed guidelines, principles and constitutional mandates of delimitation. The extent to which guiding principles followed during the process of delimitation serve to provide effective representation to maximum possible SC/ST population has also been examined.

The study establishes the potential utility of GIS for preparation and evaluation of electoral delimitation plans. A simple yet effective methodology based on GIS capabilities of dynamic mapping, map overlay and spatial statistics has been demonstrated for delineation of reserved constituency boundaries in such a manner that efficacy of representation is maximised.

Study Area

The study area comprises reserved ACs of 10 districts located in north eastern part of Rajasthan State namely Jhunjhunu, Sikar, Jaipur, Alwar, Bharatpur, Dhaulpur, Karauli, Sawai Madhopur, Tonk and Dausa (Figure 1).

As per Census 2001 the total population of the study area was 20.39 million which constituted 36.08 percent of total population of Rajasthan. Choice of the region has been guided by substantial concentration of SC as well as ST population in these districts comprising contiguous regions of high concentration of both SC and ST population. Out of State's total, 37.5 percent SC population and 26.17 percent of ST population resided in the study area in 2001. Jaipur followed by Dausa, Karauli, Sawai Madhopur and Alwar districts ranked among the top ten districts in terms of proportion of their ST population to total ST population of the State. Jaipur, Alwar and Bharatpur districts ranked among the top ten districts in terms of proportion of SC population to total SC population of Rajasthan. Both SC and ST populations comprised more than 20 percent of district's total population in Dausa, Karauli and Sawai Madhopur districts.

In 2001 SC and ST populations comprised 17.16 and 12.56 percent of the total population of Rajasthan. Accordingly 34 and 25 seats out of total 200 assembly seats in State Legislative Assembly have been reserved for SC and ST respectively in Delimitation of 2002. Prior to delimitation 12 and 6 assembly seats in the study area were reserved for SCs and STs respectively which have increased to 14 and 7 after delimitation.

Database and Methodology

Geospatial database along with cartographic and analytical capabilities of GIS implemented in ArcGIS version 10 forms the basis of study. Nature and type of data used has purely been guided by the prescribed constitutional guidelines of delimitation.

The data used may broadly be categorised under two heads: (1) spatial, and (2) aspatial data. Spatial data includes village boundary vector maps of the ten districts. Aspatial data broadly comprises of three types of information: (1) village wise census data

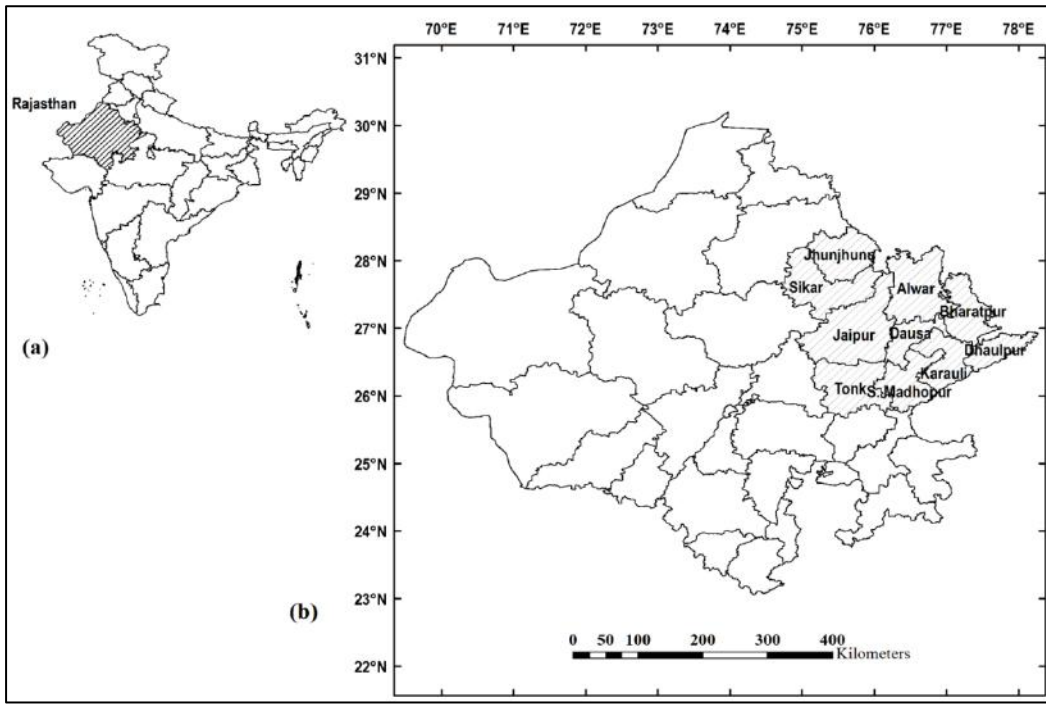

Fig. 1. Study area (a) Location of Rajasthan in India (b) Location of Study Area in Rajasthan

of 2001- primarily total population and SC/ST population; (2) administrative jurisdiction of each village at PC, Inspector Land Revenue Circle (ILRC), Tehsil and District levels; and (3) pre and post delimitation electoral jurisdiction of each village in terms of AC (Source: ECI, 1976 & 2008). Population data of Census 2001 has been used in the study since the same has been used by the Delimitation Commission for demarcation of constituency boundaries.

Village wise census database with administrative and electoral jurisdiction of each village was *joined* to village boundary vector shape file. Administrative boundary maps at PC, ILRC, Tehsil and district level, pre and post delimitation AC maps with population statistics were generated by *dissolving* village boundary to respective levels. SC and ST population distribution was mapped at various administrative scales using interactive and dynamic mapping capabilities of GIS.

Simply mapping the proportions does not provide a real picture of the distribution of the phenomenon. If the attribute is simply mapped the classification method used, the number of classes and the class ranges selected all affect whether a pattern is apparent or not. Statistical tools of pattern analysis - the spatial statistics indices embedded in GIS - use the underlying value of each feature for identification of patterns, thus use of statistics gives us confidence that what looks like a cluster really is a cluster (Mitchell, 2009). The spatial statistics tools fall into two categories: (1) Global statistics, and (2) Local statistics. Global methods identify and quantify the pattern created by features in the study area as a whole.

Local statistics identify the relationship between individual features and their neighbouring features, thus enables identification of clusters of features. The z-score and p-values represent the statistical significance of computed index values.

Getis-Ord General G statistic (henceforth abbreviated as G-statistic) has been used to measure nature of distribution and degree of overall clustering of SC/ST population. G-statistic (Anselin, 1995; Getis and Ord, 1992) is a global pattern index which measures degree of concentration of high (hot spots) and low values (cold spots) in the study area. A large value of G indicates that high attribute values are found together, while a small value indicates clustering of low values. A small and statistically significant p-value indicates statistical significance of the results. The magnitude and sign of z-score value indicates direction and intensity of clustering. A z-score near zero indicates no apparent clustering. A positive z-score indicates clustering of high values. A negative z-score indicates clustering of low values (ArcGIS help).

Within the study area statistically significant clusters of high and low SC/ST concentration (hot spots and cold spots respectively) have been identified at all administrative scales using Hot Spot Analysis (Getis-Ord Gi* statistic). The tool returns a Gi* local statistic, z-score value and a p-value for each feature which together indicate whether the observed spatial clustering of high and low values is more pronounced than one would expect in a random distribution. Statistically significant high positive Gi* z-score values represent clusters of administrative units having high proportion of SC/ST population. Negative Gi* z-score values represent cold spots i.e clusters of administrative units having low proportion of SC/ST population. The higher or lower the z-score, the more intense is the clustering. A z-score near zero may result due to no apparent spatial clustering either because surrounding values are near the mean proportion or when the target feature is surrounded by a mix of high and low values.

Pre delimitation and post delimitation AC boundary maps have been overlaid on SC/ST distribution and spatial concentration maps (prepared by mapping local Gi* z-score values) to assess the conformity between reserved constituency boundaries and SC/ST concentration areas. The analysis has been restricted in scope to the reserved constituencies only.

Discussion and Analysis

Both SC and ST reserved seats in the study area have increased in number after delimitation. The constituencies have undergone boundary changes to varying extents ranging from being retained intact through minor changes to major boundary revisions, change in reservation status, being dissolved, newly created or re-constituted. Nevertheless, it is difficult to identify any common explanation to the nature of changes that have been made. Fig. 2 illustrates the pre delimitation and post delimitation distribution of SC and ST reserved ACs in the study area.

Efficacy of SC/ST Representation: Pre Delimitation vs Post Delimitation

Status of SC Representation

Prior to delimitation there were 12 SC seats in the study area. These were Surajgarh in Jhunjhunu district, Lachhmangarh in Sikar district, Dudu and Phagi in Jaipur district, Niwai in Tonk district, Dausa in Dausa district, Khairthal and Kathumar in Alwar district, Weir and Rupbas in Bharatpur district, Hindaun in Karauli district and Khandar in Sawai Madhopur district. Six of these seats - Dudu, Niwai, Kathumar, Weir, Hindaun and Khandar - have been retained as SC constituencies after delimitation with revised boundaries.

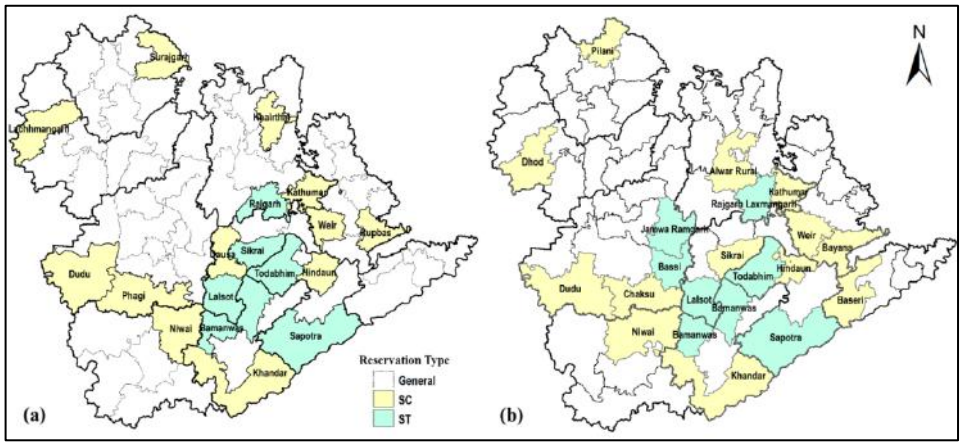

Fig. 2. Distribution of SC and ST Constituencies (a) Pre Delimitation (b) Post Delimitation

Surajgarh, Lachhmangarh and Dausa have been retained but dereserved and Pilani, Dhod and Sikrai have been reserved for SCs in their place. In Jaipur district Phagi has been reconstituted as Chaksu SC constituency, and newly constituted Bagru constituency has also been reserved as SC constituency. Khairthal and Roopbas constituencies have been dissolved. Alwar Rural, a newly created constituency, and Bayana, after major boundary revisions, have been reserved for SC. SC seats are well distributed across the region with all districts having at least one SC seat. Nevertheless, two sets of five contiguous SC constituencies exist - (1) Kathumar, Weir, Bayana, Hindaun and Baseri; and (2) Bagru, Dudu, Chaksu, Niwai and Khandar - in excess of accepted maximum limit of two within or across the districts, which violates the adopted norms for location of SC seats.

Prior to delimitation the 12 SC seats provided representation to 7.4 percent of the total SC population of Rajasthan and 19.73 percent of the total SC population of the study area. The 14 SC seats, 40 percent of the total SC seats in the State Legislative Assembly provide representation to 9.12 percent of total SC population of Rajasthan and 24.33 percent of total SC population of the study area. Thus considerable discrepancy exists between representation in terms of number of seats in State Legislative Assembly and actual proportion of population being represented.

Table 1. Proportion of SC /ST Population in SC /ST Reserved Constituencies Before and After Delimitation

A. SC Constituencies				B. ST Constituencies			
Post Delimitation		Pre delimitation		Post Delimitation		Pre delimitation	
AC name	% SC	AC name	% SC	AC name	% ST	AC name	% ST
Hindaun	29.71	Hindaun	29.27	Lalsot	37.35	Lalsot	37.35
Weir	27.33	Weir	27.07	Sapotra	34	Sapotra	36.46
Bayana	26.29	Roopbas	26.52	Bassi	31	...	...
Khandar	24.56	Khandar	24.42	Jamwa Ramgarh	29.85	...	...
Bagru	23.61	...		Todabhim	29.26	Todabhim	30.72
Alwar Rural	22.26	Khairthal	20.69	Bamanwas	28.96	Bamanwas	30.79
Kathumar	22.17	Kathumar	22.12	Rajgarh-Laxmangarh	27.91	Rajgarh	33.23
Sikrai	22.07	Dausa	21.28			Sikrai	24.3
Niwai	21.21	Niwai	21.13				
Baseri	21.03	...					
Chaksu	20.62	Phagi	20.83				
Pilani	19.46	Surajgarh	19.22				
Dudu	19.31	Dudu	18.6				
Dhod	17.55	Lachhmangarh	17.32				

Table 1(A) compares SC representation in SC reserved constituencies before and after delimitation. SC population does not form even one- third of the population size of constituencies especially reserved to safeguard their interests and their strength has seen no significant improvement after delimitation too. Even after the major boundary changes, reconstitution of existing and creation of new SC constituencies, there has been only marginal increase in the relative proportion of SC population getting representation in reserved constituencies. In Bayana and Chaksu the proportion of SC population has declined after delimitation. If viewed in the light of constitutional mandate of 'reserving SC seats in those areas where the proportion of their population to the total is comparatively large', the spirit of creating SC majority constituencies seems to have been diluted.

Status of ST Representation

Before delimitation the 6 ST seats in the study area were Rajgarh in Alwar district, Lalsot and Sikrai in Dausa district, Todabhim and Sapotra in Karauli district, and Bamanwas in Sawai Madhopur district. After delimitation Lalsot has been retained without any change in boundaries while Todabhim, Sapotra and Bamanwas have been retained with minor boundary revisions. Rajgarh has been reconstituted as Rajgarh-Laxmangarh. Sikrai has been converted into SC constituency. Bassi and Jamwa Ramgarh, general seats before delimitation, have been converted to ST seats after major boundary revisions.

Similar to status of SC representation, the delimitation has not paid any significant dividends in terms of strengthening ST representation in the region. The 7 (28 percent of total ST seats) ST constituencies together provide representation to 8.56 percent of total ST population of Rajasthan and less than one third (32.73 percent) of the total ST population of the study area which is approximately 5 percent higher than pre delimitation.

Prior to delimitation proportion of ST population in ST reserved constituencies ranged between 24.35 percent in Sikrai to 37.35 percent in Lalsot (Table 1B). After delimitation too Lalsot having been kept intact ranks first. Thus similar to SC constituencies STs form a minority in all ST constituencies. Notably ST representation has declined consequent upon delimitation in all other ST constituencies, maximum being in Rajgarh-Laxmangarh (approximately 5 percent). ST representation in newly designated ST seats- Bassi and Jamwa Ramgarh - is also not very promising. It is pertinent to mention here that absolute ST population of Sikrai is 76209 which is substantially higher than that of Bassi and Jamwa Ramgarh and is also larger than its SC population. Still Sikrai has been converted to an SC constituency.

Thus, considerable gap exists between the theory and practice of ST representation in the region. The constitutional mandate of reserving ST seats in 'areas where their population to the total is largest' aims to safeguard the interests of maximum possible ST population through political representation. But delimitation has visibly fallen short of its objectives.

Spatial Distribution of SC/ST Population and Location of Electoral Boundaries

The observed discrepancies and gaps have primarily resulted from the methodology adopted by the Commission for allotment of SC and ST seats to constituencies. Spatial distribution of SC and ST population is not considered prior to demarcation of boundaries of SC/ST constituencies. First boundaries of all constituencies are finalized and subsequently SC/ST seats are allotted on the sole basis of proportion of SC/ST population without adopting any lowest threshold, resulting into SC/ST minority constituencies. The process has not only deprived large sections of SC/ST population from due electoral representation but has also diluted their political negotiation power by splintering their concentration areas to join with majorities of unreserved sections of population. The following sections examine the reserved constituency boundaries in light of SC/ST concentration areas.

SC Reserved Constituencies

Table 2A shows the G-statistic of SC distribution at PC, ILRC and tehsil level. Fig. 3 shows the spatial distribution of SC population as percentage of SC population to total population of respective administrative unit at PC (Fig. 3a), ILRC (Fig. 3b) and Tehsil (Fig. 3c) level overlain by post delimitation AC boundaries. Results of Hot Spot Analysis have been presented in Fig. 3 (d to f) which illustrate the conformity between SC constituency boundaries and hotspots of SC concentration.

The choropleths of SC proportions indicate a more or less even distribution of SC population across the region at all administrative levels. Nevertheless concentration strengthens at lower administrative levels. Relatively high concentrations occur in southern part of Jaipur District (Phagi and Chaksu tehsils), north eastern part of Tonk District (Peeplu

and Niwai tensils), Bonli and Khandar tehsils of Sawai Madhopur District, scattered pockets of Kishangarh Bas and Kathumar tehsils of Alwar district, and almost entire Dausa, Karauli, Bharatpur and Dholpur district

Table 2. G-Statistic for SC and ST Population Concentration

Administrative Level	A. SC Distribution			B. ST Distribution		
	G value	Z-score	p-value	G value	Z-score	p-value
Patwar Circle	0.002	7.09	0	0.005	21.46	0
ILRC	0.015	5.11	0	0.033	13.75	0
Tehsil	0.069	2.07	0.04	0.156	6.43	0

At tehsil level proportion of SC population ranges from 7.66 percent to 29.27 percent, which accentuates to a lowest at complete absence of SC population to a highest of 97.9 percent at PC level. Particularly high concentrations occur in six PCs - Dolada, Nizamnagar, Nagla Khokla, Helak Ji, Mahendwara (60 to 70 percent SC population) and Rundh Rupbas (97.9 percent SC population). Out of these only two- Dolada and Rundh Rupbas form part of SC constituencies.

Increasing clustering of high SC proportions at lower administrative scales is also corroborated by increasing strength of G-statistic from tehsil to PC level. This underlines the need to consider SC distribution at PC level while determining the boundaries of SC constituencies.

Contrary to the picture presented by simple mapping of proportions Hot Spot Analysis reveals that clear pockets of SC concentration exist in the region. Two contiguous hot spots spread across southern Bharatpur, eastern Dausa, Karauli and western part of Dholpur districts, and southern part of Sawai Madhopur district. The contiguity of high concentration areas presents a convenient distribution pattern to be divided into SC majority constituencies.

