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CLASSIFICATION OF SATELLITE IMAGES USING MULTI-SPECTRAL INDICES: A DECISION TREE APPROACH

Kuldeep Dileep Mete and Balasubramani K.

Department of Geography, Bharathidasan University, Tiruchirappalli - 620 024
E-mail: geobalas@gmail.com

Abstract

The classification of remotely sensed imagery is an important and critical step in the field of land use planning. Eventhough various algorithms are readily available to classify the satellite images, the application of decision tree logic provides promising results. The decision tree used in this study was embellished and make precise by using ten indices with help of IRS-P6 LISS IV data and Landsat-8 OLI and TIRS data. The vegetation indices such as Normalized Green (NG), Normalized Red (NR), Normalized Near Infrared (NNIR), Vegetation Index Green (VI Green), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Modified Soil Adjusted Vegetation Index-2 (MSAVI-2), and Optimized Soil Adjusted Vegetation Index (OSAVI) were generated using green, red and infrared bands of LISS IV image. The Normalized Difference Built-up Index (NDBI) and Built-up Area (BUA) were created using Short Wave Infrared wave (SWIR) band and Near Infrared Band (NIR) bands of the LANDSAT-8 image. By observing these indices values for different Land Use / Land Cover (LU/LC) classes, threshold values were determined and decision tree was developed using the Knowledge Engineer tool of ERDAS. Then the developed decision tree was used to classify the images and finally post-processed to remove the outliers. The accuracy assessment of classification was performed and it shows 90.83 percent of overall accuracy and 0.8764 of Kappa coefficient. The decision tree approach gives better accuracy in image classification compared to merely using reflectance value of spectral bands. This will help to get accurate information of LU/LC classes for land use planning.

Keywords: Vegetation Indices, Decision Tree, Knowledge Engineer, Classification, LU/LC

Introduction

Remote Sensing (RS) and Geographical Information System (GIS) are now widely used for analyzing land and water resources for various development and planning measures. Image classification is the most necessary step in RS and GIS for any kind of study of an area (Abd El et al., 2011; Lu et al., 2013). There are different classification algorithms and methods have developed and tested to classify satellite images. However, most of the classification algorithms are generally parametric and based on Gaussian

distribution. The classification based on Artificial Neural Network (ANN) and decision tree are becoming very much popular nowadays. These classification methods include non-parametric techniques. Even though the decision trees methods are used for many years especially in television broadcasting, still it is in the development phase in image classification. Decision tree method generally used for the classification, because it is the simple hierarchical structure for the user understanding and decision making. Decision tree classification techniques have been used successfully for a wide range of classification problems. These techniques have substantial advantages for remote sensing classification problems because of their flexibility, intuitive simplicity and computational efficiency.

Eventhough, multiple data mining algorithms including Artificial Neural Network, Nearest Neighbour Rule and Baysen classifiers available for classification of an image, decision tree method provides easiness to create a hierarchical structure of decision tree based on conditions or rules to classify the image. Therefore, the decision tree classification algorithm is gaining increased acceptance of land cover classification (NRSC, 2006). It is also very useful for problematic scenes because of its ability to handle noisy and missing data (Quinlan and Kaufmann, 1993).

Vegetation indices have been widely used in remote sensing for assessment and analysis of biomass, water, plants and crops (Jackson and Huete, 1991). Hence, vegetation indices based classification will be very much useful in identifying Land Use / Land Cover (LU/LC) classes and provides a strong base applying for conditions and rules to differentiate the pixels. Hence, an attempt made in this study to use decision tree classification based on different vegetation indices. In addition to vegetation indices, water and built up indices are also used for extracting water and built-up areas.

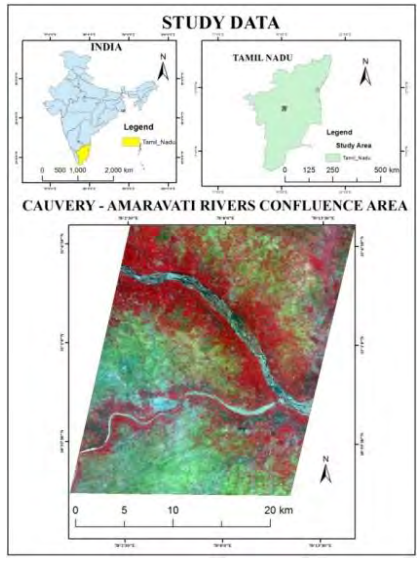


Fig. 1. Confluence of Cauvery and Amaravati Rivers

The study area chosen to test decision tree classification comprises southern part of Namakkal and northern part of Karur Taluks of Tamil Nadu. The study region has the presence of confluence of Amaravati and Cauvery rivers. It is located at an average elevation of 120 metres from mean sea level. The river Cauvery flows from northwestern direction to southeastern direction and Amaravati river flows from southwestern direction to northeastern direction. The prominent geomorphic units identified in this area are alluvial plain and pediplain. The northeast monsoon chiefly contributes to the rainfall in the study area. The average annual rainfall of the study area varies from about 620 mm to 745 mm. The mean maximum temperature ranges from 26.7 ºC to 38.56 °C. The daytime heat is oppressive and the temperature reaches as high as 43.9°C (Subburaj, 2008).

Database and Methodology

The decision tree based image classification process normally requires a high-resolution satellite image. In this study IRS-P6 LISS IV data with the 5.8-metre spatial resolution was used. This image rectified with UTM projection and WGS 84 Datum. To calculate the built-up index, Short Wave Infrared (SWIR) and Near-Infrared Band (NIR) bands of LANDSAT 8 satellite Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) data were used. ERDAS IMAGINE 9.2 was used for decision tree formation and classification and ArcGIS was used for map layout preparation.

Vegetation indices are more sensitive than the pixel values of individual bands (Baret and Guyot, 1991). Hence different vegetation indices are developed using the spectral band combinations of green, red, and infrared of LISS IV image. There are eight vegetation indices viz. Normalized Green (NG), Normalized Red (NR), Normalized Near Infrared (NNIR), Vegetation Index Green (VI Green), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Modified Soil Adjusted Vegetation Index – 2 (MSAVI – 2), and Optimized Soil Adjusted Vegetation Index (OSAVI) were generated. The indices such as Normalized Difference Built-up Index (NDBI) and Built-up Area (BUA) were generated using Short Wave Infrared wave (SWIR) band and Near-Infrared Band (NIR) band of LANDSAT – 8 images. The equations used for generating indices are mentioned hereunder:

$$NG = \frac{Band\ Green}{Band\ Green + Band\ Red + Band\ NIR} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$NR = \frac{Band\ Red}{Band\ Green + Band\ Red + Band\ NIR} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$NNIR = \frac{Band\ NIR}{Band\ Green + Band\ Red + Band\ NIR} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$VI\ Green = \frac{Band\ Green - Band\ Red}{Band\ Green + Band\ Red} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$NDVI = \frac{Band\ NIR - Band\ Red}{Band\ NIR + Band\ Red} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$NDWI = \frac{Band\ Green - \ Band\ NIR}{Band\ Green + \ Band\ NIR} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (6)$$

$$OSAVI = \frac{Band\ NIR - Band\ Red}{Band\ NIR + Band\ Red + L}(1 + L) \ldots\ldots\ldots (Where\ L = 0.16) \ldots\ldots . . (7)$$

$$MSAVI\ 2 = \frac{(2 * Band\ NIR + 1\ - \sqrt{(2 * Band\ NIR + 1)^2 - 8 * (Band\ NIR - \ Band\ Red)\ )}}{2}$$

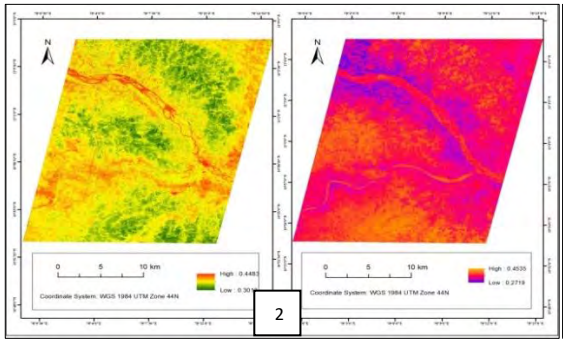
…..(8)

$$MNDBI = \frac{(Band\ 6\ SWIR) - (Band\ 5\ NIR)}{(Band\ 6\ SWIR) - (Band\ 5\ NIR)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

$$BUA = NDBI - NDVI \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . . (10)$$

*(Sources: (1) Sripada et al., 2006, (2) Sripada et al., 2006, (3) Sripada et al., 2006, (4) Gitelson et al., 2002, (5) Rouse et al., 1974, (6) McFeeters, 1996, (7) Rondeaux et al., 1996, (8) Qi et al., 1994, (9) Zha et al., 2003.(10) He et al., 2003**).***

Each equation was carefully examined and applied to the satellite datasets for generating vegetation and built-up indices. The indices are prepared as individual layers for identifying and defining threshold values for different LU/LC classes (Fig.2, 3, 4, 5 and 6).