A close scrutiny of location of SC constituency boundaries and pockets of SC concentration reveals considerable discrepancy between the two. Apparent causes of departures may be summarized under four major observation heads:

1. Adherence to higher level administrative boundaries (higher than PC) has resulted into SC constituency boundaries cutting across SC dominated areas. This is particularly evident in case of Alwar Rural, Weir, Bayana, Niwai and Khandar constituency. For example, Khaithal and Harsoli ILRCs of Kishangarh Bas tehsil of Alwar district form a significant hot spot of SC concentration at PC level. At tehsil level Kishangarh Bas tehsil is one of the pockets of highest SC concentration in the district. During delimitation, overemphasis has been placed on administrative cohesiveness of constituencies at highest possible administrative level. The boundaries of Alwar Rural and Khairthal constituencies has been made co-terminus with tehsil boundaries. Consequent upon reconstitution of the constituencies and dereserving Khairthal the SC

2. dominated PCs have been included in a general constituency despite being spatially contiguous to newly created Alwar Rural SC constituency. Similarly Niwai constituency has been made co- terminus with Niwai and Peeplu tehsils after delimitation. Demarcation of boundaries at tehsil level has practically excluded a statistically significant SC hotspot comprising PCs of Hatauna, Tonk and Ghas ILRCs of Tonk tehsil from Niwai SC constituency, despite being contiguous to it. Notably both the above mentioned SC hotspots were formerly parts of respective SC constituencies.
3. Adherence to higher level administrative boundaries (higher than PC) has resulted into SC constituency boundaries cutting across SC dominated areas. This is particularly evident in case of Alwar Rural, Weir, Bayana, Niwai and Khandar constituency. For example, Khaithal and Harsoli ILRCs of Kishangarh Bas tehsil of Alwar district form a significant hot spot of SC concentration at PC level. At tehsil level Kishangarh Bas tehsil is one of the pockets of highest SC concentration in the district. During delimitation, overemphasis has been placed on administrative cohesiveness of constituencies at highest possible administrative level. The boundaries of Alwar Rural and Khairthal constituencies has been made co-terminus with tehsil boundaries. Consequent upon reconstitution of the constituencies and dereserving Khairthal the SC dominated PCs have been included in a general constituency despite being spatially contiguous to newly created Alwar Rural SC constituency. Similarly Niwai constituency has been made co- terminus with Niwai and Peeplu tehsils after delimitation. Demarcation of boundaries at tehsil level has practically excluded a statistically significant SC hotspot comprising PCs of Hatauna, Tonk and Ghas ILRCs of Tonk tehsil from Niwai SC constituency, despite being contiguous to it. Notably both the above mentioned SC hotspots were formerly parts of respective SC constituencies.
4. Even at lower administrative levels the constituency boundaries have been arbitrarily determined without consideration for SC concentration areas as in Kathumar, Baseri and Hindaun constituencies. For example, revisions made at ILRC level in Kathumar constituency have combined SC minority Khudiyana and Moliya ILRCs of Laxmangarh tehsil in Kathumar. On the other hand the statistically significant contiguous hot spot comprising PCs of ILRC Baroda Meo, including Nizamnagar PC, of the same tehsil has been excluded and merged with Ramgarh, a general constituency. Vast difference exists in population size of Kathumar and Ramgarh ACs. Inclusion of ILRC Baroda Meo in Kathumar constituency would have balanced the voting power of both constituencies. Similarly, boundaries of newly constituted Baseri SC constituency have excluded SC dominated PCs of Kasba Bari and Talab Shahi ILRC adjoining Baseri, even when boundaries have been carved at ILRC level. Large population difference exists between Bari and Baseri AC, Baseri being underpopulated.
5. Dereserving of former SC constituencies viz. Surajgarh, Khairthal and Dausa has deprived SC population of the region from due representation. The newly reserved constituencies lack justification in terms of enhanced representation. Farat, Bhaothari and Jakhod PCs form the only hot spot of SC concentration in Jhunjhunu district. These PCs were earlier part of Surajgarh SC constituency. Surajgarh has been dereserved and these PCs are now part of a general constituency despite being contiguous to

Pilani SC constituency. Notably, Pilani is much underpopulated than Surajgarh. Similar dilution of SC representation has occurred in Dausa and Baniyana ILRCs of Dausa tehsil which forms one of the highest SC concentration pockets of Dausa district and is part of Dausa constituency, formerly SC and converted to general seat after delimitation.

6. Inherent contradiction in methodology and districtwise allotment of SC seats in proportion to SC proportion without due regard to SC distribution and concentration has resulted in allotment of SC minority Dhod constituency in Sikar district despite of the fact that no significant hot spot of SC concentration exists in the district at any administrative level. On the other hand contiguous large pockets of SC concentration of Bharatpur and Dausa districts are bereft of due representation.

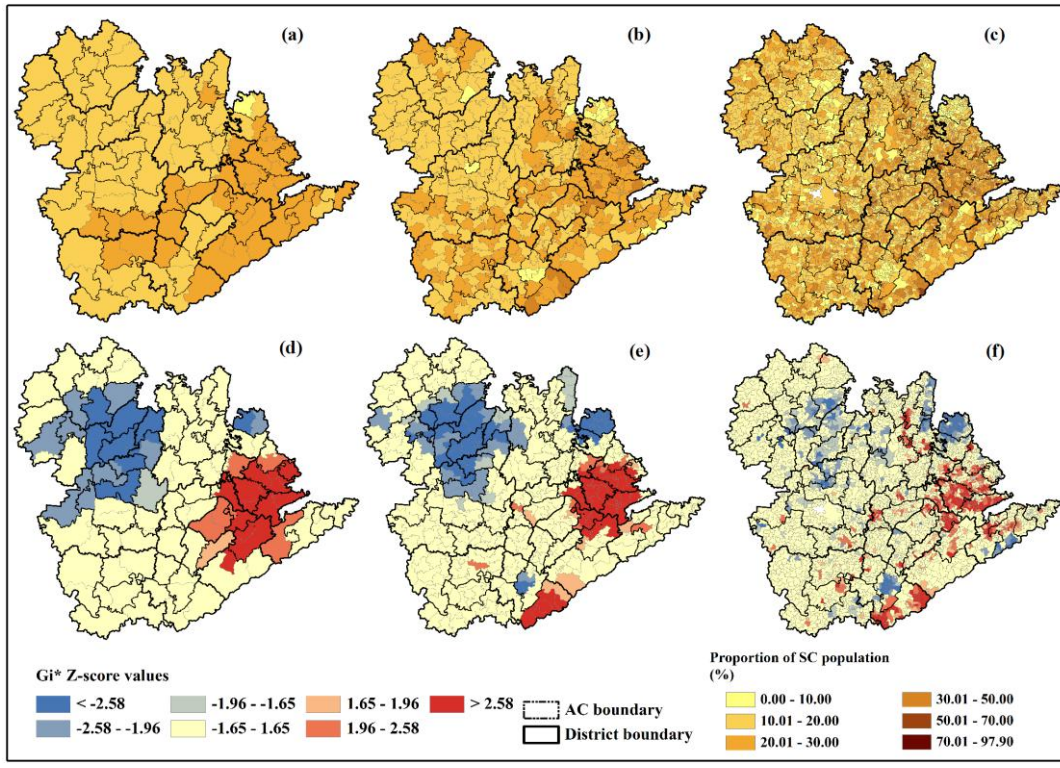

Fig. 3. Conformity Between Post Delimitation SC Constituency Boundaries and SC Population Distribution (a) Distribution at Tehsil Level (b) Distribution at ILRC Level (c) Distribution at PC Level (d) Hotspots at Tehsil Level (e) Hotspots at ILRC Level and (f) Hotspots at PC Level

ST Reserved Constituencies

Table 2B shows the G-statistic of ST distribution at PC, ILRC and tehsil level. Spatial distribution of ST population at various administrative levels overlain by post delimitation AC boundaries has been illustrated in Figure 4 (a to c). Results of Hot Spot

Analysis at PC, ILRC and tehsil level have been presented in Figure 4 (d to f). Jhunjhunu, Sikar, Bharatpur and Dholpur districts have been excluded from the analysis owing to insignificant concentration of ST population in these districts.

ST population is extremely clustered in the region at all administrative scales. Pockets of highest concentrations are fairly contiguous at tehsil as well as ILRC and PC levels which present a very convenient distribution pattern to be enclosed as ST majority constituencies within the prescribed administrative constraints. Jamwa Ramgarh, Bassi and Chaksu tehsils of Jaipur district, southern Alwar (especially Rajgarh and southern part of Thanagazi tehsils), parts of Deoli and Uniara tehsils of Tonk district, southern and eastern parts of Dausa district (especially Lalsot, Dausa and contiguous pocket of Baswa and Mahuwa tehsils), and major part of Sawai Madhopur and Karauli districts are areas of highest concentration of ST population. Clustering is strongest at PC level. At tehsil level proportion of ST population ranges between 0.21 to 38.5 percent which is accentuated to 0.00 to 91.96 percent at PC level. In 38 PCs ST population is more than 70 percent, while in about 200 PCs ST proportion is higher than 50 percent.

Magnitude of z-score values of G-statistic also manifests increasing spatial concentration at lower administrative levels. Hence it is imperative to consider ST distribution at PC level while delineating ST constituencies.

Assessment of conformity of ST constituency boundaries to spatial distribution of ST population reveals that although location of ST constituencies closely corresponds to regions of high concentration of ST population, more often than not, constituency boundaries cut across clusters of highest concentration of ST population. Overemphasis on administrative homogeneity at tehsil level is visibly the major cause of this discrepancy, as in Bamanwas, Lalsot and Jamwa Ramgarh. Nevertheless, the observation holds true for those constituencies too where boundaries have been demarcated at ILRC/PC level as in case of Todabhim, Bassi and Rajgarh Laxmangarh.

Rajgarh -Laxmangarh is an example of dilution of ST strength consequent upon delimitation. Former extent of Rajgarh constituency comprised major part of Rajgarh tehsil and very effectively encompassed the contiguous ST dominated region of the tehsil at ILRC and PC levels. The revised extent of the constituency includes parts of Rajgarh and Lachhmangarh tehsils. ILRCs of western part of Rajgarh tehsil having extremely high concentration of ST population have been excluded from Rajgarh-Laxmangarh and have become part of Thanagazi general constituency. Remaining part of Rajgarh has been combined with a more or less ST minority region of Lachhmangarh tehsil, except for a small ST dominated pocket located in ILRC Bichgaon. As a result ST representation has significantly declined in the constituency after delimitation.

Similarly, areas at ILRC and PC levels having highest concentration of ST population (more than 50 to 70 percent ST population) in the region and spatially contiguous to newly laid boundaries of Bassi and Jamwa Ramgarh constituencies have been bereft of political representation. ILRC Kotkhawada has been split at PC level in such

a manner that part having relatively low concentration of ST population has been retained in Bassi while part having higher concentration has become part of Chaksu SC constituency. Other ST dominated PCs of Chaksu and Shivdaspura ILRCs of Chaksu tehsil and Goner ILRC of Sanganer tehsil also adjoin Bassi but have not been included therein. Notably Bassi is an extremely underpopulated constituency. Exclusion is not justified in terms of population constraint too.

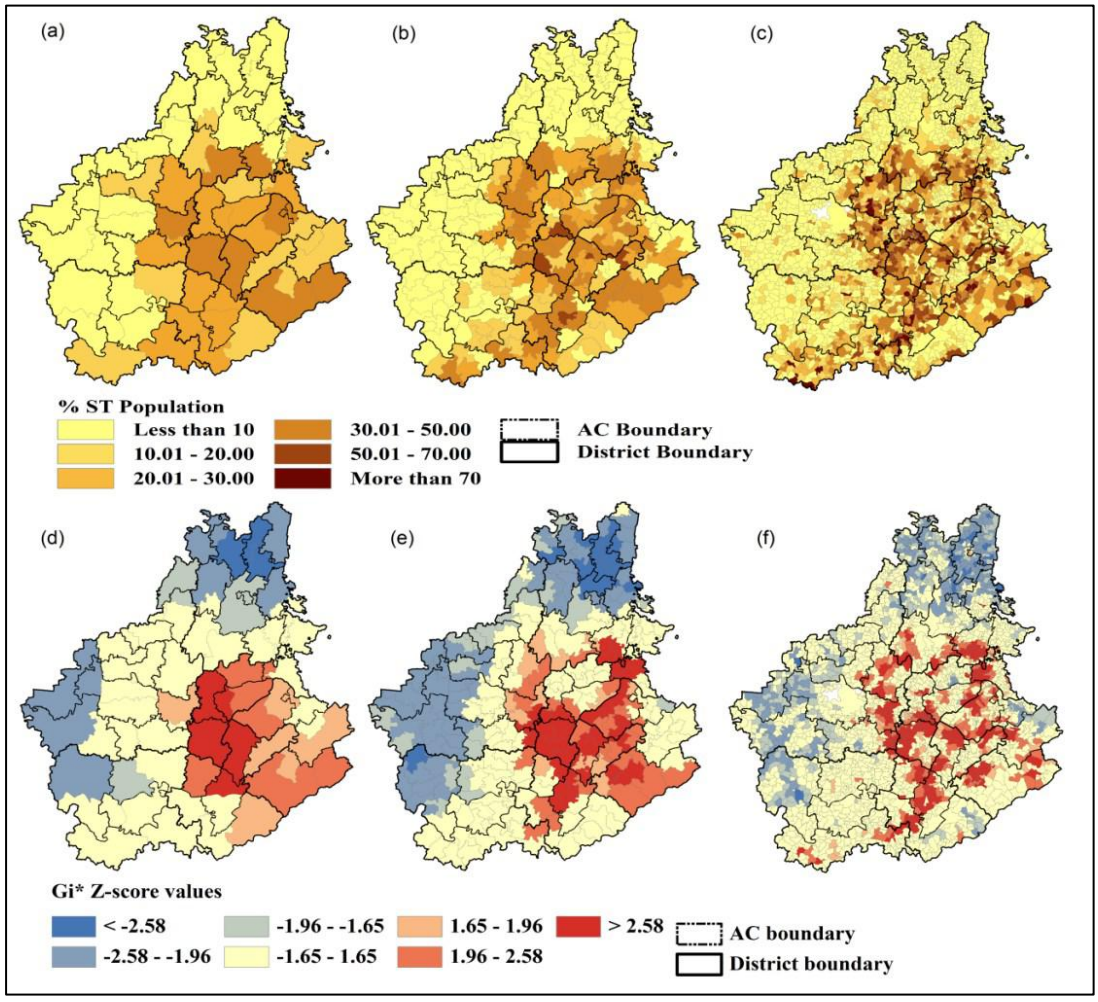

Fig. 4. Conformity Between Post Delimitation ST Constituency Boundaries and ST Population Distribution (a) Distribution at Tehsil Level (b) Distribution at ILRC Level (c) Distribution at PC Level (d) Hotspots at Tehsil Level (e) Hotspots at ILRC Level and (f) Hotspots at PC Level

Boundary changes in Bamanwas constituency have primarily aimed at administrative homogeneity at tehsil level. Revised extent of the constituency is co-terminus with Bamanwas and Bonli tehsils. The constituency has a striking bow-collar

shape, which places it against the 'geographical compactness' criterion. As a part of boundary adjustments ST minority areas of Bonli tehsil have been transferred from Sawai Madhopur general constituency to Bamanwas, and ST majority areas of Malarna Doongar tehsil included in Bamanwas ST constituency have been transferred to Sawai Madhopur constituency. Similarly revised extent of Jamwa Ramgarh constituency which has been made co-terminus to Jamwa Ramgarh tehsil has excluded ST dominated PCs of Amber and Chandwaji ILRCs of Amber tehsil which border Jamwa Ramgarh constituency. These PCs are part of Amber general constituency. Jamwa Ramgarh is also an underpopulated constituency. Appropriate distribution of ST dominated PCs would have equalized the population of the two constituencies.

Conclusion

Several inherent contradictions in the methodology of delimitation as well as loopholes in implementation of guidelines and principles for delimitation of reserved constituencies have been observed. The numerically straight forward process followed for assignment of reserved status to assembly constituencies has successfully provided adequate representation to the respective sections of population in terms of numbers of representatives. However it has grossly fallen short of its objectives where effective representation is concerned. Boundaries of reserved constituencies cut across regions of highest concentration of SC/ST population resulting into SC/ST minority constituencies thus diluting their representative power. Due consideration of SC/ST concentration areas prior to finalization of reserved constituency boundaries can effectively mitigate the observed departures. A strategy beyond simple mapping by proportions is required.

Use of tools of spatial statistics implemented in GIS environment along with the utilities of dynamic mapping, map overlay and integration can be extremely helpful in understanding the physical as well as social geography of proposed extent of electoral constituencies. Global and local pattern indices provide significant information about the administrative level at which clustering of concerned social groups is highest and identify pockets of highest concentrations which can be included undivided in reserved constituencies thereby maximising the efficacy of representation.

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DOKLAM STANDOFF : GEOPOLITICAL LESSONS FOR INDIA AND CHINA

Rahul Kumar[1] and Muraree Lal Meena[2]

[1] Department of Geography, Sarvodaya P.G. College Ghosi, Mau - 221 005
[2] Department of Geography, Banaras Hindu University, Varanasi - 221 005
E-mail: naturelovingrahul@gmail.com

Abstract

The Doklam confrontation is focused on small patch of remote pasture land in Bhutan. But its location is perceived to be great strategic importance for both India and China. At the core of the dispute is where the final trijunction point is located, the point at which India, China, and Bhutan meet lies. Bhutan claims that the tri-junction point lies at a location known as Batang-La, four kilometers north of the Doka La pass where the standoff between Indian and Chinese troops was ongoing. Meanwhile, China claims the tri-junction point at Gyemochen, a point some two-and-a-half kilometres south of the Doka-La pass. Gyemochen marks the terminus at the Indian border of what India regards as a strategic redline: the Jampheri ridge, which marks start of the descent into the foothills of southwestern Bhutan that leads into the strategically vital Siliguri Corridor. Despite India's fortification of this area over the years, the corridor is perceived as an immense strategic vulnerability. The study tries to highlights the Chinese, Indian and Bhutanese perspectives on Doklam Confrontation. The paper tries to analyse the geopolitical lessons learnt through Doklam confrontation. The study is focused on changing geopolitical dimensions of India and China relations. The study is based on both primary as well as secondary data sources. The secondary data is collected from archives of foreign ministerial reports, articles and policy papers of various governmental and non-governmental organizations.

Keywords: Geopolitical Dimensions, Geo-strategies, Tri-junction, Doka-La-Pass, Gyemochen, Silliguri Corridor.

Introduction

Doklam plateau is a disputed area of 89 sq. km in western Bhutan, near East Sikkim. Doklam is known as Donglang in China and it is one of the disputed territories between China and Bhutan. The crisis occurred on 8 June 2017, when People Liberation Army (PLA) troops crossed over to the Bhutanese territory with road construction machinery, to build a motor able road connecting Chumbi Valley and the Doklam Plateau. In response, the Indian Army from the nearby Sikkim garrison quickly moved inside the Bhutanese territory and prevented the PLA from constructing the road. The standoff continued till 28 August when both the countries agreed to pull back their troops with the media hailing it as a diplomatic victory.

However, two months later, in October 2017, online news portal *The Print* published a few satellite images indicating the build-up of approximately 3,000 PLA troops opposite Sikkim; this was not the case earlier. Clearly, the military situation in Doklam has not normalized and unease continues to persist in the region. The PLA's disposition in the satellite images was very clear because of the absence of any passive measures to hide its deployment. Since it is unlikely for a professional army to neglect even routine defensive measures, it would be logical to assume that the PLA wanted the world and India to pick up these images (Bardalai, 2018).

India's primary concern was that the road being built threatened India's security by giving China easier access to the strategically vulnerable Siliguri Corridor via Sikkim. Also known as the "chicken's neck," the Siliguri Corridor is a 12 miles wide strip that forms the only physical link between the seven northeastern states with the rest of India. What lies at the heart of the Doklam dispute? China argues that the India-China-Bhutan trijunction is at Gyemochen, which is far south of where India and Bhutan mark the tri-junction, near Batang-La. China claims around 89 sq. km in a region south of where India and Bhutan say the trijunction lies (Figure 2). The dispute is not just about the area of the territory in Doklam; it is one of only four areas over which China and Bhutan have dispute. Both countries have not any diplomatic relations.

The construction of the road in Doklam clearly changes the security dynamics to our detriment significantly. They are changing the status quo in a very major way and it has serious security implications for us. The Chinese are changing the trijunction unilaterally, and this affects us as the Chinese military presence here will be widened and deepened. The construction of the border road clearly changes the security dynamics to our detriment significantly. For India, securing the Doklam Plateau is seen as essential to maintain its control over a land corridor that connects to its northeastern States. The main objective of the study is to analyse the Chinese, Indian and Bhutanese perspectives on Doklam Confrontation. The paper tries to critically examine the geopolitical lessons learnt through Doklam confrontation. The study is focused on changing geopolitical dimensions of India and China relations.

Methodology

In order to attain the objectives of this study the data has been collected from various sources. The study is mainly based on secondary data collected from archives of Indian Foreign Ministry, reports, articles and policy papers of various organisations. Cartographic techniques are used for analysis and interpretation.

Geography of Doklam

Doklam or Zhoglam is a plateau which lying between Tibet's Chumbi valley to the north, Bhutan's Ha Valley to the east and India's Sikkim state to the west has been depicted as part of Bhutan in the Bhutanese maps since 1961, but it is also claimed by China.

Dongkya range that normally runs in the north–south direction gently curves to east–west at the southern end of the Chumbi Valley, running through the Batang La and Sinchela passes and sloping down to the plain. A second ridge to the south, called the Zompelrior Jampheri ridge, runs in parallel to the first ridge, separated by the Doklam or Doka La valley in the middle.

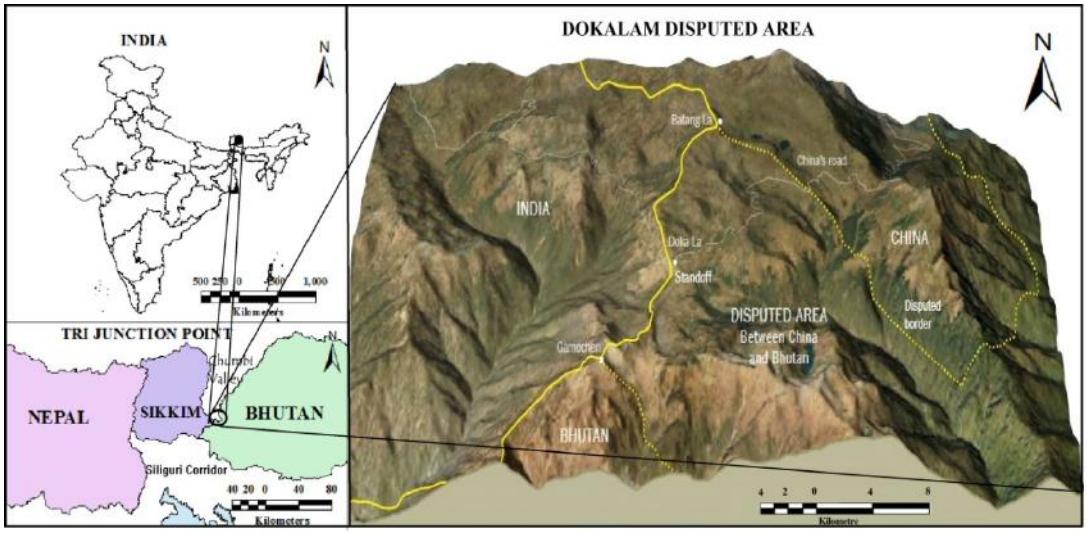

Fig. 1. Location of Doklam

At the top of the valley, the two ridges are joined, forming a plateau. The highest points of the plateau are on its western shoulder, between Batang La and Mount Gipmochi, and the plateau slopes down towards the southeast. A stream flows down the Doklam valley collecting the run-off water from the plateau, and joins the Amo Chu River about 15 km to the southeast. The 89 sq km area between the western shoulder of the plateau and the joining point of the Doklam stream with the Amo-Chu River is called Doklam. In June 2017 China started to construct a road which joins Doklam with Yadong which is the well-connected place of People's Liberation Army (PLA). In June 2017 a military standoff occurred between China and India as China attempted to extend a road on the Doklam plateau southwards near the Doka-La pass and Indian troops moved in to prevent the Chinese. India claimed to have acted on behalf of Bhutan, with which it has a 'Special Relationship' (Panda, 2017).

Historically when the Kingdom of Sikkim was founded in 1642, it included all the areas surrounding the Doklam plateau: the Chumbi Valley to the north, the Haa Valley to the east as well as the Darjeeling and Kalimpong areas to the southwest. During the 18th century, Sikkim faced repeated raids from Bhutan and these areas often changed hands (Harris, 1977). The Doklam plateau sandwiched between these regions is likely to have been part of these territories (Chandran and Singh, 2015). Siliguri and Chumbi Valley were

part of a highway of trade between India and Tibet. In the 19th century, the British Indian government sought to open up the route to British trade, leading to their sovereignty over Sikkim with its strategic Nathu La and Jelep La passes into the Chumbi Valley. Indian intelligence officials state that China had been carrying out a steady military build-up in the Chumbi Valley, building many garrisons and converting the valley into a strong military base (Bajpai, 1999).

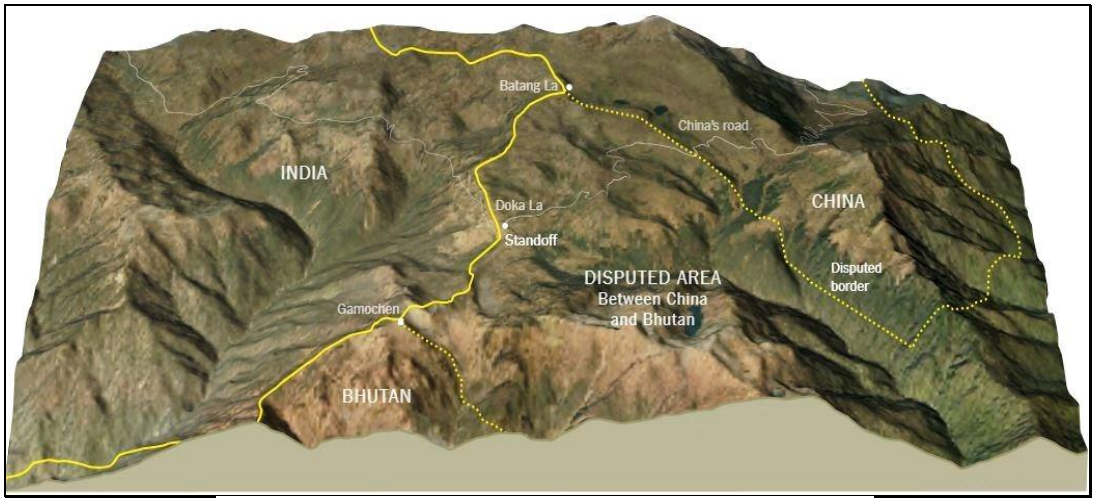

Fig. 2. 3D Image of the Dokalam Disputed Area

Source: DEM obtained from Landsat data, April, 2018, USGS

Historically when the Kingdom of Sikkim was founded in 1642, it included all the areas surrounding the Doklam plateau: the Chumbi Valley to the north, the Haa Valley to the east as well as the Darjeeling and Kalimpong areas to the southwest. During the 18th century, Sikkim faced repeated raids from Bhutan and these areas often changed hands (Harris, 1977). The Doklam plateau sandwiched between these regions is likely to have been part of these territories (Chandran and Singh, 2015). Siliguri and Chumbi Valley were part of a highway of trade between India and Tibet. In the 19th century, the British Indian government sought to open up the route to British trade, leading to their sovereignty over Sikkim with its strategic Nathu La and Jelep La passes into the Chumbi Valley. Indian intelligence officials state that China had been carrying out a steady military build-up in the Chumbi Valley, building many garrisons and converting the valley into a strong military base (Bajpai, 1999).

Historically Sikkim-Tibet border was defined in 1890 through the Anglo-Chinese Convention that was signed in Kolkata on March 17, 1890. Article I of the convention said that the boundary of Sikkim and Tibet would be "*the crest of the mountain range separating the waters flowing into the Sikkim Teesta from the waters flowing into the Tibetan Mochu*" The beginning point of the boundary line would be 'Mount Gipmochi on the Bhutan frontier'. As it is evident, Bhutan played no role in this, nor did Sikkim or Tibet. The agreement was between two empires-the British and the Qing.

The Tibetans refused to implement the convention and for this they were punished when the British stormed Lhasa and later signed a convention with the Chinese in 1906 and 1910 recognizing the authority (suzerainty, they said) of China over Tibet in exchange for a number of rights. In the recent exchanges between India and China, it would appear that while Beijing stands by the 1890 convention, India's position is somewhat ambiguous. In its sole formal statement of June 30, 2017, the Indian spokesman said that there was an agreement between China and India in 2012 that "tri-junction boundary points between India, China and third countries will be finalized in consultation with the concerned countries.

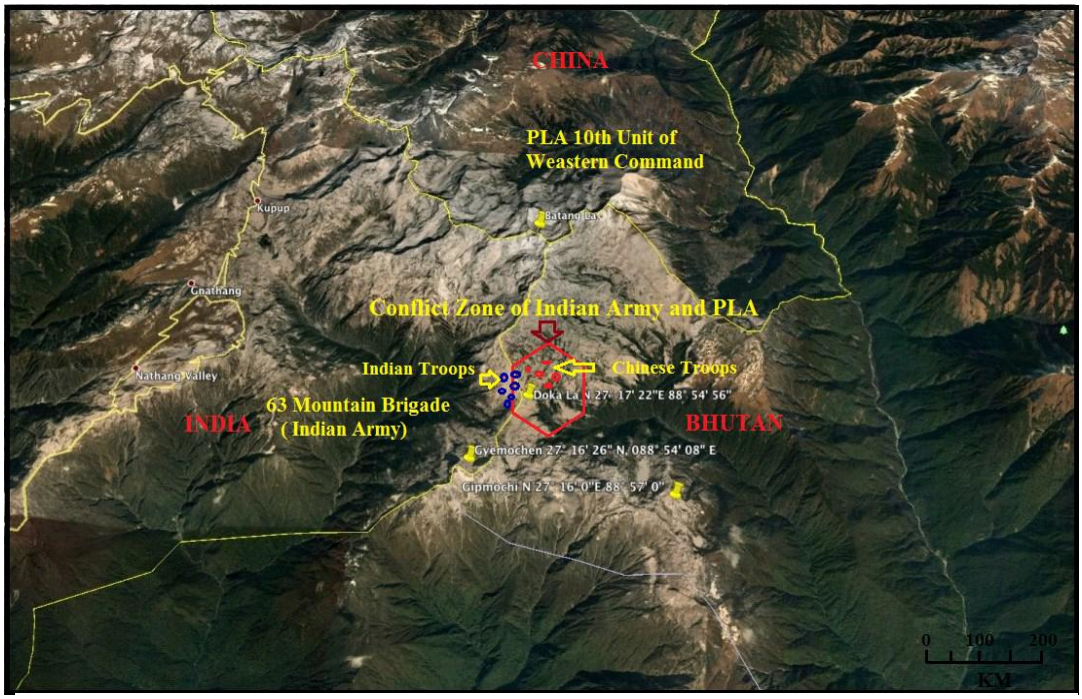

Fig. 3. High Resolution Satellite Image of Doklam and Deployment of Troops

Source: LISS-III satellite data of December, 2017 and Database USGS

Chinese Perspective on Doklam Issue

From a Chinese perspective, Indian troops entered into the Chinese territory illegally. In fact, because there is no dispute between China and India on the Sikkim segment of the borderline, this is not really an issue between China and India. This is the case, because several Indian officials have confirmed this on various occasions, including during meetings between special representatives on the Sino-Indian boundary issue. So, from Beijing's perspective, after the standoff began, India said that it entered into the Doklam area in order to stop road construction by China, allegedly because Bhutan's foreign ministry said China is unilaterally changing Status-quo that the Chinese road may penetrate into Bhutanese territory and had asked China to return to the status quo before 16 June, 2017.

Essentially, India is conceding that it is seeking to claim territory on behalf of Bhutan. The Indian position in and of itself implies that it tacitly admits that it is not a problem between China and India. Rather, India is just a third party. But irrespective of how India frames its arguments, the reality is that: no matter what kind of 'Special Relationship' India has with Bhutan, it has no right to interfere in this issue according to universally recognized international law because Bhutan is an independent country. By doing so, India is reflecting what some regard as its long-held ambition to control the Indian subcontinent and treat the small countries surrounding it, including Bhutan, as effective client states. When Bhutan was showing some signs of improving its ties with China, which is comprehensible, that alarmed India. India no doubt sees this as an opportunity to drive a wedge between China and Bhutan and maintain its control on Bhutan. Although it is true that the border issue between China and Bhutan has not been settled yet, the two sides have been engaged in 24 rounds of negotiations and should be entitled to work out their differences independently without any interference. It is also important that (from a Chinese perspective) because Beijing has always emphasized that the Donglang area belongs to China, it therefore follows that the construction of a road is a normal activity in its own territory. Indian conduct during the standoff is also no doubt partly motivated by broader geopolitics.

One explanation for India's actions is that, just as Indian media outlets have said, New Delhi is concerned that the Yadong Area in China's Tibetan Autonomous Region is a dagger aimed at the India's vulnerable '*Chicken-Neck*' area of Siliguri with a thin strip of land separating India and Bangladesh. If China builds roads in that area, it will quickly cut off the transport connection between the north-eastern parts of India with the rest of the country if a war breaks out. The recent standoff between the two Asian giants is also a reflection of India's deep mistrust and strategic anxiety towards China. Although both China and India are emerging power, the mistrust gap between both countries has not narrowed, but widened, in the last two decades. Rising nationalist sentiment since Prime Minister Narendra Modi took power ties between the two sides, as evidenced by the rhetoric India has seen since the standoff began. Some Indians also tend to look at the Sino-Indian relationship through a prism of broader geostrategic competition. In recent years, India has frequently complained about the unusual Chinese naval presence in the Indian Ocean. In addition to this, because of the ongoing India-Pakistan rivalry and the close relationship between China and Pakistan, India has deep doubts about the intentions of China in building the China-Pakistan Economic Corridor as part of the Belt and Road Initiative. In reaction to this, for the past several years, India has intensified its cooperation with other Asia-Pacific powers such as the United States, Japan, Australia, as well as some Southeast Asian countries such as Vietnam and Myanmar, especially in the security field. This has only further damaged the level of mutual trust between China and India.

So, the Sino-Indian standoff is a result of a complex set of reasons. What might be a way out? China insists that the precondition for any talks or negotiations should be that

Indian troops must withdraw to their own side of the border, since it was the Indians who entered the Dong Lang area illegally first. In other words, China started psychological warfare against India through its state media. India must stop its aggressive actions. Although, both side communicated each other through various diplomatic channels to resolve the concern dispute. Instead, India is reportedly stepping up military preparations on the borderline, which is very provocative. China had spread its propaganda that if the confrontation continues, China will take any measures to defend its sovereignty and territorial integrity. India should realize the danger of a continued standoff, which not only damages New Delhi's interests, but also poses a threat to the stability of South Asia as whole. The best solution is for India to withdraw from the Dong Lang area and engage in negotiations with China. Otherwise, it may pay a high price for its own actions. China has long desired an independent Bhutanese stand without Indian advocacy and interference on the boundary issue. Chinese academia often dubbed India's interference as hegemony in South Asia. When Chinese vice foreign minister Liu visited Thimphu in August 2013, he talked about broadening relations. Chinese officials always indicated that for any steps to settle the boundary dispute once and for all, establishing diplomatic ties between the two countries is necessary. The Chinese have for years wanted to open an embassy in Thimphu. It had promised to upgrade the Bhutanese consulate in Hong Kong to an embassy, to promote increased tourist flows and exchange of visits, among other things. Chinese Scholars argues that in mid-June 2017, after some Indian troops crossed the border and entered into Chinese territory. China considers its area of the Donglang (Doklam or Doka La) area the two countries have been engaged in a standoff

Indian Perspective on Doklam Issue

For the first time, the Chinese are constructing a motorable road from Dokola towards the Bhutan army camp at Zompelri. It might be their assessment that Bhutan would not be able to resist. Even though Bhutan has conveyed to the Chinese side, both on the ground and through diplomatic channels that the construction of the road inside Bhutanese territory was a violation of earlier bilateral agreements. The Chinese might also have assessed that India will not step into this situation. They want to change the status quo on the ground through unilateral action, which they have done elsewhere as well. China has certain territorial claims in Bhutan. There have been creeping encroachments since 1988. But there is no permanent presence of the People Liberation Army (PLA) or of Chinese graziers in Doklam.

India and China were broadly in agreement on the boundary have the Sikkim sector. It is agreed on the basis of alignment, which is the highest watershed in the area, but both sides are fully aware that more negotiations are required among the special representatives to fix the alignment of the boundary on maps and also demarcate it on the ground. The Chinese side is cognizant of significant differences with regard to the tri-junction point, as can also be seen from the maps of India, China and Bhutan. As the Indian Ministry of External Affairs (MEA) statement has pointed out, that Chinese have specifically agreed on tri-junction point will be finalised through consultations among the concerned

countries. There are also differences on interpreting the watershed boundary between India and China in the Sikkim sector. There have been incidents in the past due to different interpretations of the boundary in northern and eastern Sikkim. There is an understanding with Bhutan that any attack on Bhutanese sovereignty will be considered as an attack on India. Indian troops in Bhutan are basically on a training mission.

Bhutan cannot sustain or withstand Chinese pressure alone. The main motive of the Chinese seems to be to drive a wedge between India and Bhutan, with whom India have excellent bilateral relations. Bhutan was the only South Asian country that stood by India when India decided to boycott the BRI summit in Beijing. From time to time, Bhutan has received Chinese blandishments to de-link from India and thus receive not only extensive economic help but also a better deal on the Sino-Bhutan boundary. Bhutan has steadfastly refused. While China has repeatedly only referred to the 1890 treaty, Indian officials have pointed out that if the issue was settled in Sikkim, then why did China agree to the understanding on tri-junction boundary points in 2012.

For India, there are two other issues which cause direct concern to India. The Chinese are unilaterally changing the tri-junction point. This is in violation of the understanding India have reached with them in 2012. As the MEA statement has noted, the construction of the road will involve a significant change of status quo with serious security implications for India.

Bhutanese Perspective on Doklam Issue

The Bhutanese Ambassador Maj. Gen. (Retd.) V. Namgyel in New Delhi, responded through an interview that appeared in The Hindu on June 28, noting that the road construction was in an area which is disputed between China and Bhutan and was, in fact moving towards a camp of the RBA at Zompelri (Jampheri) ridge. He said, “Bhutan has conveyed that the road construction by the PLA is not in keeping with the agreements between China and Bhutan. India has asked them to stop and refrain from changing the status quo.” The Bhutanese government issued a press release on June 29, reaffirming Namgyel’s remarks. It provided a backdrop to the events: “On 16th June 2017, the Chinese Army started constructing a motorable road from Dokola in the Doklam area towards the Bhutan Army camp at Zompelri. Bhutan has conveyed to the Chinese side, both on the ground and through the diplomatic channel, that the construction of the road inside Bhutanese territory is a direct violation of the agreements (*on maintaining the status quo pending a settlement*) and affects the process of demarcating the boundary between our two countries (Press Release of Royal Government of Bhutan, 2017).

Bhutan hopes that the status quo in the Doklam area will be 13 maintained as before 16 June 2017. As the India-China standoff persists, the key question is where Bhutan actually stands. India’s claim that Bhutan is fully with India on the issue seems questionable. The official statement issued by the Bhutanese government on June 29 does not make the country’s position explicit. The 1949 Friendship Treaty (updated in 2007) guides the contemporary Indo-Bhutan relationship and aims to ensure India’s non-

interference in Bhutan's internal affairs. Article 2 of the 1949 friendship treaty version, however, entrusted India with the power to guide Bhutan's foreign policy. But Article 2 of the 2007 version freed Bhutan from seeking India's guidance on foreign policy and obtaining permission over arms imports, among other things. The article now only says that India and Bhutan "shall cooperate closely with each other on issues relating to their national interests. Neither government shall allow the use of its territory for activities harmful to the national security and interest of the other." Even before the revised treaty, Bhutan's UN membership in 1971 had fundamentally impaired the sacredness of the old Article 2. Bhutan is an independent country. It raised its diplomatic representation in New Delhi to the full ambassadorial level in 1971 (India-Bhutan Friendship Treaty, 2007).

Notwithstanding all the geopolitical pulls and pressures, Bhutan has steadfastly stood behind India as its most reliable ally. But the impression among the Bhutanese now is that India has been coming in the way of Bhutan reaffirming its status as an independent state, especially in the foreign policy arena. People in Bhutan think that India has for too long prevented their country from normalizing diplomatic ties and negotiating a border settlement with China. India, on its part, fears that any boundary deal will not only impact Indian security but also impinge on its own negotiating position with China on the boundary issue. From Bhutan's perspective, India's position is adversely impacting its ties with China. This is the main issue that is leading to complexities and confusion, including the standoff at Doklam.