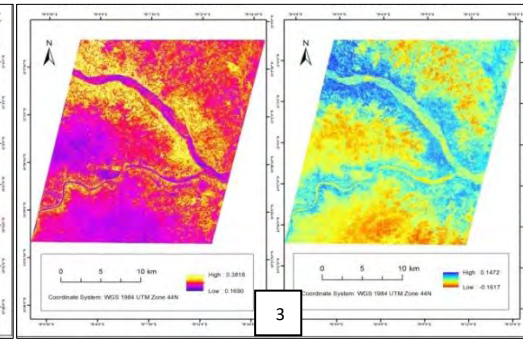


Fig. 2. Normalised Green & Normalised Red Indices

Fig. 3. Normalised Near Infrared & Vegetation Index Green indices

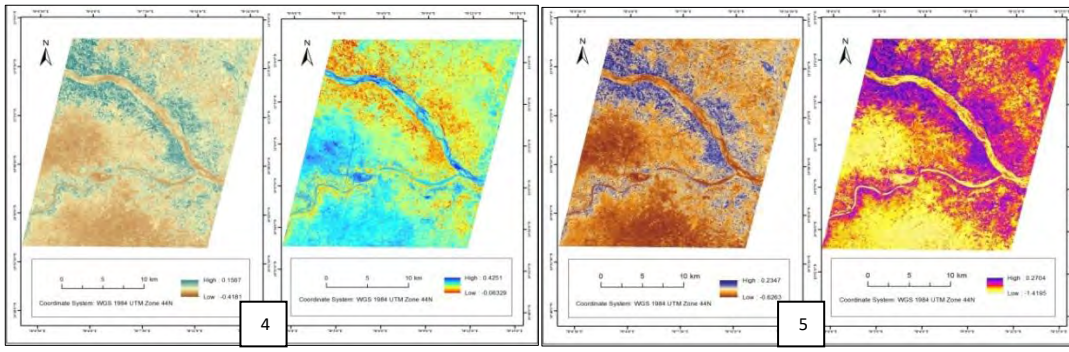


Fig. 4. Normalised Difference Vegetation Index & Normalised Difference Water Index
Fig. 5. Optimised Soil Adjusted Vegetation Index & Modified Soil Adjusted Vegetation Index

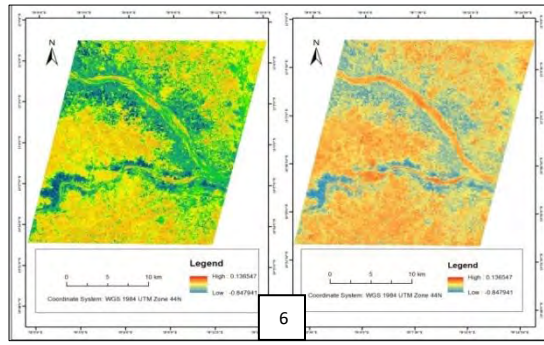


Fig. 6. Normalised Difference Built-up Index & Built-up Index

Formulation of Decision Tree

A decision tree method is a graphical representation of a decision-making process that can easily interpreted by users. Starting from the root, each node applies a test deciding which of the child branches to take for subsequent tests. This continues recursively until a leaf node is reached (Quinlan, 1993). The decision tree makes homogeneous groups as per defined variables in rules and makes partition in the dataset. The tree is simpler, and technically it seems easy to use. It is more interesting to get a tree that is adapted to the probabilities of variables to be tested. Decision tree-based classification requires spectral reflectance measurements or indices in different layers for making the perfect decision regarding each class. In this study, Knowledge Engineer in ERDAS IMAGINE was used to formulate the decision tree. Initially, the hypothesis was created and then rules were decided according to LU/LC classes. The threshold values were determined for each class of LU/LC based on the derived indices. Finally, the confidence level was defined and the whole structure was prepared as a model. The structure of the knowledge engineer based decision tree is shown in Figure 7.

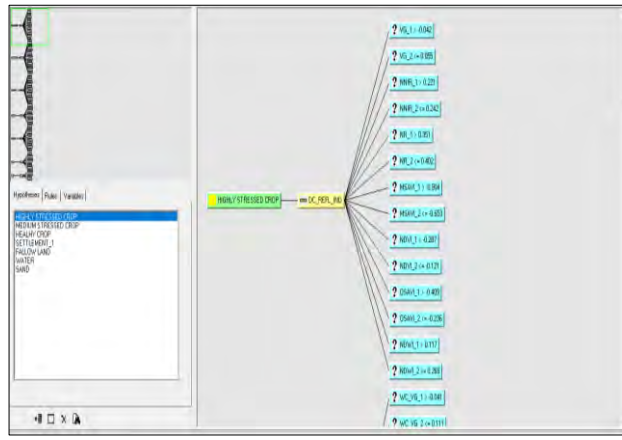


Fig. 7. Structure of Decision Tree using Knowledge Engineer Tool in ERDAS

In the present study, a total of 2,000 index values were measured to define a threshold to distinguish different LU/LC classes. For each case of LU/LC class, 50 random points were identified and threshold values for each index were determined. Accordingly, a sum of 350 index values was measured for each class of highly stressed crop, medium stressed crop, healthy crop and fallow land. For settlement, water and sand LU/LC classes, a total of 200 index values were measured for each class. These index values were carefully examined and the threshold was determined for each LU/LC classes against each index. A confidence level of 0.75 was adopted unanimously for all classes to run the model in knowledge engineer. The variables for each class and their threshold values are presented in Table 1.

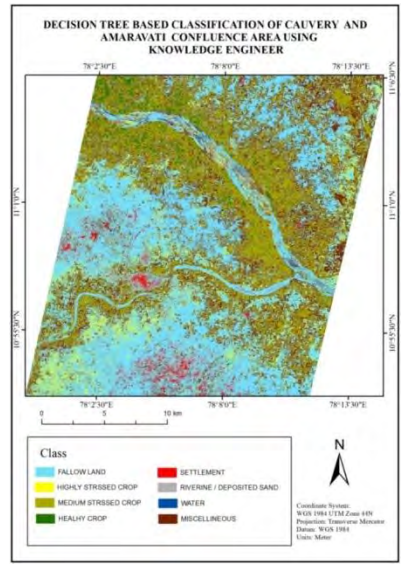


Fig. 9. Classified Image Using Multi-Spectral Indices and Decision Tree Approach

Table 1: Indices and Threshold Values for Different Classes of LU/LC

LU/LC	Index	Threshold Range
Highly Stressed Crop	VG	> - 0.045 And <= 0.055
	NNIR	> 0.221 And <= 0.242
	NR	> 0.351 And <= 0.402
	MSAVI	> -0.904 And <= -0.653
	NDVI	> -0.287 And <= -0.121
	OSAVI	>-0.409 And <= -0.236
	NDWI	>0.117 And <= 0.269
Medium Stressed Crop	VG	> - 0.041 And <= 0.111
	NNIR	> 0.196 And <= 0.336
	NR	> 0.289 And <= 0.409
	MSAVI	> -0.499 And <= 0.065
	NDVI	> -0.137 And <= 0.055
	OSAVI	> -0.257 And <= -0.025
	NDWI	> -0.101 And <= 0.209
Healthy Crop	VG	> 0.005 And <= 0.151
	NNIR	> 0.225 And <= 0.399
	NR	> 0.248 And <= 0.357
	MSAVI	> -0.049 And <= 0.237
	NDVI	> -0.043 And <= 0.163
	OSAVI	> -0.045 And <= 0.201
	NDWI	> -0.065 And <= 0.109
Fallow Land	VG	> - 0.124And <= 0.074
	NNIR	> 0.199 And <= 0.281
	NR	> 0.345 And <= 0.457
	MSAVI	> - 0.921 And <= - 0.499
	NDVI	> -0.043 And <= 0.163
	OSAVI	> - 0.599 And <= - 0.317
	NDWI	> 0.316And <= 0.402
Settlement	NNIR	> 0.182 And <= 0.335
	BUA	> -0.125 And <= -0.025
	MSAVI	> -1.301 And <= -0.365
	NDWI	> 0.165 And <= 0.403
Water	NNIR	> 0.201 And <= 0.216
	OSAVI	> - 0.465 And <= -0.398
	NG	> 0.401 And <= 0.437
	NDWI	> 0.301 And <= - 0.388
Sand	MSAVI	> - 0.999 And <= - 0.541
	BUA	> 0.091 And <= 0.169

Results and Discussion

Landuse / Land Cover Classes

After successful formulation of decision tree, the given LISS IV image was classified into eight LU/LC classes namely fallow land, highly stressed crop, medium stressed crop, healthy crop, settlement, sandy, water and miscellaneous. Table 2 shows the LU/LC classes and respective geographical coverage.

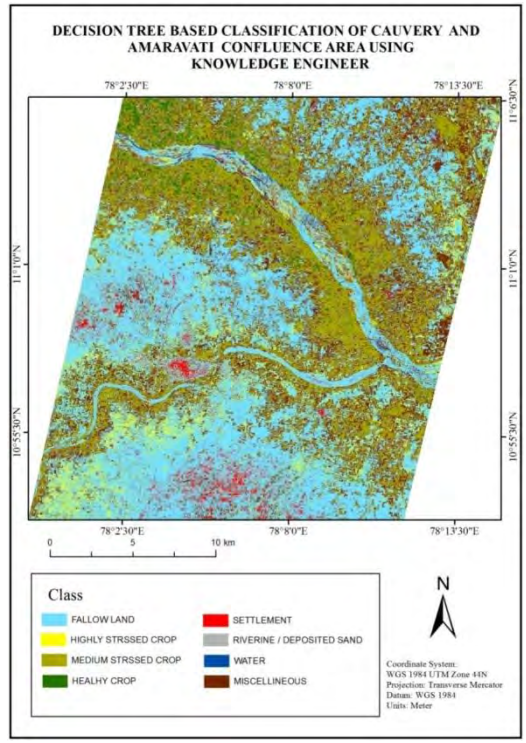


Fig. 9. Classified Image Using Multi-Spectral Indices and Decision Tree Approach

Table 2. Areal Distribution of LU/LC Classes

Sl. No.	Class	Area in km²	Area in Percent (%)
1	Fallow Land	276.83	43.87
2	Medium Stressed Crop	130.54	20.68
3	Highly Stressed Crop	43.22	6.85
4	Healthy Crop	17.27	2.73
5	Settlement	13.24	2.09
6	Riverine / Deposited Sand	8.94	1.41
7	Water	1.64	0.26
8	Miscellaneous	139.24	22.06
Total Area		630.94	100

In the present study, fallow land was classified based on VG, NNIR, NR, MSAVI, NDVI, OSAVI and NDWI indices. Different categories of crops were measured based on the spectral reflectance of crop canopy. Many studies have reported that NIR and Red are highly helpful in discriminating crop performance and productivity (Blackmer et al., 1996; Blum, 2011). The highly stressed crop has low chlorophyll concentration, hence it is observed with low reflectance in NIR band and accordingly thresholds were devised using VG, NNIR, NR, MSAVI, NDVI, OSAVI and NDWI indices. Since healthy crop has better reflectance values in NIR band, the same indices were used to classify but with different threshold limits.

One of the critical steps in image classification is extraction of settlements, because of similar reflectance of the sandy area and inter-mixing of vegetation pixels. In this study, NNIR, BUA, MSAVI and NDWI indices were used to demarcate settlements. MSAVI and BUA indices are used to identify sandy areas and NNIR, OSAVI, NG and NDWI indices were used to extract water bodies. The threshold limits for each index were identified by inspecting LU/LC classes through each index layer.

Accuracy Assessment

Accuracy assessment of LU/LC classifications is necessary to evaluate the quality of maps developed from remotely sensed data (Stehman, 1996). In image classification, the term 'accuracy' means a measure of consistency with reliable information in a spatial point with data on the classified image (Jensen,1996). Accuracy assessment or validation has become a standard component of any land cover or vegetation map derived from remotely sensed data (Congalton, 2005). There are multiple ways to estimate the accuracy of the classification. The most powerful and simplest technique is constriction of error matrix (also known as a confusion matrix, correlation matrix, or covariance matrix). Many statistical measures of thematic accuracy can be drawn from the error matrix including overall accuracy, percentage of commission and omission errors and Kappa coefficient (K) (Congalton and Green, 1999). The overall accuracy is computed by dividing the total correct pixels by the total number of pixel in the error matrix (Story and Congalton, 1986).

The computation of the accuracy of the classified individual class was done based on the producer's accuracy and another is the user's accuracy, similar to overall accuracy. The error matrix of the present study is presented in Table 3 and different classes of accuracy are presented in Table 4. The results show that the overall accuracy of the classification is 90.83 per cent.

Table 3: Error Matrix of the Classified Study Area Image

Classified Data	Miscellaneous	High stress Crop	Medium Stress Crop	Healthy Crop	Settlement	Fallow Land	Water	Sand	Row Total
Miscellaneous	35	0	0	0	0	3	0	0	38
High stress Crop	0	5	0	0	0	1	0	0	6
Medium Stress Crop	0	0	20	1	0	0	0	0	21
Healthy Crop	0	0	0	5	0	0	0	0	5
Settlement	0	0	0	0	4	0	0	0	4
Fallow Land	3	1	0	0	1	37	0	1	43
Water	0	0	0	0	0	0	1	0	1
Sand	0	0	0	0	0	0	0	2	2
Column Total	38	6	20	6	5	41	1	3	120

Accuracy assessment through error matrix depends on several sampling points, as fewer sampling points may lead to misspecification of classes (Foody, 2002). This can be

overcome by estimating the Kappa coefficient (K) (Congalton, 1999). It yields a K statistics that is a measure of agreement of accuracy, which is 0.87, showing a better accuracy of LU/LC classification compared to merely using reflectance value of spectral bands.

Table 4. Values of Overall Accuracy, Producer's Accuracy and User's Accuracy

Classified Data	Reference Total	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Miscellaneous	38	38	35	92.10%	92.10%
High Stress Crop	6	6	5	83.33%	83.33%
Medium Stress Crop	20	21	20	100.00%	94.24%
Healthy Crop	6	5	5	83.33%	100%
Settlement	5	4	4	80.00%	100%
Fallow Land	41	43	37	90.24%	86.05%
Water	1	1	1	100.00%	100.00%
Sand	3	2	2	66.67%	100.00%
Totals	120	120	109		
Overall Classification Accuracy					90.83%

Conclusions

The LU/LC classification should be a precise or accurate for the study of Earth's environment, through which the decision-makers can develop proper development and planning measures. This study explored a reliable as well as a convenient tool for classification of LU/LC using spectral indices. The knowledge engineer tool in ERDAS software provides the easiest user interface for the formation of decision trees. Compared to supervised and unsupervised classification algorithms, this decision tree approach yields a better accuracy for classification rather than using reflectance value of satellite image.

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SPATIAL DISTRIBUTION OF SCHOOLS AND IDENTIFICATION OF UNSERVED SPATIAL GAPS USING GEOGRAPHIC INFORMATION SYSTEM: A CASE STUDY OF SIVAGANGA DISTRICT, TAMIL NADU

Kumar V.[1], Kumaraswamy K.[2], Rutharvel Murthy K.[3] and Thiagarajan D.[4]

[1]Directorate of School Education, Government of Tamil Nadu, Chennai - 600 006
[2]Department of Geography, Bharathidasan University, Tiruchirappalli - 620 024
[3]Department of Geography, Arignar Anna Government Arts College, Namakkal - 637 002
[4] Government Girls Hr. Sec. School, Nachiarkoil, Kumbakonam - 612 602
E-mail: rv.geoguy@gmail.com

Abstract

Geographic Information System (GIS) is a useful tool in the analysis and evaluation of the performance of different services and to identify disadvantaged urban areas for the redistribution of services. The distribution of schools including primary, middle, high and higher secondary are subjected to identify their service areas by generating buffer zones with respect to the distance of their categories. Sivaganga District of Tamil Nadu has been chosen for this study. The secondary data sources like annual reports from Directorate of School Education, Government of Tamil Nadu and Sarva Shiksha Abhiyan (SSA) reports were used. Educational details were also collected from the Chief Educational and District Educational Offices in Sivagangai District. The location of schools were captured using Global Positioning System (GPS) and ArcGIS software is used for generating the spatial outputs of served and unserved areas. Finally, the spatial gaps for all school categories are classified as served and unserved gaps. The highest served gaps were found in Kalaiyarkoil, Ilayankudi and Kallal and the lowest served gaps were found in S. Pudur Block. Among the unserved areas, Devakkotai Block stood with maximum area followed by Manamadurai and Thiruppuvanam Blocks and the minimum unserved areas were found in S. Pudur Block followed by Singampunari Block.

***Keywords**:* GIS, GPS, buffer, Service area, Spatial gaps

Introduction

Geographic Information System (GIS) is a useful tool for analysing and evaluating the performance of different services, and to identify disadvantaged urban areas for the redistribution of services. It is also considered as a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Burrough and McDonnell, 1998). GIS can be used for many

different purposes in public services, especially in educational planning and management (Attfield et al., 2002; Kong et al., 2007). Educational services are one of the most important public services that must be provided to members of any locality (Shquair, 2009). The planning and distribution of schools depend on several criteria like: the distance, population and other landusecharacteristics. However, the urban expansion in those areas and assessment of needs for the future population in the respect of educational services are also considered.

The GIS is a system for storage, analysis, management and presentation of the data and maps associated attributes as spatial information that is spatially referenced to the Earth's surface (Eray, 2013). In general, GIS relates to all the features and the processes that occur on the surface of the Earth. It is applied in many developed countries of the world in educational facilities mapping to support decision-making. Educational services planning include a wide range of educational planning and management issues. The spatial gaps in school locations are mapped to identify the relationships among the school locations and the distribution of school age population through analysing the gaps.