However, it appears that this is not the first time the Chinese have intervened and built roads not only in disputed territory, but also inside Bhutan. Bhutan's shares a 470-km-long border with China and according to some Chinese reports, over 25% of this border remained disputed for decades. China wanted Bhutan to cede a 269 km^2 area in west Bhutan, including Dramana, Shakhatoe and Sinchulung, in exchange for which it had offered to give Bhutan a 495-square-km area in Pasamlung and Jakarlung in China. In the Doklam plateau in the west, the Chinese People's Liberation Army (PLA) is known to have made frequent intrusions since the mid-1960s. Talks with China began in 1972, but since 1984, negotiations became bilateral without India's participation. The two countries managed to sign an Agreement on Maintenance of Peace and Tranquillity in the Bhutan-China Border Areas in 1998. Thus far, 24 rounds of discussion have taken place under the agreement. The last round was held in August 2016 in Beijing between Chinese vice foreign minister Liu Zhenmin and Bhutanese foreign minister Lyonpo Damcho Dorji. However, the Chinese have recently claimed that Bhutan and China have a basic consensus on the functional conditions and demarcation of their border region.

At the heart of the issue is the lingering suspicion in India about the possibility of Bhutan ceding the Doklam plateau located on the strategic tri-junction of Bhutan, the Chumbi Valley in China and the state of Sikkim in India The area is extremely critical for India's security as it overlooks the Siliguri corridor. China, on the other hand, has held a tough position on Doklam and has been upgrading infrastructure networks, including roads in nearby areas, on the lines that it has built in Aksai Chin area. Recently, as per the treaty

obligation, Bhutan has kept India's interest in mind and evaded a settlement with China. The general approach of the country could neither bargain nor impose its will on the matter, and therefore Bhutan stand along with India. Through this conflict, Bhutan has appeared to want to settle the Doklam issue once and for all, and thereafter maintain friendly and equidistant ties with both India and China. India must note that Bhutanese position has been changing in a subtle way, especially the manner in which their boundary negotiation with China was proceeding without the knowledge of India. Bhutan neither accepted the swap nor tried to regain the 'cartographically ceded land. Both countries had agreed to the border demarcations in Pasamlung and Jakarlung.

The settlement in the north was to pave the way to determine the course of action to settle the western border in Doklam. It seems that agreement on a political compromise had been reached during the 19th round of boundary talks held in January 2010. Perhaps this was also the outcome of the meeting between the then Bhutanese Prime Minister JigmeThinley and the then Chinese Premier Wen Jiabao in June 2012 in Rio de Janeiro. The agreement also perhaps included the decision to establish diplomatic ties. The Chinese claimed that China and Bhutan gained remarkable headway on the boundary issue during the 20th round of talks held in Thimphu on August 10, 2012.

The popular perception in Bhutan is it has no military capability and strategic considerations to hold on to Doklam, Jakarlung and the Pasamlung areas. Moreover, China has not even considered disputes in the Jakarlung and Pasamlung areas. But Doklam is different; this issue of the Doklam Plateau is very, very scary. Bhutanese perceptions are getting visibly louder on social media and the growing aspirations of the people suggest that Bhutan's ability to withstand pressures from both China and India has become paramount. However, Doklam may well turn out to be a watershed moment in India-China relations, and yes, there are plenty of important lessons for Indian policy-makers to learn.

Challenges for Maintaining Peace and Tranquility along Border

Geography was in India's favour in Doklam, which may well be one of the reasons why China backed down. But there is no guarantee that the next incursion (and the country better believe that another is likely) will be on favourable terrain for the Chinese. The Modi government has done well to start building infrastructure in the North East region, but the roads to our borders are far behind what the Chinese have. India need to bridge the gap fast, and the country need to quickly find alternate pathways to the Siliguri corridor.

Geopolitical Future After Doklam Issue

According to academician and research analyst that long-term conflict between India and China is impossible because of the 70 billion dollars (approximately) of trade between them. There has been less number of conflicts between strong trading partners. One of the key lessons of Doklam is that the government needs to take a look at the strategic dominance of Chinese companies in key areas of the Indian economy, including sensitive areas like communication. China has spent so much time and money for building

up Pakistan partly because it bottles up India in South Asia. India is now correctly taking steps to return the favour by building strategic relations with countries like Japan and Vietnam that are equally concerned about China. India is willing to sell BrahMos missiles to Vietnam. Pakistan itself would hardly be a threat if it were not for Chinese backing and military support. On the other hand, the jostling for strategic space between India and China is going to be one of defining features of the next few decades and India may as well get used to it. China will be a 38 trillion-dollar economy by 2030.

Conclusion

What should be way forward policy for India? The answer of this question lies in two other related questions: first, is there a way to find a mutually acceptable solution without compromising India's security; and second, should India continue to live with more such stand-offs in future and let the issue remain for our next generations to find a solution? The answer to the first question is easier. A mutually acceptable solution taking into consideration of India's security as well as its long-standing and deep relations with Bhutan could be found in consultation with the King of Bhutan. Any further standoff will make worse our bilateral relations with China and Bhutan. India and China must ensure peace and tranquility along the border for peaceful economic growth.

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LIVELIHOOD VULNERABILITY INDEX - IPCC APPROACH IN LAKE TANA SUB-BASIN, ETHIOPIA

Solomon Addisu Legese

Department of Natural Resources Management, College of Agriculture and Environmental Sciences, Bahir Dar University, Bahir Dar, P.O. Box 79, Ethiopia
E-mail: soladd2000@yahoo.com

Abstract

The livelihood vulnerability analysis uses multiple indicators to assess exposure to natural disasters due to climate change or variability, social and economic characteristics of households that affect their adaptive capacity, and current health, food, and water resource characteristics that determine their sensitivity to climate change impacts. By this study, it has tried to present to clearly identify the vulnerable regions of LakeTana sub-basin rural livelihoods by expressing the LVI as a composite index comprised of seven major components. The results found that upper sub-basinhouseholdshave a higher livelihood vulnerability index than the lower (0.392 versus 0.368, respectively). This suggests that relatively greater exposure to the adverse shocks of climate change in the upper than the lower sub-basin.Toconclude, the LVI has to be designed to provide development stakeholders and public health participants with a practical tool to take into consider demographic, social and health factors contributing to climate vulnerability at the district or local level. It has to be also designed to be flexible so that development planners can refine and focus their analysis to suit the needs of each locality.

Keyword: - livelihood, vulnerability, livelihood component, climate change, Pragmatic approach, Lake Tana Sub-basin, Ethiopia

Introduction

Climate change impacts are expected to disproportionately affect the poor, young, elderly, sick, and otherwise marginalized populations (Kasperson, 2001). Globally, climate policies of developed nations including increased reliance on bio-fuels may have a detrimental impact on staple food markets and consequently the nutrient needs of already malnourished populations (Boddiger, 2007). Further, expansion of bio-fuel crops may potentially encourage clear cutting tropical rainforest, a critical carbon sink. They emphasized the need to understand not just the climate science but also climate projections in the context of human societies, political systems, social hierarchies, and underlying health profiles.

In addition to these broad-scale influences, local factors have also been shown to affect vulnerability at the household level. Eriksen et al. (2005) cited in (Hahn, Riederer et al. 2009) described how Kenyan and Tanzanian households where each member specializes in a limited number of intensive, cash-yielding coping strategies were generally less vulnerable than those whose members spread their time among several marginal livelihood activities. They also noted that many rural households lack the skills and access to capital needed to engage in the most desired, cash-yielding coping activities, and found that time availability, especially among women, was an important determinant of the ability to engage in favoured coping strategies.

This paper shows the Livelihood Vulnerability index by vulnerability assessment set of methods used to systematically integrate and examine interactions between human and their physical and social surroundings(Khajuria and Ravindranath 2012). Vulnerability assessments have been used in a variety of contexts. Susceptibility valuation has arose to discourse the need to quantify how communities will adapt to changing environmental conditions. Various researchers have tried to bridge the gap between the social, natural, and physical sciences and contributed new methodologies that confront this challenge (Khajuria and Ravindranath 2012).

By this study, it has tried to present to clearly identify the vulnerable regions of Lake Tana sub-basin rural livelihoods by expressing the LVI as a composite index comprised of seven major components. This approach uses primary data from household surveys to construct the index (Legese, Olutayo et al. 2016). It also presents a framework for grouping and aggregating indicators on the sub-basin level, which can be critical for development and adaptation planning.

Methodology

Description of the Study Area

Ethiopia is located in Northeastern or East Central Horn of Africa lying between 3 and 15 degrees North latitude, 33 and 48 degrees East longitude (Figure 1). Ethiopia is surrounded by Somalia in the east and Djibouti, by Kenya in the south, by Eritrea in the northeast and by the North and South Sudan in the west. It has a total area of 1.1 million km^2 and encompasses of 12 river basins with varying size and water resource potential (CSA, 2007). The Blue Nile basin, locally called *Abay*, is located in the north-western part of Ethiopia, the largest river basin in the country, is one of those basins which consist of Lake *Tana s*ub-basin(Gebremicael, Mohamed et al. 2013).

The major components were aggregated from the sub-components of the livelihood vulnerability using the local upper and lower sub-basin resident households. The data were generated using questioners developed from Table 1.

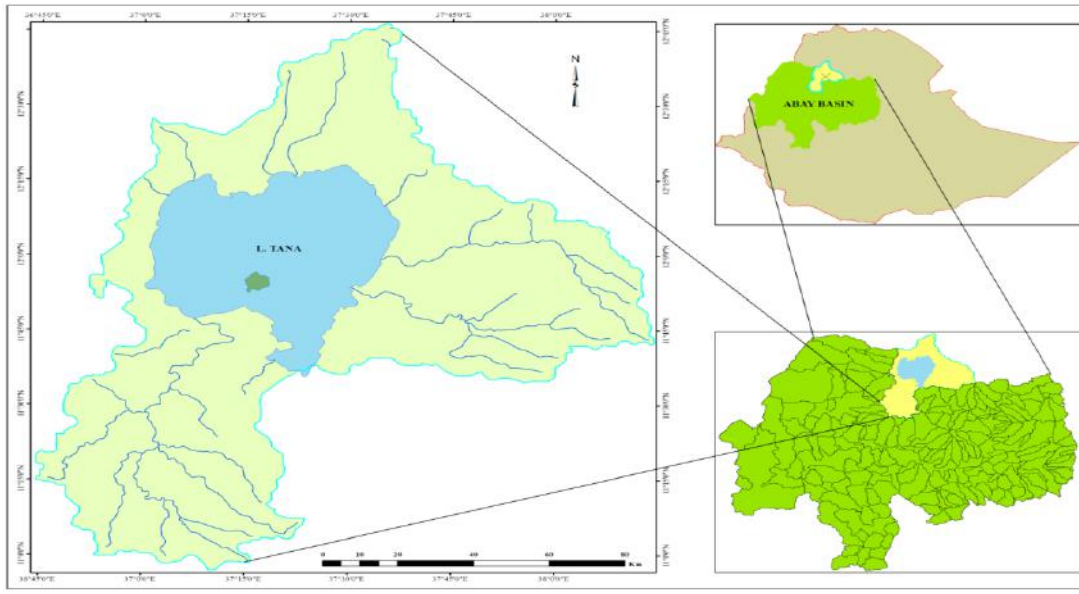


Fig. 1. Location of the Lake Tana

Table 1. Major Components and Sub-components Comprising the LVI

Major Components	Sub-components	Explanation of Sub-components	Survey Question and Source
Socio-Demographic profile	Dependency ratio	Ratio of the population <15 and > 65 to 16-64 years of age.	list the ages and sexes who eats and sleeps in this house?(Amoatey and Sulaiman 2018),
	% of female-headed HH	% of HHs where the primary adult is female.	Are you the head of the household? HH Survey (2014)
	% of HHs where head of HH has not attended school	% of HHs where the head of the HH reports that they have attended no school.	Have you ever gone to school? HH Survey (2014)
	% of HH with orphans	% of HHs that have at least 1 orphan living in their home.	Are there any children less than 18 years old from other families living in HH Survey (2014)
Livelihood	% of HH with family member working in a different community	% of HHs that reportthe existence of at least 1 family member who works outside of the community	How many of your family members go to a different community to work? World Bank (1997)
	% of HHs dependent solely on agriculture	% of HHs that report only agriculture as a source of income.	Do you or someone else in your HH practice agriculture? World Bank (1997)

	Average Agricultural LDI	The inverse of (the number of agricultural livelihood activities +1) reported by a HH,	Do you or someone else in your HH practice agriculture? Adapted from DHS (2006)
Health	Average time to health facility	Average time it takes the HH to get to the nearest health facility.	How long does it take you to get to the nearest health facility?World Bank (1997)
	% of HHs with family member with chronic illness	Percentage of HHs that report at least 1 family member with chronic illness.	Is anybody in your family chronically ill? HH Survey
	% of HHs where a family member had to miss work/ school	% of HHs that report at least 1 family member who had to miss school /work due to illness.	Any family been so sick in the past two weeks? WHO/RBM (2003), (Legese, Olutayo et al. 2016)
	Average Malaria Exposure*Prevention Index	Months reported exposure to malaria*Owning at least one bed net indicator	Which months of the year are with high malaria incidence? How many mosquito nets do you have? WHO/RBM (2003)
Social Networks	Average Receive: Give ratio	Ratio of (the number of types of help received by a HH in the past month + 1) to (the number of types of help given by a HH + 1).	In the past month, did relatives or friends provide help to you and your family and vice veral? World Bank (1997)
	% of HH that have not gone to their local government for assistance	% of HHs that reported not asking their local government for any assistance	In the past 10 months, have you or someone in your family gone to your community leader for help? WHO/RBM (2003)
Food	% of HHs dependent on family farm for food	% of HHs that get their food primarily from their personal farms.	Where is the source of family food? HH survey, 2014
	Average number of months HHs struggle to find food	Average number of months HHs struggle to obtain food for their family	Does your family have adequate food the whole year? World Bank (1997)
	Average Crop DI	The inverse of crops grown by a HH +1).	What kind of crops does your HH grow? World Bank (1997)
	% of HHs that do not save grain	Percentage of households that do not save grain from each harvest.	Does your family save some of the grain you harvest to use it during a different time of the year? HH survey

	% of HHs that do not save seeds	% of HHs that do not have seeds	Does your family save seeds to grow next year? Developed for this study
Water	% of HHs reporting water conflicts	% of HHs that report having heard about conflicts over water in their community.	have you heard about any conflicts over water in your community by last year?(Legese, Olutayo et al. 2016)
	% of HHs that utilize a natural water source	% of HHs that report a creek, river, lake, pool, or hole as their primary water source.	Where do you collect your water? (Legese, Olutayo et al. 2016)
	Average time to water source	Average time it takes the HHs to travel to their primary water source.	How long does it take to get to your water source? (Legese, Olutayo et al. 2016)
	% of HHs that do not have a consistent water supply	% of HHs that report water is not available at their primary water source every day.	Is this water available every day? World Bank (1997)
	Inverse of the average number of liters of water stored per household	The inverse of (the average number of liters of water stored by each household + 1).	What containers do you usually use to store water? How many liters does each container hold? (Legese, Olutayo et al. 2016)
Natural disasters and climate variability	Average number of flood, drought, and hailstorm events in the past 10 years	Total number of floods, droughts, and hailstorm that were reported by households	How many times has this area been affected by a flood/ hailstorm /drought in 2001–2013? Williamsburg (2004).
	% of HHs that did not receive a warning about the pending natural disasters	% of HHs that did not receive a warning about the most severe flood, drought, and hailstorm event in the past 10 years.	Did you receive a warning about the flood/hailstorm /drought before it happened? Williamsburg (2004).
	% of HHs with injury as a result of natural disaster in the past 10 years	% of HHs that reported either an injury to or death of one of their family members as a result of the most severe flood, drought, or hailstorm in the past 10 years.	Was anyone in your family injured/ dead in the flood/hailstorm, drought? (Legese, Olutayo et al. 2016)

	Mean SD of the daily average max. temperature	SD of the average daily maximum temperature by month from 2001–2013	2001–2013 data; weather station NMA, 2014
	Mean SD of the daily average min. temperature by month	SD of the average daily min. temperature by month between 2001 and 2013 was averaged	2001–2013 data; weather station NMA, 2014
	Mean SD of average precipitation by month	SD of the average monthly precipitation between 2001 and 2013 was averaged	2001–2013 data; weather station NMA, 2014

The sub-basin was subdivided based on the climate hazard exposure namely flood for the lower sub basin (LSB) and drought for the upper sub-basin (USB)(Legese, Olutayo et al. 2016). This was done based on the local knowledge and ground truth exercise with local administration and the community leader during the reconnaissance survey (Legese, Olutayo et al. 2016). Landscapes with a slope of two percent and altitude less than 1825 m.a.l were delineated as flood plain areas (Legese, Olutayo et al. 2016). This was finally recalculated by employing flood zoning analysis technique (Yasir, Crosato et al. 2014), which uses the weighted sum overlay of slope, elevation, drainage density, land use/cover and soil types. Selection of sample households was done on the selected administrative *kebeles* from each agro-ecology sub-basins. Independent samples of households were calculated from a sample frame (number of households in each sub-basin)(Addisu, Fissha et al. 2016). Sample size calculation for selection of households from each sub-basin considers: (i) the proportion (p) for the different variables of investigation (p=0.5); (ii) design effect of 2 to make for non-random effect; (iii) 10% margin of error at 95% confidence; and (iv) 5% non-response rate (Cochran, 1977) cited in (Legese, Olutayo et al. 2016). The sample size was calculated as:-

$$noi = \frac{d(z\,x/2)^2 * p(1-p)}{\varepsilon^2}$$

$$ni = \frac{noi}{1(noi-1)\frac{1}{Ni}}$$

Ni references to the total number of households in each sub-basin (i=1, 2, 3); n_{0i}references to non-adjusted sample size for each sub-basin, n_i = adjusted sample size for each for each sub-basin; $z\,x/2$ =value of normal distribution at 95% confidence (z=1.96); P = the proportion for the key variables to be investigated (p=0.5); ε = margin of error (10%); and, d = design effect, (Addisu et al., 2016)

Based on the above formula, 276 sample households were the minimum sample size required for the study and a total of 300 households were administered (Addisu et al., 2016).

The LV amalgamated catalogue in Lake Tana sub-basin includes seven major components: Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H) Food (F), Water (W), and Natural Disasters due to Climate Variability/Change (NDCV)(Addisu, Fissha et al. 2016). These were selected by the participatory approach from both the upper and the lower sub-basin and local leaders. Each major component is comprised of several indicators or sub-components. These were developed based on the reconnaissance field visit and a review of literature on each major component. As indicated in Table 1, an explanation of how the assessment questions used to collect the data and the original source of the survey questioners. The livelihood vulnerability index (LVI) uses a balanced weighted average approach (Hahn, Riederer et al. 2009). Because each of the sub-components was assessed on a different scale of measurement, it was first necessary to standardize each as an index value. The calculation used for this conversion was adapted from the human development index to compute the life expectancy index, which is the ratio of the difference of the actual life expectancy and a pre-selected minimum and the range of pre-determined maximum and minimum life expectancy (UNDP, 2007).

$$indexSB = \frac{SB - S\min}{S\max - S\min} \quad (1)$$

where, SB is the original sub-component for lower or upper sub-basin, and *Smin* and *Smax* are the minimum and maximum values respectively for each sub-component determined using data from both sub-basins. The maximum and minimum values were also transformed following this procedure and the above equation used to standardise this sub-components. After standardisation of the component indicators, the sub-components were averaged as follows to calculate the value of each major component:

$$MB = \frac{\sum_{i=1}^{n} indexSBi}{n} \quad (2)$$

where, MB is one of the seven major components for lower/upper sub-basin SDP, LS, SN, H, F, W, or NDCV. Index SBi represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components in each major component. Once the values for each of the seven major components for a sub-basin were calculated, they were averaged using the following equation to obtain the sub-basin level LVI(Legese, Olutayo et al. 2016):

$$LVIB = \frac{\sum_{i=1}^{7} WMiMB}{\sum_{i=1}^{7} WMi} \quad (3)$$

Which can also be expressed as:-

$$LVIB = \frac{\begin{array}{l} wSDP(SDB1) + wLS(LSB) + wSN(SNB) + wH(HB) \\ + wF(FB) + w(WB) + wNDCV(NDCVB) \end{array}}{wSDP + wLS + wH + wSN + wF + wW + wNDC} \quad (4)$$

where, LVIB is the livelihood vulnerability index for lower or upper sub-basin (B) equals the weighted average of the seven major components of the livelihoods. The weights of each major component of the rural livelihoods, wMi, are determined by the number of sub-components that make up each major component and are included to ensure that all sub-components contribute to the overall LVI (Sullivan, 2002). In this study, the LVI was scaled from 0 (least vulnerable) to 0.5 (most vulnerable). The major components and sub-components of vulnerability indicators for the LVI calculations were stated(Legese, Olutayo et al. 2016).