The distribution of schools including primary, middle, high and higher secondary schools are subjected to identify their service areas by generating buffer zones with the distance respect to their categories. The service area (buffer area) or zone of influence or sphere of influence were drawn for primary, middle, high and higher secondary schools in Sivaganga District using buffer tool in ArcGIS software. These buffer zones gave ideas to visualise the areas getting benefited by the schools based on the norms framed by the Department of Education, Tamil Nadu. These buffer zones provide information on schools available with least distance, which could make students trouble-free to reach the primary, middle, high or higher secondary schools.

Study Area

The Sivaganga District extends latitudinally from 9º43' N to 10º20' N and longitudinally from 77º 47' E to 78º 49 ' E. It is bounded by Pudukkottai District on the northeast, Tiruchirappalli District on the north, Ramanathapuram District on southeast, Virudhunagar District on southwest and Madurai District on the west. Sivaganga town is the District Headquarters. The District has 2 revenue divisions, 6 taluks, 12 blocks and 521 villages. Total area of the District is 4,189 sq.km (Figure 1).

Database and Methodology

The Survey of India toposheets, both in digital and analogue formats were used to prepare the base map. The annual reports from Directorate of School Education, Government of Tamil Nadu and Sarva Shiksha Abhiyan (SSA) reports were procured and used as secondary data for the academic year 2011-2012. For this study, the secondary data sources were considered as main source.

The education related information was also collected from the Chief Educational and District Educational offices in Sivaganga District.

The locations of schools were captured using Global Positioning System (GPS) - Garmin eTrex instrument. The software ArcGIS version 9.3 was used for generating the spatial outputs of served and unserved areas and played vital role in analysis.

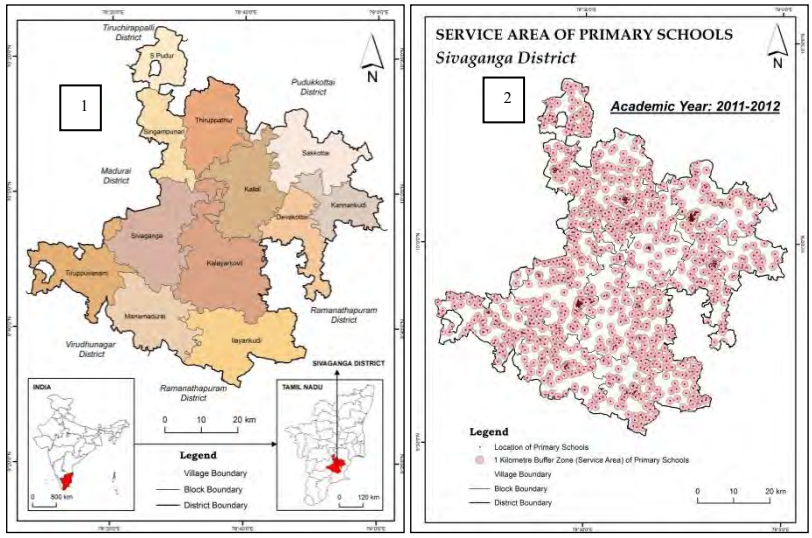


Fig. 1. Sivaganga District
Fig. 2. Service Area of Primary Schools

Results and Discussion

Service Areas of Primary Schools in Sivaganga District

As per the guidelines of the Department of Education, Government of Tamil Nadu, the service area for primary schools is considered to be 1 kilometre around a primary school. The primary schools must be at a reachable distance so that the students at the age group of 5 – 10 could be benefited without much risk. Particularly in the villages and remote areas, the transport facilities are not well developed. More clusters of primary schools were found in Singampunari, Thiruppathur, Sakkottai, Devakottai and Sivaganga blocks. A cluster of more than 25 schools was found in Sakkottai block. Devakottai and Sivaganga blocks have nearly 15 primary schools in the same location. Thiruppathur and Singampunari blocks have 12 and 8 schools in clusters respectively. In Manamadurai block, it has 8 schools in its cluster and in Illayankudi block, one can find 12 primary schools in the nearby areas. In Sivaganga District, the buffer zones for primary schools cover most parts of the District. The blocks like Singampunari, Thiruppathur, Sakkottai, Devakottai and Sivaganga have the most clustering of buffer zones of primary schools (Figure 2).

Service Areas of Middle Schools in Sivaganga District

The service area for middle schools has been fixed to be 3 km from the location of the school. It is the maximum distance specified by the Government of Tamil Nadu for the middle schools. The middle school students are the children at the age group of 11 to 13 years. These children are quite grown up than the primary school age group and can be sent to the nearby small towns or big towns within 3 km for schooling. Some cluster of middle schools were found in Karaikudi, Kazhalanivasal and Sakkalakkottai areas in Sakkottai Block; Devakottai, Kannankottai, Thachanvayal, Mannaivikotai areas in Devakottai block; and Kottagudi, Kilapatti, Arasani, Kasambankulam areas in Sivaganga block. The Sivaganga, Thiruppuvanam and Illayankudi blocks are dominantly covered with middle school service areas. S.Pudur block is the smallest block in the District which has 11 middle schools. The buffer zones of middle schools dominantly cover the entire northern and the southern fringes of the study area. The eastern and the western parts are not well served with middle schools.

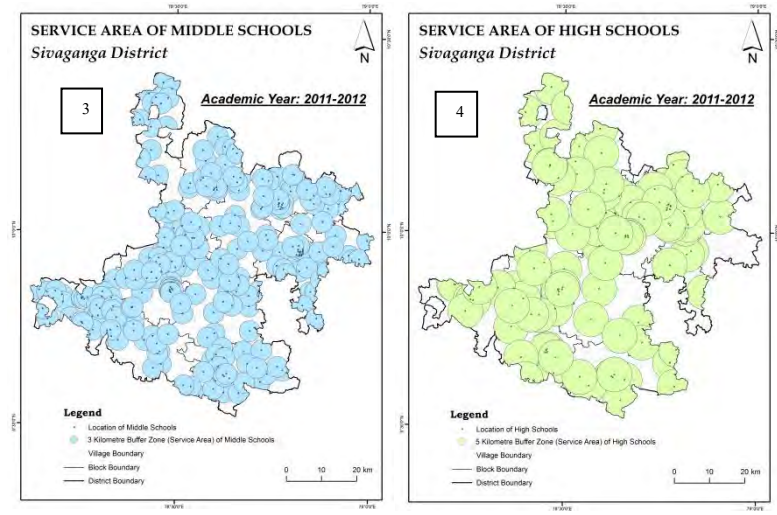


Fig. 3 & 4. Service Area of Middle and High Schools

In Sakkottai block, the Chettinadu and Peryottai villages in the north and southern parts of Ambakudi, Illuppakudi, Amaravathi Pudur and Sankarapuram areas in the south are found without middle school services. Devakottai block was widely covered with middle school service excepting a few patches of gaps in the northern margins. The Kannankudi block shows less number of middle schools. Ten middle schools in the block serve most of its areas. The Kallal block has 11 middle schools, besides the 4 schools in Kallipattu, Sevarakottai, Keelayur and Naduvikottai villages which are found in nearby areas. The Ilayankudi block was found with more number of middle schools (buffer zones) overlapping each other, leaving some gaps in the four corners of the block, along the margins.

Thiruppuvanam block was well served with a number of middle schools, as substantial part of the block was covered with the middle school buffer zones (Figure 3).

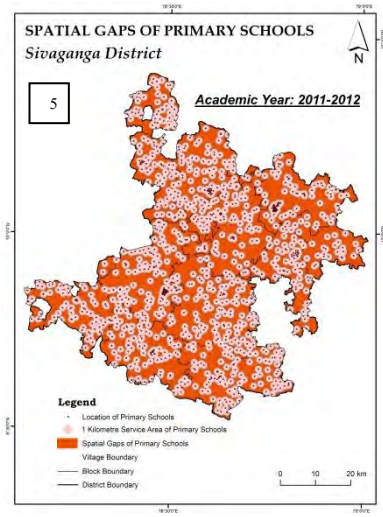
Service Areas of High Schools in Sivaganga District

According to the norms laid down by the Tamil Nadu Government, each high school should serve 5 km radius of area from the school location. The high schools were built for the purpose of promoting high school education to all types of people. Especially in village areas, the restrictions for female children to undergo higher education are high. In such situations, if the schools are at the nearby distances, this group of population may get benefited. The high school students include children at the age group of 14-15 years old. The buffer zones of high schools in Sivaganga District reveal that the high schools cover most parts of the District except the eastern portions. One can also find clustering of high school in Sakkottai and Sivaganga blocks. In Sakkottai block, there are 7 high schools found and in Kallal block it was with 5 schools. Among the 12 blocks in Sivaganga District, the S.Pudur block was the least served area with the buffer zones of high schools. Here one can find small fragments of 5 buffer zones. The Sakkottai block was found to be well served with a number of high school buffer zones merged with each other. In the southern part of Sakkottai block, the buffer zones of Kannankudi, Devakottai and Kallal blocks also well served the high school education. The Kallal block was well covered with high schools in most of its parts leaving few patches empty at the southeastern corner. In Kannankudi block, a few areas were served with the high school buffer zones found in the western part of the block and that also merged with the service areas of Sakkottai and Devakottai blocks. The Kalaiyarkoil block has a few number of high school service areas just adjoining each other along the rims in the central part.

In Ilayankudi block, the high school buffer zones are found in the northern margins and southern margins leaving the central part vacant. In Manamadurai block, most of the portions were covered with high school buffer zones leaving very little patches as gaps in the southwest, central and northeastern parts. The high school buffer zones in Thiruppuvanam block were found with very least coverage. The buffer zones in the east are merged with the buffer zones of Sivaganga block. The buffer zones are more crowded in the central part (Figure 4) of the region.

Service Areas of Higher Secondary Schools in Sivaganga District

The higher secondary school is the highest level in school education, Sivaganga District was served by 96 number of total higher secondary school in the year 2011-2012. If the higher secondary schools are spaced at some particular ideal distance, everyone in the nearby villages or towns get benefited. This minimum distance is calculated to be 8 km of space for higher secondary schools' service area. Higher secondary school education is very important and it decides the future career of each and every student. The establishment of higher secondary schools requires more land, sufficient teachers, well equipped laboratories and other infrastructural facilities.



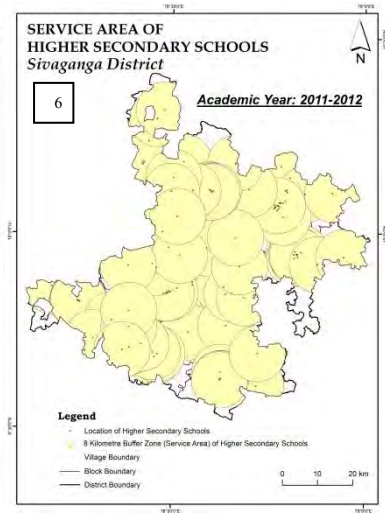


Fig. 5. Service Area of Higher Secondary Schools
Fig. 6. Spatial Gaps of Primary Schools

Here the buffer zone encloses 8 km around each higher secondary school; the buffer zone covers most of the areas in Sivaganga District, leaving very little gaps along the marginal areas. In most of the places, the buffer zones are found to be merged with each other (Figure 5).

Spatial Gaps of Primary Schools in Sivaganga District

Sivaganga District is a developing region with all types of facilities, especially in educational services. There are a total of 1,442 schools in Sivaganga District. Among these, 1,002 numbers are primary schools. The primary schools educate the beginners. The primary school students are at the age group of 5-10 years old. It will be very hard for these kids to move longer distances for education purpose of their own. Some of the places have more number of schools and some others are very sparse or not even a single school in the area. These unserved areas were identified as spatial gaps (locational gaps) (Table 1 and Figure 6).

Spatial Gaps of Middle Schools in Sivaganga District

In the year 2011-2012, among 1,442 schools in Sivaganga District, middle schools accounted with 240 schools. These schools are spread at an uneven distances. According to the norms of Government of Tamil Nadu, each middle school should serve 3 km of its surroundings. The distribution of schools should be arranged in such a way that each school should serve its buffer limits. But the uneven distribution of schools leaves some areas as the gaps, where the students from such areas are not benefited by the service of middle schools. These unserved areas are termed as locational gaps of the middle schools. The buffer zones of served areas are shown by blue colour and the

locational gaps (unserved areas) are denoted with red colour sketches in the map (Table 1 and Fig. 7).

Table 1. Spatial Gaps (in sq. km) of Schools in Sivaganga District in 2011-2012

Sl. No.	Name of the Block	Primary Schools	Middle Schools	High Schools	Higher Secondary Schools	Total
1.	Sivaganga	206.6	95.1	35.1	4.4	341.2
2.	Kalaiyarkoil	274.8	158.7	164.3	1.7	599.5
3.	Manamadurai	173.2	136.4	42.8	35.7	388.1
4.	Thiruppuvanam	166.2	55.8	132.7	30.1	384.8
5.	Ilayankudi	201.7	99.8	107.1	50.6	459.2
6.	Devakottai	114.4	50.8	72.5	70.6	308.3
7.	Kannankudi	127.8	44.3	137.4	14.9	324.4
8.	Sakkottai	205.0	68.4	34.5	11.6	319.5
9.	Thiruppathur	141.9	91	39.8	38.8	311.5
10.	Singampunari	89.9	94.5	22.1	-	206.5
11.	S.Pudur	62.2	32.1	17.1	17.7	129.1
12.	Kallal	214.9	120.2	80.4	4.7	420.2
Total		1978.6	1047.1	885.8	280.8	4192.3

Spatial Gaps of High Schools in Sivaganga District

The high school education of any area is very important for the development of human power in that area. So the promotion of high school education is very important. According to the suggestions put forth by the Government of Tamil Nadu, each high school should serve at least 5 km of its surroundings. There are 104 high schools available in Sivaganga District in the year 2011-2012. These schools serve their buffer zone. But these buffer zones do not fully cover the entire study area. Some of the places are left out without any influence of the high schools and such unserved places are called the locational gaps of high schools. The pale green colour in the map shows the served areas of high schools and the red colour shows the spatial gaps (unserved areas) of high schools (Table 1 and Figure 8).

Spatial Gaps of Higher Secondary Schools in Sivaganga District

Sivaganga District is well endowed with higher secondary schools. In the year 2011-2012, there were 96 higher secondary schools found in the entire District. These higher secondary schools provide higher education to the student population in Sivaganga District. A total number of 96 such schools satisfy the educational needs of higher secondary school age population. It happens that in some of the places, the schools are concentrated for one reason or other and some of the places are left vacant. In order to bring out a balance in this, the Government of Tamil Nadu has specified certain norms, where it is advised to construct higher secondary school at such a distance that each higher secondary school should serve 8 km of its surroundings. This is called the buffer zone (service area) of the higher secondary schools. There are also some areas which are not included in any of the buffer zones or not served by the buffer zones. These uncovered areas are mentioned as locational gaps.

Here an attempt was made to search out these locational gaps and suggest a new location for the construction of higher secondary schools in Sivaganga District. The locational gaps of higher secondary schools in Sivaganga District were found along the marginal areas of the blocks like S.Pudur, Thiruppathur, Kannankudi, Devakottai, Illayankudi, Tiruppuvanam and Sivaganga blocks (Table 1 and Figure 9).

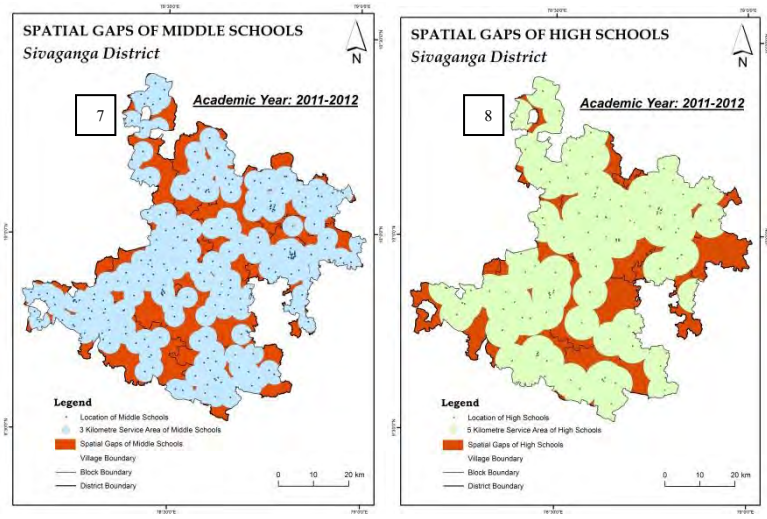


Fig. 7 & 8. Spatial Gaps of Middle and High Schools

Served and Unserved Areas of Spatial Gaps among Primary Schools in Sivaganga District

During the year 2011-2012, the spatial gaps (unserved areas) of primary schools are identified with the help of their locations and service areas by generating the 1 km buffer zones. The total area of Sivaganga District is 4,189 sq. km, whereas the estimated / identified gaps of primary schools together falls with 1,978.6 sq.km without considering the landuse/ cover features of the District. Among these areas, Kalaiyarkoil block was identified with the maximum area of gaps with 274.8 sq.km followed by Kallal, Sivaganga, Sakkottai and Ilayankudi Blocks with 214.9 sq.km, 206.6 sq.km, 205.0 sq.km and 201.7 sq.km respectively. The minimum gaps were observed in S.Pudur and Singampunari blocks with 62.2 sq.km and 89.9 sq.km respectively. The dominant areas of gaps were found in Kalaiyarkoil block located in the western half of the block.

As per the norms of School Education of Government of Tamil Nadu, the regions or areas without primary schools could also get the primary education (1^{st} to 5^{th}) through the presence of middle schools. Based on this rule, the gaps of primary schools are intersected with middle school service areas to find out the areas exactly unserved by primary education. At last, the unserved areas are reduced and the greater areas of gaps were found in Manamadurai and Kalaiyarkoil blocks with 77.3 sq.km and 71.4 sq.km respectively.

The lesser areas of gaps were identified in S.Pudur Block with 7.6 sq.km (Table 2 and Fig. 10).