Results and Discussion

The frequency of missing respondent was between 0 and 5% for most of the questionnaires and there were no significant difference between lower and upper sub-basin sample households in missing response rates (Fisher's exact >0.05). The sub-component values for each sub-basin as well as the minimum and maximum values for both combined are described below.

In this study, the average family size per household for the lower and upper sub-basin were found to be 6.13±0.67 and 6.23±0.69, respectively, which is higher than the national average of 4.1±0.6persons (CSA, 2008). The higher population has further implications on livelihood opportunities, natural resources, social services and economic development of the region as well as on the climate change adaptation initiatives. The lower sub-basin (LSB) respondents reported a higher proportion of female-headed households and a smaller proportion of household heads who did not attend school than the upper sub-basin (USB) respondents. The proportion of female-headed households was found to be 9.33% in the LSB and 4.33 in the upper one. On the other hand, from a range of households' characteristics, the educational level of head of the households was found to be important determinant of resilience to climate change induced shocks. Access and effectiveness of early warning information from different sources, better reactions and rehabilitation skills during and after natural shocks, alter agricultural operation and adopt extension strategies (Amoatey and Sulaiman 2018).

Therefore, education is one of the key factors in building the resilience level of households to climate change impacts. The results of this study showed that a significant number of households (73.33% in the LSB and 78.67% in the USB) have not attended school. This is higher than the countrywide average (47%) reported by CSA (2008) cited in (Legese et al., 2016). These outcomes suggest that both sub-basin respondents have been extremely vulnerable to climate change risks. The dependency ratio and the number of orphans found to be higher in the lower sub-basins (1.7 and 22 %) than the upper ones (1.2 and 16.67%), respectively (Table 2). It was computed based on the age structure of the households in the sub-basin such as age from 0 to 15 and greater than 65, considered as dependent population in the age group of 16 to 64 (productive age group) (CSA, 2008) cited in (Legese et al., 2016).

Table 2. Livelihood Component Indicator Results

Major component	Sub-component	LSB N=150	USB N=150	Max. value	Min. value
SDP	Dependency ratio	1.7	1.2	8	0
	Female-headed HHs (%)	9.33	4.33	100	0
	Mean age of female head of HHs (1/years)	0.023	0.026	0.05	0.01
	HHs not attended school (%)	73.33	78.67	100	0
	HHs with orphans (%)	22	16.67	100	0
LS	HHs working in a different community (%)	17.23	11.35	100	0
	HHs reliant on agriculture (%)	90	91.3	100	0
	Mean agricultural LDI	0.266	0.301	0.5	0.14
SN	Mean receive: give a ratio	0.992	0.909	8	0.3
	Mean borrows: lend money ratio	0.846	0.909	2	0.5
	HHs who assistance by Government /12 months	44	62	100	0
Health	Mean time to health facility	211	492	560	120
	Prolonged illness (%)	55.63	39.6	100	0
	Family member miss work due to illness (%)	9.93	8.19	100	0
	Mean exposure deterrence index of malaria	4.03	0.9	12	0
Food	HHs dependent on farm for food (%)	99	93.3	100	0
	number of months, food shortage	1.99	3.091	12	0
	crop diversity index	0.17	0.22	1	0.1
	HHs do not save crops (%)	20.23	6.71	100	0
	HHs not saves seeds (%)	18.61	16.11	100	0
Water	Reported water conflicts (%)	92.05	54.36	100	0
	HHs used natural water source (%)	92.72	88.59	100	0
	time taken to water source	30	54	360	1
	HHs do not have consistent water (%)	15.89	67.11	100	0
	Water stored per HH (1/ the average number of liters)	0.02	0.03	1	0.0007
NDCV	No. of climate hazards/decade	18	21	24	1
	HHs didn't get a warning (%)	74.89	76.89	100	0
	injury/death(%)	30	27.42	100	0
	Mean Tmax. (1993–2012)	0.9	0.8	1.9	0.4
	Mean Tmin. (1993–2012)	0.99	0.92	3.1	0.3
	Mean RF (1993–2012)	130.9	148.3	213	95

Note: HHs=households, LSB=lower sub-basin, USB=upper sub-basin, SD=standard deviation, LDI=livelihood diversification index, RF=rainfall, T=Temperature max=maximum, min= minimum (Legese et al., 2016).

Livelihood strategies of both sub-basins percentage of households with family members who have been working in a different community for their additional income (off-farm and non-farm activities) found to be 17.23% for the LSB and 11.35% for the USB. The percent of households who depend solely on agriculture as a source of income were higher for both sub-basins (90% LSB and 91.3% USB).

On the other hand, some indicators such as the Livelihood Diversity Index (LDI) were created because an increase in the crude display that the higher number of livelihood activities undertaken by a household is associated with a decrease in vulnerability. In other words, any households (HHs) that cultivates crops and raises animals will be less vulnerable to the impacts of climate change than a household that engaged in only crop production. The diversity of livelihood sources plays a vital role in that in an event when one of the livelihood means is damaged by climate change induced shock, households would survive on the other alternatives (Aymone, 2009). The IPCC in its fourth assessment report also stated that diversifying income sources stand as the primary measure of households' vulnerability and resilience. The more the household relies on multiple sources of income generations, the smaller it is affected by climate change shocks. In this analysis, livelihood diversity measured by counting the different types of farming, livestock and non-farm income produced during a year (2013). By taking the inverse of the crude indicator, a number that reflects this line of reasoning and assigns higher values to households with a

lower number of livelihood activities (World Bank, 1997). In this study, the LDI values of the respondent households imply that there have been a number of agricultural practices like crop production, animal rearing and off-farm in the LSB (0.266) than the USB (0.301). In general, the livelihood strategies of the respondents in both cases were found to be highly dependent within their community and agriculture is their common sources of income.

On the other hand, social networks build a sense of community that contributes to the resilience of individuals and groups. In the study area, the types of networks that are important for strong social bond include families, friends and community institutions. These groups contribute a better relationship within a social group; a sense of friendship, identity and social cooperation; and strong linkages to outside group that can bring additional social, financial or political resources. In the study area, the most common social network, developed between the community highly dependent on receiving and giving help, borrowing and lending money as well as establishing cooperation with the local government and local institutions such as*Idir, Mahiber, Iqub, Senebte, Debo*, etc. The participation in local institutions is a strong determinant of household's resilience to adverse impacts of climate change(Amoatey and Sulaiman 2018). Based on this, the average number of households who received assistance compared to those giving to others is found to be 0.992(LSB) and 0.909 (USB). This implies that households were giving and receiving assistance almost at a similar rate in both sub-basins. A household gives assistance for others at one time and receives at another time in similar or different cases. Similarly, the respondent household average borrowing and lending money ratios computed to be 0.846 for the LSB and 0.909 for the USB. The percent of households who reported on receiving assistance from the local government and local institutions during the last 12 months found to be higher for the USB (62%) than the LSB (44%). The USB rural communities have got food aid during hard seasons of the year, participated in watershed development and soil and water conservation practices than the LSB residents.

The health status of the community has been assessed based on the accessibility of health facility, the family members who were chronically sick, family members who missed work or school and the average malaria exposure and prevention index. Based on these variables the respondent households reported that LSB residents took shorter time to reach the nearby health facility (211 minutes) than the USB residents (492 minutes). This is due to the fact that the availability of many urban settlements and access to the main asphalt road from *Bahir Dar* to *Gonder* town. The percentage of households who were chronically sick for the past 12 months (2013/14) was higher in the LSB (55.63%) than the USB (39.61%). This might be due to the fact that the households in the LSB are highly vulnerable to malaria and waterborne diseases since water lodging and wetlands are common in the area. On the other hand, the percent of households reported who missed work or school in the past 12 months were slightly higher in the LSB (9.93%) than the USB (8.19%). This can be attributed to the same reason mentioned earlier. Moreover, the average malaria exposure and prevention index was calculated based on the months reported with exposure to malaria and owning at least one bed net indicator (have bed net=0.5, no bed net=1). Accordingly, the calculated value of the average malaria exposure

to prevention index in LSB found to be higher (4.09) than the USB (0.9) which implies that the LSB residents exposed to malaria incidence for at least four months and the USB exposed for less than one month.

Food security assessment in the region was done based on the parameters, which are common in the area, including those who depend on agricultural practices, average number of months, households struggle to work for food, average crop diversity index, and percent of households who do not save crops and seeds. The result showed that almost all residents have been depending on the production from farm for their livelihoods. Whereas, the average number of months the USB households struggle to find food found to be greater (3.09 months) than the LSB (two months). This is because LSB households have access to irrigation and use residual moisture for extra food production, whereas households in the USB had restricted or little access. The average crop diversity index was calculated based on the inverse of (the number of crops grown by a household). The higher crop diversification index value indicates smaller number of crop types cultivated in the area, implying that households were highly vulnerable. The value indicated that farmers in the LSB (0.17) have cultivated as many crops as possible and are less vulnerable than those in the USB (0.22). Moreover, households who save crops for hard seasons are less vulnerable than those who do not. In this case, LSB respondents save crops and seeds (20.23 and 18.61%, respectively) better than the USB (6.71 and 16.115), respectively.

Water resources assessment was conducted using frequency of conflicts, households who depend on naturally available water, accessibility, consistency and the inverse of liters of water stored by households. Based on this, the percentage of households who reported to be involved in the water conflict in the LSB was (92.05%) which was higher than the USB (54.36%). This is due to the extensive use of irrigation by the LSB residents. On the other hand, almost all respondents reported that the major water sources are from naturally available sources like rivers, lakes, hand dung walls, rainwater, etc. which are highly vulnerable to any fluctuations of weather phenomenon. Fewer households have got tap water in both sub-basins. The average time taken by residents to reach water sources for LSB residents is found to be 30 minutes and 45 minutes the USB. The respondents who didn't have a consistent water supply in the USB (67.11%) were higher than the LSB (15.89%); and this is dependent on the nature of the rainfall. The proportion of respondents in the LSB was lower due to their access to groundwater and *Lake Tana* during dry season. The inverse of the average number of litres of water stored per household for LSB (0.02) was greater than the USB (0.03).The other livelihood vulnerability indicator component is natural disaster that arises due to climate change and or variability. Due to the frequency of shocks, traditional coping mechanisms adopted by vulnerable communities are eroding(Tesso, Emana et al. 2012). During previous drought, floods, disease out-breaks; landslides and shocks episodes, households have been able to draw on kinship support networks, or other assets for food, and/or migrate to areas with more plentiful natural resources. However, due to a variety of factors, including continual population growth, environmental degradations and the increasing severity and frequency

of climate change hazards, people are less able to provide informal social safety nets for the neediest households.

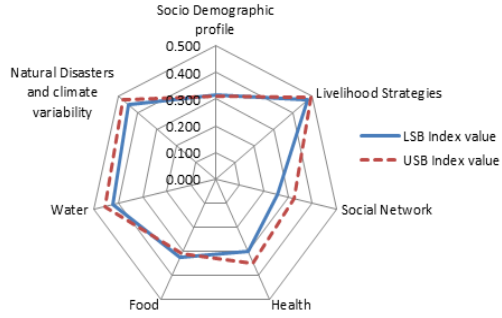
Furthermore, a combination of severe shortfalls and disruption of rainfall patterns, depletion of natural resources, ongoing conflicts and the lack of viable livelihood alternatives increase and challenge the resilience of vulnerable households. This component of vulnerability indicator assessed using the common variables like average number of flood, drought, and hailstorm occurrences for the last decade. Moreover, the percent of households who did not receive a warning, with an injury or death as a result of recurrent disaster, mean standard deviation of the monthly average of mean maximum and minimum daily temperature, and mean standard deviation of monthly average precipitation of the period 1993 to 2012 have been taken into consideration. Therefore, almost the same number of respondents reported that there were flood, drought, and hailstorm events in each year during the past decade. A significant number of households from the USB did not get a warning. This is due to the fact that the inaccessibility for infrastructures and the irregular and remote nature of the region. The percent of households with an injury/death because of the recent disaster in the LSB were due to flooding and hailstorms and the USB largely by drought and hailstorm events. The mean standard deviation of the monthly average of mean maximum daily temperature for LSB found to be 0.9 and that of the USB 0.8. Whereas, mean standard deviation of the monthly average of means minimum daily temperature is found to be 0.99 (LSB) and that of the 0.92 (USB). The mean standard deviation of monthly average precipitation for LSB computed to be 130.9 and that of USB 148.3. This implies that there is a significant variation in the weather and climate elements in both sub-basins.

Livelihood Vulnerability Index using a pragmatic approach is a numerical scale calculated from a set of variables selected from all the regions and used to compare them with one another or with some reference points. The numeric value is used in the sense of ordering or based on the computed index differences and hence, regions ranked and grouped to be relatively more or less vulnerable. Accordingly, the LVI used a balanced-weighted average approach where each sub-component of livelihood vulnerability contributes equally to the overall index even though each major component is comprised of a different number of sub-components. Because each of the sub-components measured on a different scale, it was then first necessary to standardize each as an index. The major components and the composite LVI for LSB) and USB are presented in Table 3. Based on the index calculation, the sub-component values of dependency ratio, inverse of female-headed households and households with orphans found to be greater in the LSB. This implies that under this component, the LSB residents have been highly vulnerable compared to the USB residents. This result is supported by the overall major component of socio-demographic profile index value of 0.317 for the LSB and 0.309 for the USB residents. On the second major component, though the sub-component values of households with a family member working in a different community for the USB (0.114) was smaller and indicated less vulnerability, the overall livelihood strategies index value of the USB (0.491) residents found to be highly vulnerable than the LSB (0.474).

The Social Networks indicators computed to be 0.254 for LSB and 0.324 for the USB respondents. These values has shown that the USB respondents lack social integrity as compared to the LSB respondents by the selected common parameters such as borrowing and lending money, granting and accepting any assistance and by the activities of the interactions with the local government. The LSB respondent households reported borrowing money more frequently and having more in-kind help from a family relative to the number of times they lent money or provided assistance than the USB households.Average malaria exposure by prevention index were computed using(Legese, Olutayo et al. 2016). The results disclosed that in the overall health vulnerability score for the LSB (0.300) found to be smaller than that of the USB (0.345). This is due to longer distance to a health facility in the USB than the LSB. Nevertheless, in the LSB, the sub-component index value of household members with chronically sick (0.556) and average malaria exposure by prevention index values (0.336) have been higher indicating higher vulnerability. Although the overall food vulnerability score for USB was found to be lower (0.310) than LSB (0.324), the sub-component index value of crop diversity index for USB (0.148) which indicated less diverse than the LSB (0.081). In general, based on the major component index value, the LSB residents found to be slightly vulnerable as compared to the USB residents.Along the water component, LSB respondent households also experienced a slightly vulnerability score (0.421) than USB (0.456). This value has shown that both sub-basins respondents are highly vulnerable for water resource component.

The last component, natural disaster & climate variability of both sub-basin residents had similar natural disaster vulnerability records. This component was computed according to the average number of flood, drought and hail storm events for the past 10 years in the sub-basin. Households who didn't receive early warning service and the percentage of households reporting a tragedy-related trauma or destruction were seen in both the USB and the LSB. When climate variability was integrated into the natural disaster index, however, LSB households found to be less vulnerable (0.445) than USB (0.475) households.

The USB in general received a higher LVI than LSB (0.392 versus 0.368, respectively). This suggests that relatively greater exposure to the adverse shocks of climate change in the USB than the LSB. The results of the major component analysis are presented collectively in a spider diagram (Fig.2). Furthermore, the livelihood vulnerability index uses a balanced-weighted average approach (standardised) where each sub-component contributes equally to the overall index even though each major component is comprised of a different number of sub-components (Legese et al., 2016). The scale of the diagram ranges from 0 (less vulnerable) at the center of the outside edge, increasing to 0.5 (more vulnerable) at the outside edge in 0.1 unit increments. USB is more vulnerable in terms of livelihood strategies, social networks, health profile and water resource while LSB is more vulnerable in terms of socio-demographic profile, food and natural disaster related to climate variability.



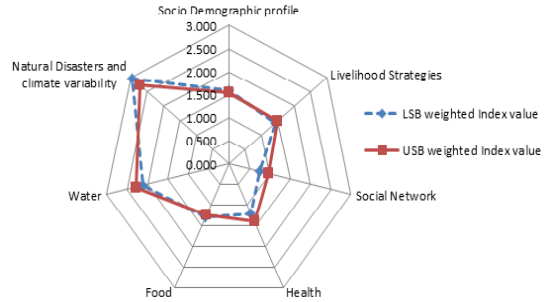


Figure 2. Standardised Vulnerability Spider Diagram of Livelihood Major Components
Figure 3. Vulnerability Spider Diagram of the Weighted Major Components

On the other hand, the LVI uses a weighted average approach where each sub-component contributes differently to the overall index since each major portion is made up of a different number of sub-elements. The weighted vulnerability spider diagram of the major components demonstrated that a similar analysis with that of the standardised one. In the weighted vulnerability spider diagram approach, the scale of the diagram ranges from zero (less vulnerable) at the center of the spider diagram, increasing to three (more vulnerable) at the outside edge in 0.5 unit increments. Figure 3 shows that USB is more vulnerable in terms of livelihood strategies, social networks, health status, and water resource while LSB is more vulnerable in terms of social demographic characteristics, food and natural disaster due to climate variability.

Conclusion

The vulnerability of rural farm households is largely determined by variety of factors that include social, economic, and natural factors (Legese et al., 2016). Households living in different agro-ecological location (sub-basin) exhibit vulnerability to different types of hazards. The effect of location in terms of sub-basin also determines households' susceptibility to the risks; where people living in the floodplain areas are relatively much vulnerable to risks of climate change as compared to highlanders, in the context of the study area. This emanates from the topography of farmlands, frequency of natural shocks, low experience of people to adapt to climate change impacts and more. Social factors like low level of literacy or lack of awareness on hazard related issues have been another exacerbating factor in the sub-basins for vulnerability. On the other hand, households living in the highland areas (USB) were vulnerable to drought, disease outbreaks and alien weeds. However, when comparison is made between the sub-basins in the study area, USB was not vulnerable because of better experience of operating agricultural activities under stressful conditions, better access to credit, and better aid from governmental and nongovernmental organizations. Though LSB households were more vulnerable, better adaptive capacity seems a factor of moderate slope of farm lands, better fertility level of farmlands, better adaptation to changing climatic conditions and relatively access to early warning information and relatively bigger size of farm land with optimal number of farm plots.

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LAND MANAGEMENT AND PERSPECTIVE PLANNING OF LANDUSE: A REMOTE SENSING AND GIS APPROACH – A CASE STUDY OF MULUGU DIVISION, WARANGAL DISTRICT, TELANGANA

Biswabandan Satpathy and Shashikala A.V.