Served and Unserved Areas of Spatial Gaps among Middle Schools in Sivaganga District

During the year 2011-2012, a majority of spatial gaps (unserved areas) among middle school locations were identified by generating the 3 km buffer zones of served areas. The identified gaps of middle schools were found with 1047.1 sq.km without considering any kind of landuse / cover features of the District. Among these areas, Kalaiyarkoil block was identified with the large area of gaps with 158.7 sq.km followed by Manamadurai (136.4 sq.km) and Kallal (120.2 sq.km) blocks. The smallest area of gaps was found in S.Pudur block with 32.1 sq.km. The highest area of gaps was found in Kalaiyarkoil block with two patches of land situated in the northern boundary.

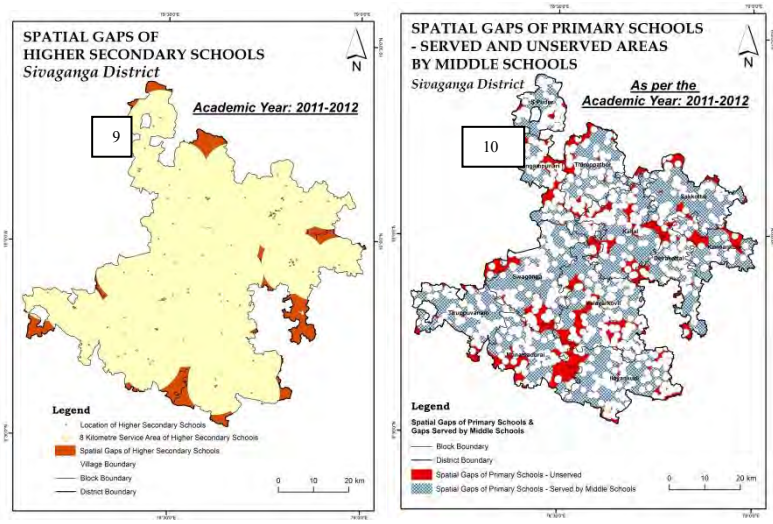


Fig. 9. Spatial Gaps of Higher Secondary Schools
Fig. 10. Primary School Gaps - Served and Unserved Areas by Middle Schools

As per the norms of School Education of Tamil Nadu, the regions or areas without middle schools could get the middle school education (6^{th} to 8^{th}) through the availability of high schools. Based on this rule, the gaps of middle schools are intersected with high school service areas to find out the exact unserved areas of middle school education. At last, the unserved areas are reduced and the large level of gaps was found in Kalaiyarkoil, Kannankudi and Devakkotai blocks with 28.2 sq.km, 26.9 sq.km and 25.2 sq.km respectively; whereas the least area of gaps was identified in S.Pudur block with 2.2 sq.km (Table 2 and Figure 11).

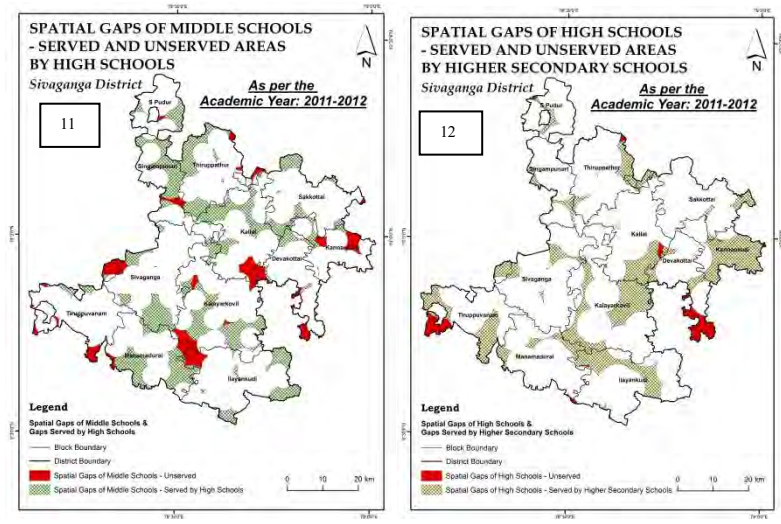


Fig. 11. Middle School Gaps - Served and Unserved Areas by High Schools
Fig. 12. High School Gaps - Served and Unserved Areas by Higher Secondary Schools

Served and Unserved Areas of Spatial Gaps among High Schools in Sivaganga District

In the year 2011-2012, a majority of spatial gaps (unserved areas) in high school locations are identified by generating the 5 km buffer zones of service areas. The identified gaps of high schools were found with 885.7 sq.km by neglecting the other kinds of landuse/ cover features of the District. Among these areas, Kalaiyarkoil block was identified with the large area of gaps with 164.3 sq.km followed by Kannankudi and Thiruppuvanam blocks with 137.4 sq.km and 132.7 sq.km respectively. The smallest area of gaps was found in S.Pudur block with 17.1 sq.km. In Kalaiyarkoil block, the gaps were found in the northeastern, western and southern borders of the block.

As per the norms of School Education of Tamil Nadu, the regions or areas without high schools could get the high school education (9^{th} and 10^{th}) through the available of higher secondary schools. Based on this rule, the gaps of high schools are intersected with higher secondary school service areas to find out the exact unserved areas of high school education. At last, the unserved areas are reduced and the largest gaps were found in Devakkotai and Thiruppuvanam blocks with 43.2 sq.km and 27.7 sq.km respectively. The entire high school gaps of Sivaganga, Kalaiyarkoil and Singampunari blocks got benefited from higher secondary school services (Table 2 and Figure 12).

Served and Unserved Areas of Spatial Gaps among Higher Secondary Schools in Sivaganga District

In the year 2011-2012, a majority of spatial gaps (unserved areas) among higher school locations are identified by generating the 8 km buffer zones of service areas. The identified gaps of high schools were found with 280.8 sq.km without considering the landuse/ cover categories of the District. Among these areas, Devakkotai and Ilayankudi blocks were identified with 70.6 sq.km and 50.6 sq.km respectively. The only block which has no gaps in the District was Singampunari (Table 2 and Figure13).

Table 2. Spatial Gaps (in sq.km) Served by other Categories of Schools in Sivaganga District in 2011-2012

Sl. No.	Name of the Block	Primary School Gaps		Middle School Gaps		High School Gaps		Higher Secondary School Gaps		Total	
		Served by Middle Schools	Unserved Gaps	Served by High Schools	Unserved Gaps	Served by Higher Secondary Schools	Unserved	Served	Unserved	Served	Unserved
1.	Sivaganga	172.3	34.3	88.5	6.6	35.1	-	-	4.4	295.9	45.3
2.	Kalaiyarkoil	203.4	71.4	130.5	28.2	164.3	-	-	1.7	498.2	101.3
3.	Manamadurai	95.9	77.3	120.3	16.1	41.6	1.1	-	35.7	257.8	130.2
4.	Thiruppuvanam	137.2	29	18.8	37	104.9	27.7	-	30.1	260.9	123.8
5.	Ilayankudi	162.9	38.8	77.4	22.4	104.6	2.5	-	50.6	344.9	114.3
6.	Devakottai	88.7	25.8	25.6	25.2	29.3	43.2	-	70.6	143.6	164.8
7.	Kannankudi	96.9	31.8	17.4	26.9	135.5	1.9	-	14.9	249.8	75.5
8.	Sakkottai	164.2	40.8	61.2	7.2	34.4	0.01	-	11.6	259.8	59.61
9.	Thiruppathur	108.2	33.6	84.6	6.5	37.3	2.5	-	38.8	230.1	81.4
10.	Singampunari	58.9	30.9	86.2	8.3	22.1	-	-	-	167.2	39.2
11.	S. Pudur	54.6	7.6	29.9	2.2	15.5	1.7	-	17.7	100	29.2
12.	Kallal	168.3	46.6	96.1	24.2	75.9	4.6	-	4.7	340.3	80.1
	Total	1,511.5	467.9	836.5	210.8	800.5	85.21	0	280.8	3148.5	1,044.7

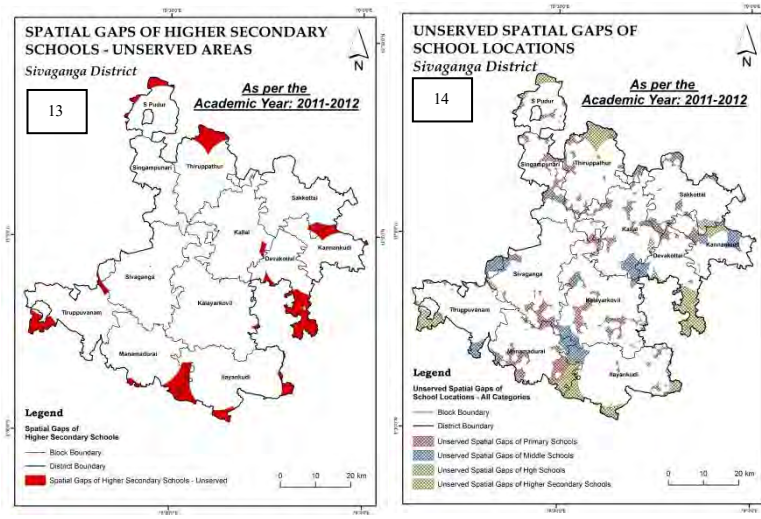


Fig. 13. Higher Secondary School Gaps - Served and Unserved Areas
Fig. 14. Unserved Spatial Gaps of Schools - All Categories

Unserved Spatial Gaps of School Locations

During the year 2011-2012, the spatial gaps of all school categories were classified into two types as served and unserved gaps. Here the served gaps are the areas which get benefitted from other categories of schools. The blocks which received maximum benefits were Kalaiyarkoil, Ilayankudi and Kallal with 498.2 sq.km, 344.9 sq.km and 340.3 sq.km respectively. The lowest area of served gaps was found in S.Pudur block with 100 sq.km. Among the unserved areas, Devakkotai block stands with maximum area of 164.8 sq.km followed by Manamadurai and Thiruppuvanam blocks with 130.2 sq.km and 123.8 sq.km respectively. The lowest unserved area was identified in S.Pudur block with 29.2 sq.km followed by Singampunari with 39.2 sq.km (Table 2 and Fig. 14).

Conclusions

Geographic Information System is a widely used tool for the studies based on spatial locations. In this study, the service areas and spatial gaps of primary, middle, high and higher secondary schools were identified for the year 2011-2012 with reference to their service areas (buffer zones) of primary, middle, high and higher secondary schools (1 km, 3 km, 5 km and 8 km respectively) using ArcGIS software. Among the spatial gaps of different school categories, the maximum area of primary school gaps were found in Kalaiyarkoil block followed by Kallal, Sivaganga, Sakkottai and Ilayankudi blocks. These gaps of primary schools were intersected with middle school service areas to find out the unserved areas of primary education. Finally, the unserved areas were reduced and the large levels of gaps were found in Manamadurai and Kalaiyarkoil blocks.

The identified gaps of middle schools with maximum areas were observed in Kalaiyarkoil, Manamadurai and Kallal blocks. Further, the gaps of middle schools were intersected with high school service areas to find out the exact unserved areas of middle school education. It was found that the unserved areas were reduced and the major gaps were found in Kalaiyarkoil, Kannankudi and Devakkotai blocks. While studying the high schools, Kalaiyarkoil block was identified with the large area of gaps followed by Kannankudi and Thiruppuvanam blocks. However, the spatial gaps of high schools were intersected with higher secondary school service areas to find out the exact unserved areas of high school education. The unserved areas of high school education were reduced and the maximum gaps were found in Devakkotai and Thiruppuvanam blocks. At last, the spatial gaps of higher secondary schools were found maximum in Devakkotai and Ilayankudi blocks, and the only block with not even a single gap in the District is Singampunari.

Finally, the spatial gaps of all school categories are classified as served and unserved gaps. Here the served gaps are the areas which are benefitted from other categories of schools. The highest served gaps were found in Kalaiyarkoil, Ilayankudi and Kallal blocks; and the lowest served gaps were found in S.Pudur block. Among the

unserved areas, Devakkotai block stands with maximum area followed by Manamadurai and Thiruppuvanam blocks; and the minimum area was identified in S.Pudur block followed by Singampunari Block.

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EMPLOYMENT DIVERSIFICATION IN RURAL TIRUCHIRAPPALLI

Iyyampillai S.

Department of Economics, Bharathidasan University, Tiruchirappalli - 620 024
Email : sipillai@yahoo.com

Abstract

One of the major changes noticed in the rural economy particularly in the recent past is fast employment diversification (ED) among the rural workers. The patterns are different and the reasons are many. Generally rural workers have been taking up new business and jobs. This aspect has been widely studied by many, but mostly using secondary data at macro level. The causes of and the patterns of ED and their impact on household economy and village economy are complicated and specific to each household and to each village. Hence, macro level studies are bound to bypass some of the important issues and insights that may be useful for appropriate policy prescription. Studies are not sufficiently available to meet this requirement. Hence, the present study has been conducted to survey two villages in Tiruchirappalli District. The study finds that the rural poor are now prepared to move out of the villages in search of better jobs. However, they are yet to be better equipped with modern skills to take part in non-farm activities.

Keywords: Employment diversification, Farm size, Non-farm employment, Main source of income

The Setting

The pattern of economic activities pursued by a person depends mostly on the skill and resource pattern available with / to him or her. However, the decisions regarding what kind of skill or resource is to be used and for what purpose are determined by the relative remunerative capacities of the skill or resource which are again influenced by the kind of demand for the activities and development that is taking place around them. Government intervention, in the economic activities in countries like India in the form of control, support, regulation etc., also influences very much the relative remunerative capacities of various activities. Hence, those who could adjust to these changes could sooner gain the fruits of economic development while the others, who find it difficult to cope with the changes, remain lagging behind. Those who could adjust to the developments are able to change or take up new occupations depending upon the relative remunerative capacities of the occupations, available and possible to them. This process of change could be briefly called employment diversification (ED). This diversification could happen vertically or horizontally.

The extent of ED could be assessed for every individual, household or for an economy on the basis of time spent or / and money earned from different activities at a particular point of time (horizontal) or over a period of time (vertical).

The process of ED, its pattern as well as pace are determined by various sets of factors viz., internal and external, and socio-economic and political factors. The advantages or disadvantages of ED are again influenced by various sets of factors. However, under the present conditions, ED is increasingly felt to yield better results and lead to improvement in the economic and social status.

For generating income in a rural economy, the villagers have to multiply the existing sources, find new sources or to deepen the existing sources of income. Which way one would go depends on many factors such as one's knowledge on various activities, resource position, and the market for various products and so on. Particularly after the green revolution, Indian farmers have been given more choices in technology, crops and activities. Thanks to development in transport, rural areas have been connected by roads which facilitate transport of goods to the urban markets in search of higher prices and also facilitate migration (temporary or permanent) to urban areas in search of higher wages. On the other hand, lower status attached to agricultural works, fall in real wages in rural areas, unfavorable terms of trade for agricultural sector and increased demand for modern goods and services due to persuasive advertisements in the mass media have forced the villagers to find new and multiple income sources.

Due to the above reasons and many other reasons, the proportion of non-farm employment (NFE) in the rural areas has been increasing not only in India but in many other countries as well (Singh, 1993). In the same way, the number of studies on diversification has also been increasing. Many studies have attempted to identify the process, nature, determinants and the effects of ED. However, most of them have based their studies on secondary data (like population Census, National Sample Survey etc.) and at macro level. The difficulties in collecting primary data at household level have acted as hindrances for attempting the micro level studies. There are advantages and disadvantages with both the kinds of methods. Which one has to be chosen is mostly determined by the nature of requirements. The available studies indicate the following:

1. The extent of ED has been increasing over the period of time (Pravin, 1995) due to the following possibilities:
    a. As the best available employment opportunities are normally pursued, there is a greater likelihood for rising income at household level.
    b. If the income sources are spread and the number of revenue generating activities is multiplied, the stabilization of household income is possible.
    c. When households take up different employments, the unemployed or under-employed persons in a household can also take up some jobs depending upon the capabilities. This has happened in many villages, where new economic

activities like gem cutting, *korai* processing, mat weaving etc. have recently come in (Saleth, 1995). The persons, mostly women belonging to forward communities (and those whose going outside the house is socially prohibited or physically constrained), also get some opportunities for utilizing their labour for earning within house premises.

d. The increase in number of activities also extends the possibility of integrating different enterprises. The best example is silk and milk. The cow dung is used to raise mulberry plants and the extra mulberry leaves after feeding their silk moth, are used to feed the cows.

2. The diversification is in favour of non-agricultural and non-rural occupations (Pravin, 1995).
3. The pace of diversification is explained by both individual efforts and government policies relating to agriculture, rural development on the one hand and the policies relating to other sectors and the process of urbanization (Vaidyanathan, 1994) on the other hand.
4. The nature and extent of ED at village level is explained by the resource patterns in the villages, location of the infrastructural facilities, particularly the availability of transport facilities (Singh, 1993), market etc., size of the villages (Basant,1993), level of literacy, the type of development that is going on around the villages etc.. Similarly, the nature and extent of ED at household and at individual levels are also explained by various factors.

However, the studies that have assessed the extent of ED at macro level could not go deeper into the household level. Hence, they are likely to miss very useful and important information and insights. In this context, a micro level study is felt necessary for proper understanding of phenomenon with all its dimensions. The present study thus finds its context. The following are the major objectives of the study: (a) to study the extent of ED in villages with different characteristics; (b) to find out the factors influencing the process of ED at household level; and, (c) to assess the consequences of ED on the household and on the village economies.

Database and Methodology

In terms of the per cent age of rural male non-farm workers (RMNFWs) to total workers, Tiruchirappalli District [17.55%] is closer to the state average [21.18%]. Hence, this district has been selected for intensive study. This district consists of 10 taluks. Among them, Tiruchirappalli taluk gets the highest per cent age of RMNFWs (42.92%). This is mainly due to the fact that this taluk is formed by larger urban area. This taluk consists of 89 villages. All these villages have been ranked on the basis of population and distance from Tiruchirappalli town. From this list of villages, two villages with almost similar characteristics have been chosen. They are *Vengur* and *Thayanur*. Ten per cent of households in each of these two villages have been selected for an in-depth survey.