Department of Geography and Geoinformatics, Osmania University, Hyderabad - 500 007
E-mail: biswabandansatpathy@engineer.com, avshashikala@gmail.com

Abstract:

Crisis is a very typical term that we discuss everywhere in our day to day life. Amongst all kinds of crisis, 'Land Crisis' is associated with various dimensions of socio-economic issues, being one of the Elementary Resource of livelihood now a day. It plays the most vital role for the survival of a sustainable life for every living being on the planet. Addressing this issue in a subcontinent like India encompasses several causes and consequences of the resource management practice and planning, in perspective view of development. According to the statistical reports,at present the countryshares approximately 17.83% of the world population, while its land is only 2% of the total geographical area of the world. This clearly indicates the pressure on the land is far beyond its carrying capacity. Productive lands, especially the arable agricultural lands are in a constant process of various degrees of Degradation, Transition, Transformation, Fragmentation and are unexpectedly turning into Wastelands, Built-up lands and other lands. Even it has been observed very frequently, that the Landuse pattern also has become complicated and dynamic. Unprotected non - forestlands, suffer the maximum degradation because of the excessive biotic pressure on it. In the last five decades, India's lush green village forests and woodlots have been deforested to the maximum level. Somewhere the deforested lands have been found to be used for agriculture or for settlements. Thence, a thorough study of the landuse and land cover and its optimal utilization has become the ineluctable part of the developmental planning in the recent times. Through careful land use planning the available land resources must be optimally utilised.

Keywords: Landuse, Action Plan, Degradation, Agriculture, Resource

Introduction

Developmental planning is a process by which we try to achieve our objectives with the limited resources available to us. This means we must select our objectives and set priorities in a rational manner. The planning process is therefore a process of decision

making about rational choices. Although ideally, we should try to use resources in the optimal way to achieve our objectives, in practice we rarely do that especially at local level. Human response to various resources is affected by the socioeconomic structures of the communities' concern. The problems related to conservation and rational utilization of resources should be examined in this context. Mandal level planning is an aerial study and supplementing the nation and state plans. It implies evolving a developmental scenario consistent to the specific needs of the people, the growth potentials of the area and the budgetary allocation available. The task is to bring about an effective functional linkage and coordination among various agencies for optimal resource utilization. The natural phenomena such as land systems, soil, climate and water resources etc… have almost instantaneous effect on environment of the society and hence be reflected while planning for sustainability of the natural resources. This increasingly will affect the sound and efficient use of present expertise available.

The selected geographical extent i.e. Mulugu Division in Warangal District of Telangana is amongst those areas which always has been showing a low economic growth although the Division is rich of various resources. The laxity of knowledge-based approach and technical skills in management planning has become the remarkable barrier in the development of the region. A majority of the population of the study area depends on the capacity of the crop pregnancy of the available cultivable lands. However, the notable retarding factor for the agricultural sector in contributing to the GDP of the Division is the existing improper land management. Hence, it calls for a perspective and adequate developmental plan at the grass root level which can optimise the actual value of the land.

Singh et al (2004) have shown with their study that the ground water potential of an area can be effectively deciphered using geo electrical data combined with GIS and remote sensing. They have integrated various thematic maps and have used IRS-IC-LISS - III scenes, geo–electrical data and litho–log data to detect zones that have ground water potential. Weight factors were assigned to the selected features in each thematic map based on their infiltration characteristics and the ground water potential zones in the Nagar block of Mirzapur District in Uttar Pradesh was differentiated. Their study revealed that a combination of all attributes helps in procuring more concise results in plotting out ground water potential zones.

A comprehensive study of the basic theories, concepts and models in agricultural geography and physical and socioeconomic variables that affect agriculture has been undertaken by Hussain (1979) in his work titled 'Agricultural Geography'. He has also dealt with agriculture mosaic at all spatial scales in an exhaustive manner. Beaty et al. (1978) dealt with scientific information on approaches adopted by different authors on planning and also information on effective land management and land use in their volume titled 'Planning the Uses and Management of Land'. Shafi (1984) in his book entitled 'Agricultural Production and Regional Imbalances' worked on the concept of agricultural productivity and the various approaches adopted to measure agricultural productivity.

The objectives of the study are to examine the physical determinants and the spatial distribution; to analyse the existing land utilisation pattern and to propose a suitable landuse for the division (action plan).

Database and Methodology

In the current paper, the data, for the taken set of periods between 2000-01 and 2010-11, has been collected from two major sources *viz. Primary and Secondary*. The third type of data is derived from the primary and secondary data after several processing and evaluations. The Primary data was collected from the Study Area through GPS and DGPS Survey as well as statistical surveys. Then the Secondary data was further subdivided into four sub categories and were collected from different Government Authorities. Those are Statistical, Geological, Topographical and Remotely Sensed data. The Agricultural Data was collected from the Directorate of Agriculture, AP. The Water Resources and Irrigation data were collected from the Central Water Commission and Irrigation & Cad Department (Irrigation Wings, AP). Most of the other statistical data and the Soil Information were collected from the Directorate of Economics and Statistics, AP. The forest data was collected from the "AP State Forest Report, 2011" published by "State Forest Department, AP". The topographical and geological information was extracted from the toposheets of 1:50000 scale, collected from the Survey of India (SOI) and Geological Survey of India (GSI) respectively. Remotely Sensed Satellite Scenes were acquired to extract the Resource Information and to prepare the Database for Resource Information System (RIS). Multi-seasonal Scenes of the Landsat-7 Enhanced Thematic Mapper (ETM^+) and Landsat-5 Thematic Mapper (TM) were collected from the official United States' Geological Survey (USGS) database, for the period of 2000-01 and 2010-11 respectively to prepare the Landuse Land Cover (LULC) maps.

The "Derived Data" is a result of several complex processing and management of these Primary and Secondary Data which includes most part of the Methodology and its Stages. The satellite scenes were processed using "Supervised & Non-Supervised" classification techniques in ERDAS Imagine, the scenes were processed and the possible Landuse/ Land cover classes were extracted from raster to vector format for further vector analysis in ArcGIS. There the specific spectral signatures of different earth features were used to distinguish the various classes from the sample training sites which were collected during the field DGPS survey. Multi temporal LULC data were compared for the change detection and percentile calculation.

For the study of the terrain, the Relief, Slope are generated from the Global 1^cs (30m) ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) Satellite DTM rectified by the GHPs (Ground Height Point) of the SOI Toposheets which helped understanding the flow direction of the surface water within the Study Area.Geological toposheets were used to study the chemical contents and the pH condition of the soil of the agro-fields which means the Fertility Information System of the Agricultural

Lands (FISSAL Database), to identify the Fine Cultivable Soil Covers (FCSC) within the Study Area.

Political Overview of the Study Area

The study area i.e. Mulugu Division, situated in Warangal District of Telangana, is bounded by Karimnagar District in the North, Medak District in the West, Nalgonda district in the South and Khammam District in the East of its borders. The Study Area extends between 17.9957°N to 18.6097°N Latitudes and 79.5593°E to 80.6665°E Longitude on the Decan plateau in central region on Gondwana Land of Indian Subcontinent. Thirteen Mandals constitute the Division's administrative jurisdiction*viz. Bhupalpalle, Mogullapalle, Chityal, Bhupalpalle, Ghanpur, Venkatapur, Eturnagaram, Mangapet, Tadvai, Govindaraopet, Mulug2, Regonda and Shayampet.* Geographically the Division occupies 448949.75Ha. of land accounting to 34.96% of the total District area and is spread over in the northern part of the District (Figure 1). Eturnagaram and Tadvai are the two largest mandals whereas Mogullapalle and Ghanpur (M) are the two smallest mandals by geographical area in the Division.

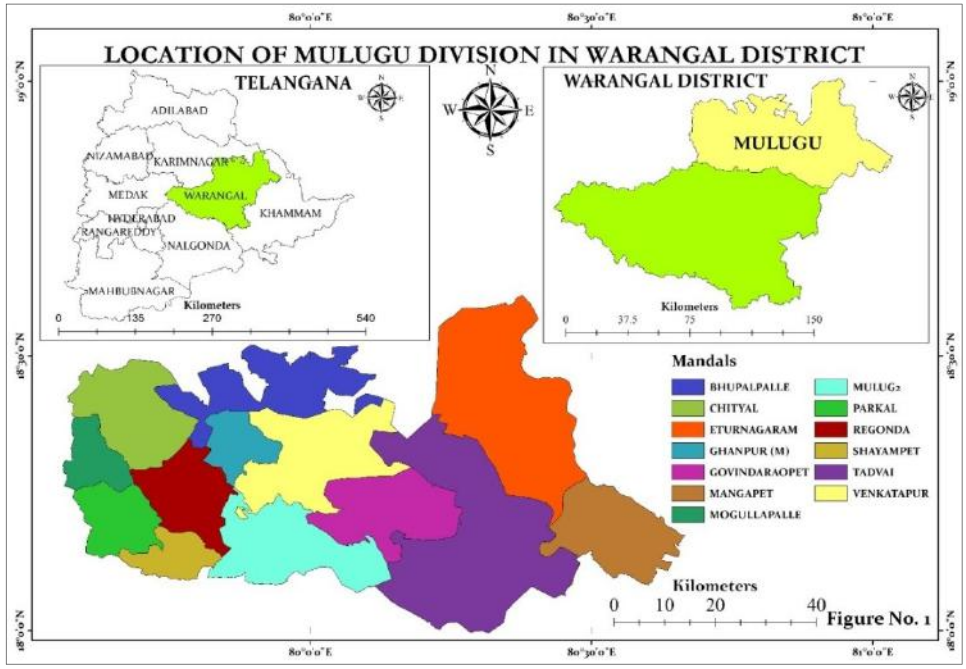

Fig. 1. Mulugu Division of Warangal District, Telangana

Source: SOI Toposheets on 1;50000 Scale

Geographical Overview of the Study Area

Slope: Most of the central part of the Division extending from North-Central to central region of south-east is hilly and hilly and highly undulated (Figure 2). In these regions the lands are elevated from 30°-45° centring round the Hill summits, which are

elevated maximum up to 61.5° making a range of hills in the central regions of the Division. Some of the high rising sporadic hills are spotted here and there in the extreme North-West, South-West, North-East and South-Eastern regions of the Division. Similar to the central hill range, these spotty mountains are also elevated from 40°-61.5° showing steep slope to all directions. But the slope of the range of hills which is diagonally creased through the central regions of the Division is observed to be negative towards the east, which means the western side of the Hill ranges are lofty up to 61.5° and the eastern side is squat from 30°-0° and finally emerges to the Godavari River basin towards the Eastern and North-Eastern border. These hills are parts of Eastern Ghats on the Deccan Peninsular. Rest of the entire Division is almost flat by nature. Overall, the topography of the Division is undulated. undulation is a bit less in the western half of the Division as compared to the other half.

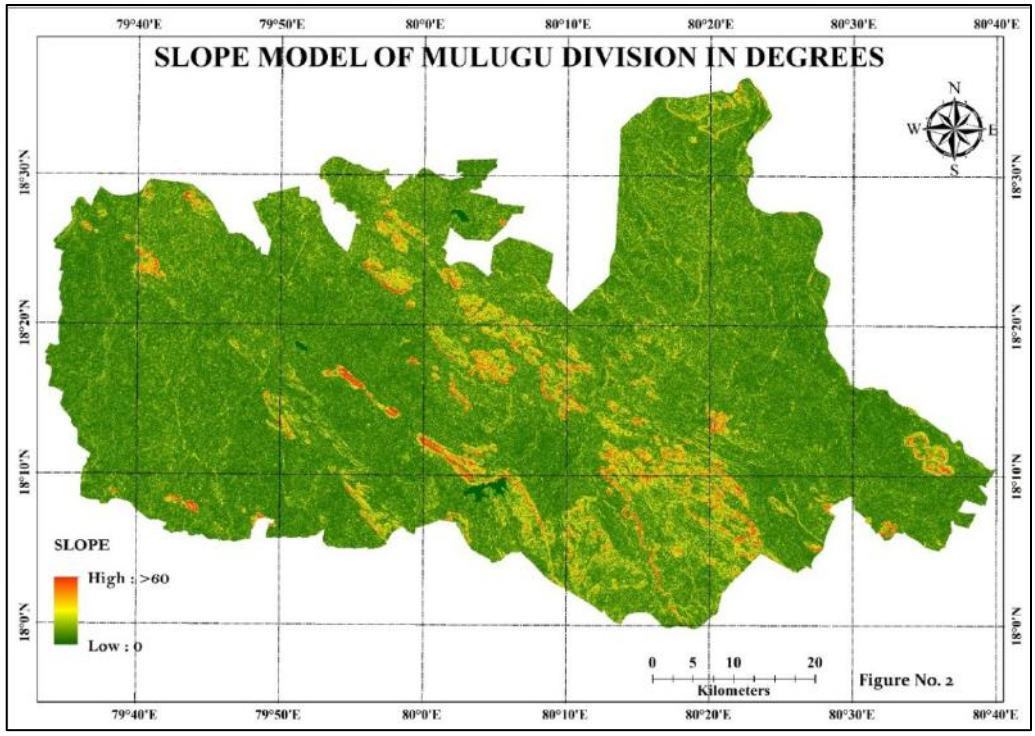

Fig. 2. Slope of Mulugu Division

Source: ASTER Global 30m DTM

Landforms: Nearly 6% of the total geographical area of the Division has been covered by Surface waterbodies and Drainage System. Apart from this, massive Residual Hills which are diagonally spread from North-West to South-Central region, total occupy nearly 13.5% of the geographical area dividing the Study Area into two halves (Eastern and Western). The major Surface Waterbodies are endowed within these massive hill valleys (Table No. 1). Next to the Hill Systems, the Inselbergs, Structural Ridges, Linear Ridges and Dikes constitute the Pediment Inselberg Complex System which occupies nearly 10% of the entire area.

These systems are mostly found parallelly spread along both sides of the Hill Systems and along the eastern sides of the river channels and surface waterbodies of the eastern region (Figure 3). Immediate after the inselberg complex, on the western side of the surface waterbodies and the river channels constitute the floodplain, which account nearly 16% of the Study Area. These are seen spread through the western part of the river basins both in the eastern and western border of the Division. Some large patches can be seen below a big waterbody within the Residual Hills and within the South-Central region. These are mostly Alluvium resting over the bedrock forming Plains. Pedi plain Weathered is spread over the maximum extent within the Division accounting to more than 50% of the study area. Both moderately and swallowed Pedi plain are found everywhere throughout the region.

Table 1. Percentage of Area of various Landforms in Mulugu Division

Sl. No.	Major Landforms	Class Area in Ha.	Percentage
1	Drainage & Waterbodies	26682.254	5.943
2	Residual Hills	60589.161	13.496
3	Pediment Inselberg Complex	45962.795	10.238
4	Floodplain	70707.937	15.750
5	Pedi plain Weathered	245007.601	54.574
6	Total	448949.746	100

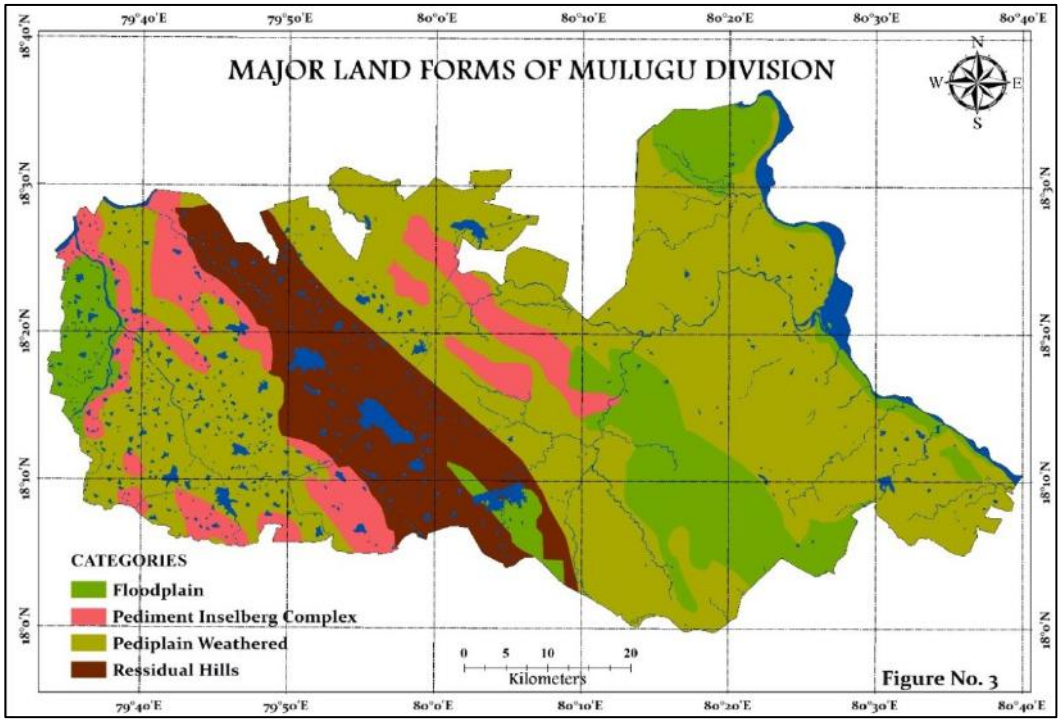

Fig. 3. Landforms of Mulugu Division

Source: Derived from GSI Toposheets and ASTER DTM Slope

Surface Waterbodies and Drainage System: The entire Division is very well webbed with drainage devices including the major rivers like Godavari and Mungeru.The major perennial river that flows along the North-eastern to eastern border of the Division is the Godavari, which because of the obstructing Central and north central and hilly forest cover the rich resource of water could hardly be used for the purpose of irrigation as most of the agricultural lands are spread through the eastern part of the Division. Another Small perennial tributary of the river Maner known as 'Mungeru', fountained from Buddaram Lake and Ghanpur Lake in Ghanpur Mandal, Ramappa Lake in Mulugu2 Mandal, flows through the agriculturally rich eastern region of the Division. Altogether the rivers, streams and rivulets have educed a number of perennial and seasonal groundwater catchments, lakes, reservoirs and some small artificial projects. The major lakes found in the Division are Bhimghanpur Lake in Bhupalpalle, Buddaram Lake and Ghanpur Lake in Ghanpur Mandal, Ramappa Lake in Mulugu2 Mandal, LaknavaramCheruvu in Govindraopet Mandal and Chalivagu Project (Artificial Tank) in Shayampet Mandal (Figure No. 4).

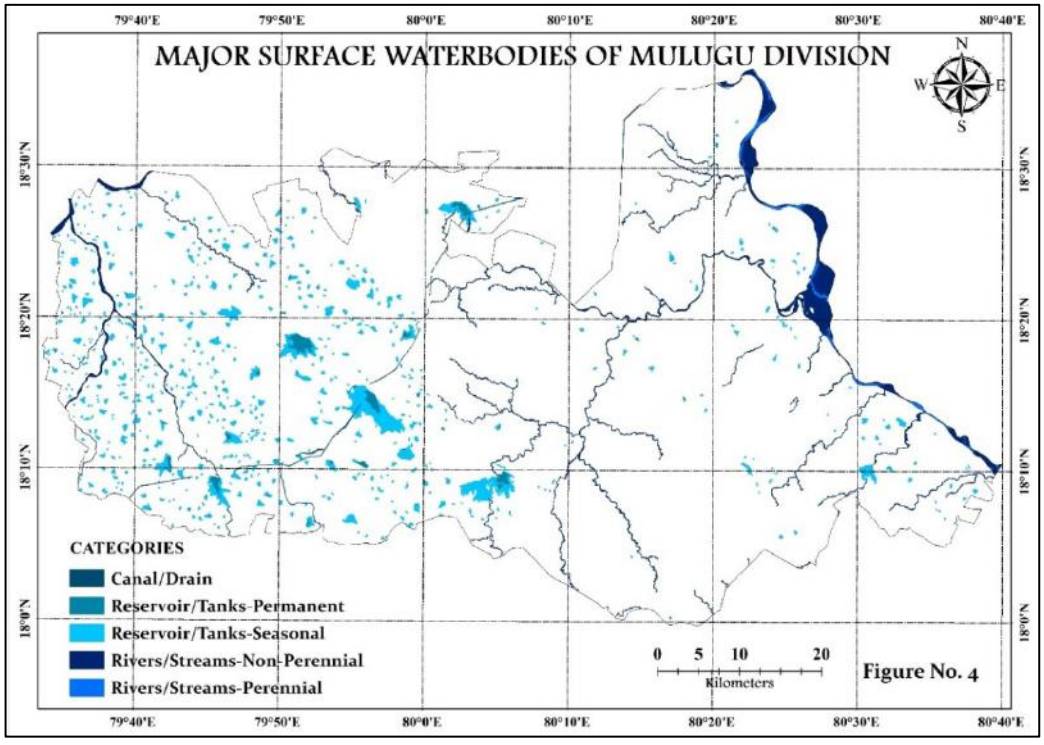

Fig. 4. Surface Waterbodies of Mulugu Division

Source: SOI Toposheets & Landsat-7 ETM+ Multi-seasonal Scenes

Distribution of Soil Types: Constant withering of the pink and grey granites surrounding the residual hills and plateau regions, a large part of the Division has filled the North-Central to South-East by shallow gravelly red soil and moderately deep calcareous black soils accounting to 24.36% of the total lands. Moderately deep calcareous black soils are spread over 14.71% of the total Division area. Because of hard soil strata and elevated

terrain in these regions, quantitatively the moisture contain is very less. Such soil type is suitable for Wheat, Paddy, Millets, Grams, Sugarcane, Groundnuts, Coconut and Ragi with an assured irrigation. But the canopy of Forest Cover and Scrubs has led the area under such soil type less of its use. Moderately deep calcareous moist clayey soils are found in some part of the south-west regions of the Division covering 6.69% of the total area. Because of moisture contain such types of lands are useful for Wheat, Paddy, Millets, Pulses, Rubber and Zaid crops. The very next type of soil which counts the second maximum area within the Division is Loamy to Clayey Skeletal Deep Reddish-brown soils spreading over 22.86% of lands (Table 2). Being highly fertile, such type of soil, which is mostly found along the foothills or less elevated lands, is more useful than the Shallow Gravelly Red ones.

Endowed with cluster of streams, perennial or non-perennial surface waterbodies on such soil type, capacitates the land to crop Wheat, Maize, Sugarcane Paddy, Fruits, Mustard and Sunflower. Clayey to Gravelly Clayey soils, which are Moderately Deep Dark brown, are found in some part of the north central, north-east and west central to south central regions of the Division (Figure No. 5) spreading over 15.98% of the total available land. Because of surface water availability, the soil is best useful for Ginger, Chili, Grams and Paddy cultivation with an assured irrigation. Nearly 6.91% of the total Division area is covered by Deep Black Clayey Soil and Moderately Deep Calcareous Moist Clayey soils, which are found in the south-western part of the Division. Such type of soil is suitable for Paddy, Sugarcane, Watermelons, Cottons, Black grams and some other Zaid crops. Light Grey Deep Sandy soils cover the north-east border of the Division, which accounts to the least coverage of area (1.28% of the Division).

Table 2. Soil Taxonomy & Percentage Distribution in Mulugu Division

Sl. No.	Soil Categories	Area in Ha.	Percentage
1	Clayey to Gravelly Clayey, Moderately Deep Dark Brown soils	71764.41	15.98
2	Deep Black Clayey soils	31011.39	6.91
3	Fine Loamy Gravelly Clayey Shallow Reddish-brown soils	19519.27	4.35
4	Light Grey Deep Sandy soils	5751.74	1.28
5	Loamy to Clayey Skeletal Deep Reddish-Brown soils	102615.18	22.86
6	Loamy to Gravelly Clay Deep Dark Reddish-brown soils	1058.09	0.24
7	Moderately Deep Calcareous Black soils	66024.66	14.71
8	Moderately Deep Calcareous Moist Clayey soils	30035.43	6.69
9	Shallow Gravelly Red soils	109366.78	24.36
10	Unclassified	9298.56	2.07
11	Water Body	1792.52	0.40
12	Settlement	711.71	0.16
13	Total	448949.75	100.00

Source: Department of Agriculture, AP

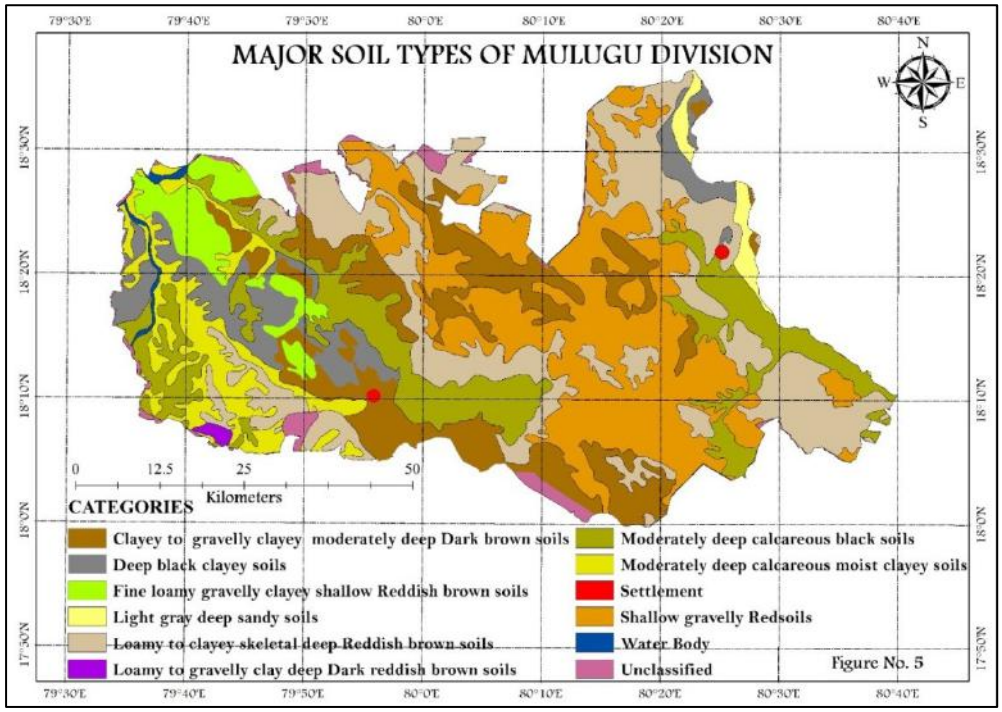

Fig. 5. Soil Type of Mulugu Division

Source: Department of Agriculture, AP

Results and Discussion

A. Existing Scenario of Landuse & Land Cover (2010-11):

Broadly the landuse and land cover of the study area has been classified into 6 categories which are shown in the Figure No. 6. A percentage distribution of various classes is also given in the Table No. 3. The major categories of Lands which are identified from the interpretation of the Multi-seasonal Landsat 5 TM Scenes are as follows:

Agricultural Lands: It includes those lands with standing crops on the date of the satellite overpass. The crops may be of Kharif, Rabi or Zaid. Interpretation of multi seasonal satellite imageries have enabled us to distinguish the lands under the use of Rabi/ Kharif or both. Further it resulted in estimating and evaluating all types of lands under agriculture including current and permanent fallow landsand merged to Net Cropped area. Such Landuse accounts to total 35.29% of the total available lands of the Division.

Built up Areas: It's defined as an area developed for human habitation and for non-agricultural use viz. buildings, transport corridors and communication networks, utilities in association with water, vegetation and vacant lands etc. The areal extent of this category of Landuse is 10859.05Ha, which accounts to 2.42% of the total geographical extent of the Division for the years 2010-11.

Forest Cover: It is an area (within the forest boundary) bearing an association predominantly of trees and other vegetation types capable of producing timber and other forest produce. The forest cover is mostly confined to be spread diagonally as a wide vegetal canopy on the Residual Hills of the Division. According to Champion and Seth, these forests are classified as deciduous dry forests and Tropical Thorn Forests. This covered a total of 234942.10Ha accounting to 52.33% of the total geographic extent of the Division during.

Table 3. Distribution of various LULC categories for the years 2010-11 in the Division

Sl. No.	Landuse and Land Cover	Area in Ha.	Percentage
2	Agricultural Lands	158419.28	35.29
1	Built up Areas	10859.05	2.42
3	Forest Cover	234942.10	52.33
4	Tree Clad Area	8369.14	1.86
7	Open Vegetation	78.72	0.02
5	Wasteland Scrubs	9601.84	2.14
6	Surface Waterbodies & Drainage	26679.61	5.94
8	Total	448949.75	100.00

Source: Landsat 5 TM Image Analysis

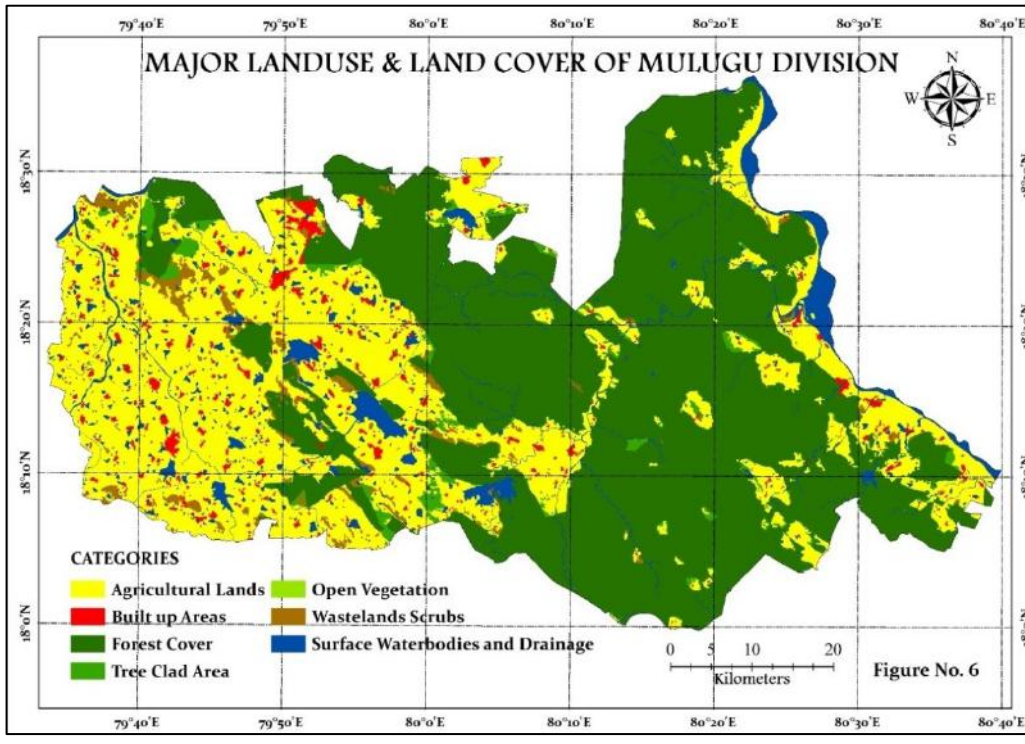

Fig. 6. LU/LC of Mulugu Division

Source: Classified from Landsat 5 TM Multi-seasonal Scenes (2010-11)

Other Vegetations: Other vegetal Covers includes any vegetation other than Agriculture and Forest cover usually are often found surrounding the Settlements as mottled or blotchy greenery including small Bushes, Shrubs, Meadowlands, Open Scrubs and Attired Tree Crops etc. Such vegetations are classified as Tree Clad Areas, Open Vegetation and Wasteland Scrubs for the convention. The Division has very negligible percentage of Tree Clad Areas and Open Vegetation accounting to 1.86% and 0.02% respectively. Wasteland is defined as "The land which is degraded and presently lying unutilized except for current fallows due to different constraints". Under this type of land two categories were identified and delineated *viz.* Land with / without scrub and barren rocky stony waste, Land with/ without scrub: These are the areas which occupy relatively higher topography like uplands or high grounds with or without scrub and are generally prone to degradation or erosion. These are exclusively hilly terrain and are clubbed to one category of Land Cover. A remarkable percentage of area (2.14%) is covered by Wasteland Scrubs in the Division.

Surface Waterbodies and Drainage: The total area covered by this category within the Division is 26680.54Ha. The major river flowing along the North-eastern border of the Division is The Godavari. Further the Division is drained by few of its tributaries towards the western margin of the Division. The details are already discussed before.

B. Suggested Action Plan:

Land is the most important productive resource amongst all other available resources on the planet. An adequate and proper utilization of it can give the optimum benefit for the livelihood and sustainability of human beings on earth.

Apart from the Built-up areas and Waterbodies of the division, rest of the land resources are divided into four categories, based on the land elevation (i.e. Plain, 15^{o} to 30^{o}, 30^{o} to 45^{o}, 45^{o} to 60^{o}), forest coverage in varying densities and tree clad areas. Since forest lands can't be used for crop yielding but best suited for Wildlife, Animal husbandry and Poultry farming, as, very good surface water and drainage is present there within.

From the Figure 7, it can be seen that the first category of lands is covered by Deciduous Dry Dense Forest with thorn trees and the lands are elevated ranging from 30^{o} to above 60^{o}. So, these areas are best suited for wildlife habitats. The second category of lands identified are mostly covered by Dense Tree Clad, Scrub Forest and Reserved Forest Plantation, wastelands scrubs on red soils where the elevation ranges from 15^{o} to 45^{o}. Since adequate drainage devices and surface water is available in these areas hence can be used for pastures and poultry farming. Although surface water facilities are existing nearby but because of the soil infertility these can be suggested so as. The third type of lands have 15^{o} to 30^{o} elevation and covered by Open Deciduous Forest. This type of canopy has grown on infertile red soil and is not suitable for cropping. Even Agroforestry can't be suggested there because of several forest protection regulations to conserve the deforestation of Southern Plateau Deciduous Dry/Moist Open Forest. So, these lands need to be conserved for Wildlife as the forest has started shrinking because of over grazing of

domestic cattle. So only poultry farming can be practiced instead of pastures. The fourth and only one category of lands are found to be spread over plain lands covered by open vegetation. These areas are mostly nearby the human settlements and the area is not much spread over as compared to the other types of land classes. These lands could also be suggested to be used for pasture grazing. Although the first three types of land classes are based on the terrain elevation, but qualitatively these are suggested under three types (First three classes) of landuse which can be seen in the Figure No 7.

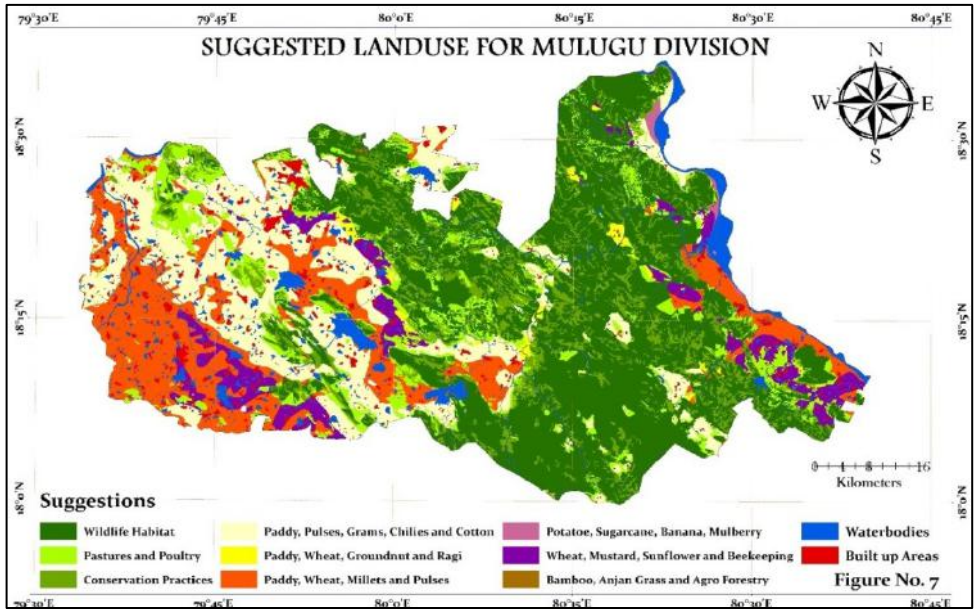

Fig. 7. Suggested Landuse for Mulugu Division

The fourth category based on the elevation below 15^{o} form the plains. These plains are further subdivided into six classes on the basis of soil types, existing cropping pattern and surface water. These are confined to the western part of the Division which are mostly agricultural lands. Every other type of soil is meant for some special types of crop to be cultivated with an assured surface water and irrigation facilities. So, the productivity gets widely affected if the appropriate crops are not cultivated on those lands. The soils covered by the fourth class of the landuse class are identified as “Clayey to Gravelly-Clayey and moderately Deep Dark Brown Soil” and “Loamy to Gravelly-Clayey Deep Dark Reddish Brown Soils” with assured surface water, drainage and irrigation facilities. These soils are mainly found in the deforested lands transformed into agricultural lands. These are usually highly fertile with forest biomass and have a very good moisture content in the soil. So, the best suitable crops suggested here are Paddy, Pulses, Grams, Chili and Cotton. The fifth class of lands are confined to have a very good drainage facility *viz. rivers and streams* flowing within and the soil is of Deep Black Clayey type. So, these types of soils are suitable for Paddy, Wheat, Groundnuts and Ragi farming. The soil type found underneath the sixth type of landuse class is ‘fine loamy gravelly clayey shallow reddish brown soils’

with good surface water facility scattered here and there. The best crop combination suggested here for these types of soils are paddy, wheat, millets and pulses. Although these types of soil quality are found in a large coverage within Regonda Mandal, but lack of irrigation and surface water retards the suggested crops to be cultivated there. So, improvement of irrigation can increase the productivity and change the crop combination on those types of lands. The seventh class of lands identified are nearby river banks. Hence the 'light gray deep sandy' soils are found there. These types of lands are best for cropping potato, sweet potato, sugarcane and bananas. Even mulberry plants can be grown for silkworm farming. No other crops can give optimum benefit on cultivating. The soils of the eighth type of land classified as per 'loamy to clayey skeletal deep reddish brown soils, moderately deep calcareous black soil'. These types of soils are usually found near by the mountain foot. So somewhere a very good drainage is seen and somewhere moist soil with cold temperature is found. These types of lands are best suited for paddy, wheat, sunflower and mustard cultivations. Again, it is suggested for honey bee farming in the mustard and sunflower farm fields. This type of mixed farming can be practiced therein. Also, these types of soils are found nearby the plateaus with scrub cover blended with the Agricultural lands near the non-perennial surface water catchment areas. With an assured irrigation facility dry land agriculture like paddy, wheat, millet and pulses can be cultivated very well. Or otherwise on the less irrigated lands rubber plants can be grown as well. The ninth and last type of lands are identified nearby the deep mountain valleys and dried river or stream valleys. So, the soil found there are of Ravine type. These lands are also identified as ravine wastelands and are highly undulated with low elevation. So, no food crops can be suggested for these types of lands. Only bamboo and anjan grass can be suggested there. Also, Agroforestry can be suggested for the best use of these lands.

Table 4. Action Plan for Optimum Landuse in Mulugu Division, Warangal District, Telangana

Sl. No.	Landforms		Geology	Slope	Soil	Surface Water	Present LULC	Proposed Landuse
1	The Hill System	Group of Massive Hills occupies the North-West to South-Central region with Broad Valley Floors accounting to 13.5% of the area.		Varying from 15° to 45° except on the Steep Hill Submits (>60°) and Valley Floors 0°.	Dark Brown, Gravelly and Deep Black Clayey Soils cover surrounding the Hillly Regions. Deep Sandy Soil spread is found along the Valleys and Surface waterbodies. Skeletal Deep Reddish Brown Soils are seen along the Hills.	Zones of Heavy run off are mostly perennial and Major Three Perennial and non-perennial surface waterbodies fall within this zone.	Landcover with few patches of Dry to Moist Deciduous Forest and Scrubs are also found here and there. Rest of the plain land agriculture is encroached.	Suitable for Conservation and Development of Vegetation Cover-Natural and Manmade Plantation.
2	Pediment Inselberg Complex	These are found in the North-West region along the River Basin and the Residual Hills and towards the North-Central region. These complexes are composed of Inselbergs, Structural Ridges, Linear Ridges and Dikes.	Granite	Moderate Slopes ranging from 5° to 20° from River basins towards Residual Hills.	Calcareous Reddish Brown and Deep Clayey Skeletal Soils are mostly found in these areas.	Zone of Run off and form drainage devices.	Mostly undulating rock out plain with small hills and crops supporting degraded vegetation mostly corresponding to Dry Deciduous Species.	Suitable for the Development of the Pastures and Poultry and Conservation Practices.
3	Pedi plain Weathered	Spread everywhere throughout the Study Area. Both Moderately and Swallowed Pedi plain are found.	Peninsular Gneiss and massive Granites traversed by joints, fractures and faults.	Mostly Undulating slope ranging between 15° to 60°.	Deep black clayey soils, Loamy to clayey skeletal deep Reddish-brown soils and Shallow Gravelly Red soils.	Zones of Run off and form drainage pattern within the Forest areas and small patches of water tanks are seen within the Agricultural lands.	Towards the western parts mostly under agriculture. Towards the Central and eastern region of the Study Area is covered by Forest.	The central part of the forest cover is suitable for Wildlife and the surrounded degraded forest should be under conservation practices. For the cultivable regions, intensive agriculture can be practiced.
4	Flood Plain	Alluvial Plains	River borne Alluvium resting over bedrock, found as a narrow stretch Major River/ Streams.	Nearly level plains.	Alluvial Soils with fine texture and clay base.	Canal Network from the River Godavari and Natural/Artificial Reservoirs proximity to the tanks to the surrounding areas.	Intensive Agriculture under canals, mostly seen under Paddy, Cotton and Maize.	Other than Paddy and Cotton, the land is suitable for Commercial Crops like Sugarcane, Sunflower, Mulberry, Bee Keeping, other crops like Wheat, Millets, Pulses and Plantation like Banana.

Conclusion

The study highlights, the need for an overall development of the Division based on a scientific and integrated approach. The approach of integration aims at a synthesis of contrasting aspects such as physical, socioeconomic and ecological development. Envisaging the lacunae in the resource management studies, a potential resource base pattern of the Division is thoroughly analysed. The basic objectives kept in mind in preparing an Action Plan (Table No. 4) based on the parameters of Physiography, Soil, Drainage, Groundwater Potential and existing Landuse patterns is to delineate Landuse categories for their usage for which they are well-suited. This study endeavours to aim planners with a detailed insight of the available resources and their locations so that smooth management planning for the development of the division can be implemented.

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Archives - 1

VALEDICTORY ADDRESS TO THE TEACHERS' COLLEGE TEACHERS' ASSOCIATION

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By

MISS J.M. GERRARD, M.A.
Principal, Lady Willington Training College, Madras

This occasion, the 1934 valedictory meeting of you Association is not a little tinged with gloom, for the future position of Geography in the school curriculum is very uncertain. By the recent resolution of the Academic Council relating to the revision of the S.S.L.C. Course, Geography has been swept out of the important sphere of compulsory subjects, jettisoned to the fate awaiting those optional subjects, which held no pass key to the exclusive groups of the Intermediate Course. The future holds little for you, Geography students, who were looking forward, I am sure, to doing some teaching in a subject which must have captured your interest with its vitality and enthraling vistas and widening contacts. To us of an older generation who struggled for many years before getting it recognised as one of the essential subjects, the change brings with it some of the bitterness of defeat. We are back again at the old position, with Geography no longer taken seriously in the upper school, except when offered as an optional subject, and the chances of that seem remote. It is difficult to prophesy at the moment; there are faint hopes that it may become a popular combination with the science group and also with commercial subjects. If Geography could be included in the Science group, as well as in the History Group, where it is placed at present, there would result the possibility of a more valuable combination of subjects than the scheme can offer as it is. For what could be better than the intensive study of two subjects with completely different methods and content and outlook, yet each enriching the study of the other? I am perfectly sure that as regards their scope as school subjects there is more possibility of scientific method in the treatment of school Geography than in the treatment of school Physiology, and that it has on that account more claim to be placed in the science group. There is indeed no reason why there should not be two different Geography syllabuses, each appropriate to the group in which it is included.

Every cloud has its silver lining, however, and from the point of view of the better teaching and development of the subject the outlook has some cheerful possibilities about it. Let us consider the present position for a moment. For three years Geography has enjoyed the advantage of inclusion among the compulsory subjects, and one assumes that it has, on that account, received the serious attention of teachers - that it has in fact been

given a “square deal” to enable it to justify its important place in the curriculum. This is far from being the case. In the first place, the syllabus is not satisfactory; it is the emasculated remnant of the original syllabus prepared by the Geography sub-committee and opposed by all the members of the S.S.L.C. Board but one. And our chief enemies in that battle were our History colleagues who were in a large majority and who knew just enough of the subject to realize its usefulness to history, but not enough to grasp the significance of Modem Geography, which has a purpose and an aim and a cultural value of its own. We might say it was the machinations of the History specialists that gave Geography only a one - third share of the time allotted to the linked subjects, of History and Geography, and that limited the final examination (on the Geography of the whole world) to one meagre hour. The effect was to crowd out .the subject, and since it was possible for the pupil to obtain a passing mark in the combined subjects, with no marks in Geography, the harassed schools were only too glad of the opportunity to adopt a “laissez-faire” policy in regard to one subject which higher authority implied was less important. The result was, of course, that little attempt was made to ensure that it was being taught by persons with some inkling of the aims and methods of Modem Geography. It is not surprising, therefore, to hear complaints on all sides that the subject is being badly taught. It is in any case one of the most difficult to teach; and while the groping enthusiast, even if he begins with no background of geographical knowledge, can do little serious harm, the indifferent and ignorant teacher can, in my opinion, do a world of harm. It is just as pitiful to see the regional sequence treated with no imagination and in a stereotyped way as to observe a lesson of the “capes and bays” method. It is exasperating to listen to pupils using terms like irrigation, agriculture, water-power, etc., without the faintest glimmering of the processes involved and the part played by man; one knows at once that there has been no attempt to build up the geographical concept implied in each; and it is positively tragic to come across evidence of bad habits of thinking - superficial generalisation, particularly. This is the danger of Geography, when not taught properly - it is apt to encourage loose thinking and bad habits of inaccuracy and slovenliness. We must face the fact that there has been a great deal of poor teaching during the last three years.

That then is the position at present, not so cheerful that we want to retain things as they are.

The trouble with our Geography teaching is that we have begun at the wrong end, rather we have begun at one end, the top, and forgotten all about the bottom. We must concentrate now on the teaching of Geography in the lower school, and in the training schools. The Madras Geographical Association can do a great deal in stimulating a real interest in the subject among secondary and elementary teachers, just as it has done among graduates. It can also help by giving guidance, and one of the first obstacles to be cleared away is the standardised syllabus. It is all wrong to believe that there must be a uniform Geography syllabus throughout all schools in the Presidency; it might make it easier for the inspecting authorities, but it is a barrier to good Geography teaching. One reason is that the uniform detailed syllabus rules out completely “Home Geography”, which should be the very fabric of the course. The Geographical Association should work out more than one type of ‘approval’ syllabus and should encourage schools to prepare

syllabuses on similar lines, each modified according to the individual needs of the school There is great opportunity here, for with no compelling and cramping examination at the end of the middle school, there is plenty of scope for experiment and for individual development in each school in harmony with its particular environment and the nature of the human material composing it. Teaching syllabuses in Geography should be planned with a due proportion of “Home Geography” and “Geography of the world” in each stage; and the difficulty is you can't finish off any one aspect at any one stage, but each must find its place concurrently with the other up through the grades, from class III to Form VI. One of the reasons for the deplorable teaching in the junior classes is the nature of the syllabus set, which is founded on a principle no longer accepted as either sound or practicable as far as syllabus are concerned. “From the known to the unknown” was once upon a time considered an excellent guide in determining the sequence of regions to which the pupil was to be introduced. It was developed into the idea of “first the village, then the taluk, the district, the country and finally the world”. This is quite dead now. Its impracticability has been realised, for it has been found impossible to arrange for a sequence of geographical ideas in their order of difficulty to fit into a scheme of this type. The geographical story must be the beginning, and you can't find such stories with the taluk as the background - it has to be the world. So, we must begin with the world as the background of the story, and at the same time there must be an awakening to simple geographical things in the immediate environment.

As a matter of fact also, we have realised, when trying to put into practical effect, that what is beyond the horizon by a few miles is generally as little known as if it were thousands of miles away. The farter part of the taluk is likely to be far less known to the young pupil than places with the magical names of Delhi, Bombay and Calcutta; it is pretty certain to be also, from a geographical point of view, deadly uninteresting. There is nothing geographical in the determination of the boundaries of taluk or district, so it is not even a geographical region. By “Home Geography” therefore is not meant taluk geography; and so when we set the Geography of the Taluk as the syllabus for class 4, we are going against the fundamentals of Geography as well as the fundamentals of Psychology. We cannot dispose of Home Geography by taking the Home Region all in a gulp, as it were. For whatever purpose we teach it, for its own sake or because it provides the best laboratory in which the child can build up, by observation and experience, his geographical concepts, the Home Region must be studied a bit at a time. And in each year of the course a certain proportion of the syllabus must be devoted to the study of the Home Region. It has to be woven into the syllabus so that it fits with the progression of geographical ideas and geographical skills, so that it is the background of the whole syllabus from Class 3 to Form VI. The prescribing of a detailed uniform syllabus, particularly in the early stages of school Geography, inevitably kills the attempt to teach the Geography of the environment in a rational way. What we require is an outline syllabus emphasizing the general ideas to be taught, merely laying down the condition that the whole world should be covered at least once in the school course, and permitting each school to design its own teaching syllabus in Geography up to Form IV. If we do this, if we try to encourage enthusiasm for the subject in the secondary training schools, guiding the Geography enthusiasts along the lines of practical and observational Geography, we shall soon begin to have little nucleii of good

teaching centres, which will gradually increase in size and influence, until in time the good work will permeate all the schools and the standard of Geography teaching will reach a plane which we know to be possible, although immeasurably high above our heads at the moment. And so this apparent set-back, which Geography has had, in being thrust out of the lime-light of the compulsory group, will, if we realise this opportunity of building a new, result in an improvement in the teaching of it and therefore develop its educational value as a subject in the curriculum. And meanwhile we shall have time to consolidate our position, and to strengthen our numbers before attacking the formidable obstacles that lie in the way of the development of the subject in University studies.

It is cheering to remember also that there are other factors working on the side of the protagonists of Geography. One of them is the increasing demand for geographical knowledge in present day life. Mackinder in a presidential speech to the Geographical Section of the British Association pointed out that it was not wholly by the initiative of the learned societies that the change came about in the higher study and teaching of Geography, but that it was due in no small degree to public demand. There is an amusing reference incidentally in that speech to his first lecture as University Reader in Geography at Oxford over 44 years ago: he had an audience of three, one man and two women. The man was a Don who told the young Geography Reader that he knew the Geography of Switzerland because he had just read the guide-book of that country from cover to cover! The two women brought their knitting! Nowadays there is developing an increasing number of occupations in which a knowledge of Geography is necessary and desirable - from the town planner to the man in business. Geography is also one of the most useful of subjects in helping to develop the international spirit. We have only to look around us to see the importance that is being attached everywhere to the engendering of this attitude in schools, and also in grown-up communities. One of the most notable features to-day in education is the increasing number of organised visits of school-boys and school-girls to other parts of the world, all carried out by the teachers and the school authorities. From England to Europe, to Asia, to America, and even Australia, parties of boys and girls set out every year; and among the countries of Europe itself the systematic exchange of groups of boys and girls has developed to an amazing extent. The League of Nations has realised the importance of Geography in this respect, and has brought out a new pamphlet entitled “Geography Teaching in regard to World Citizenship”. To the Geography teacher much in this pamphlet appears commonplace; so little is new, simply because there has always been in the teaching of Geography this tendency to internationalism.

There are certain difficulties prevailing in this Presidency, which make improvement in the teaching of the subject impossible; and it is the business of Geography enthusiasts to overcome them. One of these is the dearth of attractive story books with a geographical background suitable for Indian boys and girls. I remember the joy I used to find as a school-girl reading the adventurous stories of Henty and Ballantyne, and a series entitled “The Three Midshipmen”, “The Three Commanders”, “The Three Admirals”, describing the adventurous careers of the same three boys in the Royal Navy. These story-books carried one to all parts of the world, they thrilled with their sense of adventure, and they were invaluable aids to the learning of Geography out of school hours. Why can't you Geography

students produce such story-books-all about Indians and their adventures in different parts of the world? The material is there if you would only delve for it. What could be more thrilling than a tale of the “Pundit Explorers”-men of the Indian Survey who travelled in disguise in perilous hostile places, mapping secretly as they went? “They would leave on their journeys and disappear sometimes for years, re-appearing unexpectedly with the geographical knowledge so laboriously collected. They counted their every step by the revolution of prayer wheels, or by the beads on their rosaries. At night they would write their notes on a roll of paper inside the prayer-wheel. They recorded compass bearings of mountains and rivers passed, by means of little compasses cleverly disguised as amulets worn round their necks. They carried boiling-point thermometers inside hollow walking sticks for the measurement of altitudes.” Hari Ram and Kalian Singh and brave Kintup-they deserve to have their names perpetuated in thrilling story, and what a splendid geographical setting their adventures would make! Why are there no stories rich in geographical detail of the early Hindu colonisers in Java and Angkor, of the Arab traders that made Peninsular India their highway fr.om Canton to Basra? A certain amount of research, some attention to the form of the story, and a vivid and fairly accurate description of the dangers encountered and overcome-and you can produce a book that will be bought by every school. And incidentally there is a lucrative career awaiting those of you with the gift for writing and the perseverance to study the geographical detail.

Another serious handicap is the lack of cheap large-scale maps. Every secondary school should have a series of maps of the school locality on scales such as 80 inches to the mile, 20 inches to the mile and the one-inch map. Three maps of this type in England would cost under ten shillings. My estimate for three similar maps for the area round the Lady Willington Training College comes to Rs. 76! The trouble is that one has to buy from the Survey Department a complete set of maps because they are not sold separately- e.g., a complete set for the Mylapore division costs Rs. 48, while only one is required for the school's purpose. The prohibitive cost of maps, and for some places the lack of suitable maps makes it very difficult for teachers to teach Home Geography successfully. It is up to the Geography teachers, through the medium of the Geographical Association to prevail upon the Survey Office to consider the needs of the schools in regard to maps.

Another serious handicap is the kind of Geography text-books that is being poured on the market at present. There are dozens of text-books written by people who have hardly a bowing acquaintance with the aims and principles of Modern Geography, and who are certainly ignorant of the theory of the psychological approach to learning in the early stages of the school course. I am afraid these text-books will do a great deal of harm. Now that Geography takes a back seat again there is a hope that these hastily compiled text-books will stop appearing, and that we shall have more of the type of text modelled on the lines of the best Geography text-book writers like Leonard Brooks and “Fairgrieve and Young”, written in the vernacular and carefully produced.

Let me in conclusion, quote a pertinent passage from an English essayist, C.A. Montague, as a warning to all Geography teachers and an incentive to text-book writers! The occasion is a review of Mackinder 's “Britain and the British Seas” :-

“Only now do many of us begin to see how well they kept from us at school the secret of the joy of finding how the earth works. Some of us once had it and from them it was firmly taken away. They were born of the kind that pries young, asking when they play on sands, why there are tides, or what goes on in the sky that there should ever be rain. These are they that ' have to be plucked out of the earth ' for lesson times, ' rank of the soil like roots ' to learn from books what a bore their dear earth can be, with her strings of names of towns, rivers, and lakes, her mileages, her insufferable flax and jute . Pastors and masters are indomitable men, at least they were. To make large and grey book of fairy tales, the earth, dull and stale to a child importunately fingering at its covers was a task to daunt the strongest. They did it so well that many of their charges, if ever they had a hearty bite at these Eve's apples in the rest of their lives, only got it by accident. They may have been climbing the Alps and heard the unexpected detonation of a fall of rock crashing into the silence of the snow- fields, and in that instant a whole range of fascinating fact was rescued from the triteness that had put a bar between it and their minds ; for the first time they really knew how all night the frost had been driving its wedges into the granite of the peak till the sun came to draw them out, and send down the spitting stone, grinding itself to shale, to mix with the made earth in the valleys. They are in the very forge at last, with their own bodies shaken by a visible fall of the hammer at work in an unfinished world, and for the first time a living knowledge of these things rushes in upon their minds in a flooding miracle of enjoyment . . . . . To those who were taught in the old way the reading of a book like Mackinder's is a downright revelation. Geography was dry bones and behold! the dry bones stir; they give praise . . . . . .Everywhere you are captivated by some striking generalisation that seems as if by magic to shake into their right places whole masses of detached phenomena, easily fixing in position as normal details of larger wholes such seeming freaks as the lie of the rock at the top of Ben Lawers or the dots of coal in Ireland, the make of Portland Bill or the medley of tides in the Straits of Dover. To the middle-aged who parted with Geography in anger she comes again with rejoicing, bringing her sheaves with her”.

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY

Department of Geography, University of Madras, Chennai - 600 025

UG & PG Results of 9th Talent Test - 2019

THE IGS FOUNDER PROF. N. SUBRAHMANYAM AWARD

With the Cash Prize of Rs. 10,000/-
(First Prize: Rs. 5,000/-, Second Prize: Rs. 3,000/- & Third Prize: Rs.2,000)

UG Results of 9th Talent Test - 2019				
Register Number	**Name**	**Institute**	**Rank**	**Photo**
161GEO13	Jaisree H.	Department of Geography, Nirmala College for Women (Autonomous), Coimbatore - 641 018.	1	
160801	Abarna R.	Department of Geography, Government Arts College (Autonomous), Karur - 639 007.	2	
16222Q0004	Hari Prasad S.	Department of Geography, Bharathiar University Arts and Science College, Gudalur - 643 212.	3	

PROF. A. RAMESH AWARD

With the Cash Prize of Rs. 15,000/-
(First Prize: Rs. 7,000/-, Second Prize: Rs. 5,000/- & Third Prize: Rs.3,000)

PG Results of 9th Talent Test - 2019				
Register Number	**Name**	**Institute**	**Rank**	**Photo**
B605011	Prajitha M.	Department of Geography, Madurai Kamaraj University, Madurai - 625 021.	1	
P172215	Tini P. Rajendran	Department of Geography, Central University of Tamil Nadu, Thiruvarur - 610 005.	2	
17MAG210	Sivaranjani M.	Department of Geography, Government Arts College, Coimbatore - 641 018.	3	

Please Note:

1) The Winners are requested to make arrangements to attend the award ceremony function being arranged in the *IGS Annual Conference* to be held at Bharathidasan University, Tiruchirappalli on Friday, the 15th March, 2019 at 2:00 p.m.
2) For any queries, kindly contact the Coordinator Dr. K. Kumaraswamy (94421 57347) / Co-coordinators Dr. G. Bhaskaran (94444 14688) / Dr. R. Jegankumar (98947 48564) / Dr. K. Balasubramani (99440 60319).

Name of the New Universities and Colleges Participated in the 9th IGS Talent Test Examination Conducted on 23/01/2019
1) Department of Geography, Sri Vijay Vidyalaya College of Arts and Science, Nallampalli, Dharmapuri - 636 807.
2) Department of Geography,Central University of Tamil Nadu, Thiruvarur - 610 005.