Schedules used for this purpose consist of questions on socio-economic background, personal resource position, resource utilization pattern and pattern of purchase and sale of goods and services by the households.

Concepts

Employment Diversification

ED refers to the extent to which members in the selected households have engaged in different activities. The activities could be agricultural and non- agricultural or rural based and non-rural based. While all agricultural activities are rural based, some of the non-agricultural activities could be either rural based or non-rural based. And, there is no urban based agricultural activity.

The extent of ED could be measured in terms of per cent age of hours spent on different activities and / or income received from different activities. These can be worked out for every individual and / or for every household. However, as the lands are owned and operated jointly by [mostly] all the household members, it would be difficult and may be meaningless to trace the share of each member in the total income from agricultural operations. It is also possible sometimes that one or two members in a household may be full-time employee(s) in the non-rural non-farm activities. Even then, it is hardly feasible for them to be completely away from agricultural operations. The same kind of problem may arise with respect to the time criterion also. Under these circumstances, it is better to assess the extent of ED at household level not at individual level.

Both income and time criteria suffer from some shortcomings. The income earned from different activities is not necessarily directly proportional to the time spent on those activities. Longer duration of time may be spent on some activities which may not yield so much income. For instance, the income from agricultural operations is not necessarily the function of time spent on these operations, but on many more factors. Whereas, wage income is directly proportional to the time spent. Hence, the amount earned from different activities by a household has been used in this study to construct the index of ED.

Non-Farm Income

Non-farm activities include quarrying, industrial works, gem-cutting, painting, and the jobs of drivers, conductors, local business men, traders, tailors, teachers and other non-rural occupations. In Vengur, as much as 24 persons from the sample households are employed in Bharat Heavy Electricals Limited (BHEL) and other ancillary units. The employees in BHEL get a better salary than that prevails in agricultural sector. In Thayanur, majority of the non-farm workers are employed in a quarry (27) located in a nearby village. Some of them are on contract basis and some of them are casual labourers. This proportion may also change then and there. These workers get a very low wage, ranging from Rs. l6 to Rs.25 per day (in the year 1996). The farm-income refers to the income from

cultivation of crops and vegetables, agricultural labour and allied activities such as animal husbandry, poultry and also so on.

Main Sources of Income

Among all the sources, the source which gives the maximum income is defined as main source of income. If there are only two activities pursued by a household, then, the source which gives more than 50 per cent of the household income would be considered major source of income. However, when there are more than three activities, the activity which claims the maximum per cent age share in the household income could form a major source of income.

Farm Size

Besides landless households, land owning households have been grouped into four viz., marginal, small, medium and large, depending on the land ownership status; the farm categories are 0.1 to 1.0 acre, 1.10 to 2.00 acres, 2.10 to 5.00 acres, 5.10 acres and above respectively.

Non-Workers

Non-workers are defined by usual status. Some of them might have taken up some job or other in their life-time. However, those who have not joined the workforce on regular basis are defined as non-workers. This category mostly includes the children [school going and pre-school], women mainly engaged in domestic activities, the aged and handicapped persons.

Working Place

Working place is defined as the place where majority of the time is spent on earning income. Definition is slightly difficult in the case of traders, brokers and vendors who move from place to place, between villages and towns. Here the time criterion has been used to identify such persons with location. The categories have been identified on this basis. They are within the village, in nearby villages and in towns. In majority of the cases, town refers to Tiruchirappalli and its surroundings. In case of Vengur, majority of the non-rural workers are employed in ancillary units of BHEL in Thiruverambur. In Thayanur, majority of them are engaged in quarrying in a nearby village, petty trading, trading of vegetables, painting and cleaning and repairing the automobiles.

Produces Sold / Purchased Outside

The ultimate production or consumption point has been considered for the consumption goods and agricultural inputs. For instance, the groceries and cosmetics could have been purchased from the shops within the villages. However, most of them would have been produced / manufactured outside the village, hence they are considered as

purchased from outside the village. In the case of purchased inputs also similar logic has been adopted.

In the case of agricultural produces, they are either sold outside the village directly by the farmers or sold to the commission agents within the village, who take those produces and sell outside the village. Hence, almost all the quantities go outside the village only. In this case, the quantities sold directly by the farmers alone are considered, however, to have been sold outside. Here it is interesting to note that even the agricultural labourers sell some agricultural produces [that are obtained as kind-wages] outside the village for the immediate requirements of money. Then, when they are in need of the same produces, they again purchase from the market (normally at higher - prices] or from Ration Shops at lower prices.

Scheme of Presentation

Section I introduces the problem of the study. Section II presents the ED at district level in Tamil Nadu and taluk level in Tiruchirappalli District . Third section discusses the socioeconomic profile of the study villages and the respondents, in such a manner to investigate how such profile have acted as the determinants of the pace and pattern of ED; the extent of ED; and explores the possibilities for the development of the households and generalises those results for the study-village economies. Inferences are presented in the last Section.

Limitations of the Study

Two similar villages have been studied with a view to control many of the variables that are likely to influence the level, pattern and pace of ED. Hence, the results of this study would be applicable only to those villages which have got the similar characteristics of the study villages.

Non-farm employment in Rural Tamil Nadu

The proportion of rural NFE in Tamil Nadu has gradually increased from 19.15 per cent in 1971 to 19.19 per cent in 1981 and further to 20.60 per cent in 1991. Almost similar trend is observed in all the districts of Tamil Nadu between 1981 and 1991. Madras district has been excluded from the analysis for, it does not have rural workforce at all. In districts like Chengalpattu, North Arcot and Coimbatore, the improvement is very substantial. This kind of comparison is however, not possible for Tiruvannamalai, Dindugal, Pasumpon, Kamarajar and Chidambaranar districts, which have been formed after 1981. Ramanathapuram district shows a sharp decline in the extent of rural NFE. This is mainly due to trifurcation of the district. Similarly a marginal decline is observed in South Arcot and Tirunelveli districts because of bifurcation of those districts.

The levels of NFE are however, not uniform in all the districts of Tamil Nadu. In this respect, the districts like Dharmapuri, Tiruvannama1ai, South Arcot, Madurai and Pasumpon are at the bottom. Coimbatore, Thirunelveli and Kanyakumari districts are at the top. Almost all those districts with low level of NFE are in dry belt and literacy levels there are also lower. The districts at the upper end enjoy very high literacy rates. Coimbatore has been experiencing fast pace of industrialisation and urbanisation. The mapping of district-wise details on NFE shows the location effect. For instance, Kanyakumari, Tirunelveli and Coimbatore [also Madras] districts with high level of NFE do have influence on the neighbouring districts. Whereas, the districts that are far from those highly diversified districts have got very low level of NFE.

Non-Farm Employment in Rural Tiruchirappalli

Tiruchirappalli District is closer to its State average in case of extent of rural NFE. This district, similar with the State, has also shown a marginal increase in the level of non-farm employment. The taluk-wise analysis in Tiruchirappalli District indicates that the rural based taluks and taluks with dry agro-climatic characters have got very low level of ED. Whereas, Tiruchirappalli and Karur taluks with high degree of urbanisation (per cent age of urban population in taluk total population) and literacy rates, have higher level of NFE. These two taluks also seem to have influenced the neighbouring taluks namely Lalgudi, Musiri and Manapparai, where the extent of non-farm employment is between 20 and 30 per cent.

Determinants of the Extent of NFE

The above discussion suggests that the degree of urbanisation, literacy rate and extent of commercialisation in agriculture are some of the major factors that influence ED in rural Tamil Nadu. The simple linear correlation coefficients indicate that all the variables considered have positive association with the extent of rural NFE, both at State [Tamil Nadu] and district [Tiruchirappalli] levels. Though none of the correlation coefficients is statistically significant, literacy at both State and district levels and degree of urbanisation at district level have stronger association with the extent of NFE in rural areas. This is true at both the points of reference viz., 1981 and 1991. It is interesting to note that the strength of relationship of those variables at those two points of reference have not changed much. For instance, the correlation coefficient between degree of urbanisation and the extent of rural non-farm employment at district level in the year 1981 [r=0.86] is equal to that in the year 1991 [r=0.86]. Almost similar is the case with other variables also.

The collective influence of the independent variables considered on the extent of rural NFE is indicated by multiple linear correlation coefficients. At district level, those independent variables appear to explain the variation in the extent of rural NFE in a better manner than what they do at the State level. This is true again in both reference years. Excepting the degree of urbanisation (that too, only at district level in 1981 as well as in

1991), no other factor seems to have statistically significant association. The actual strength of the other factor could, perhaps, be greater at the village level, and be captured by village level study on NFE.

The analysis of relevant data (available in secondary sources like Census Reports, Season and Crop Reports and District Census Handbooks) lead to suggest the following:

1. The process of ED has started operating in all the districts of Tamil Nadu. As a result, the proportion of NFE in the rural areas is on the increase.
2. Though there may be many variables, the extent of urbanisation and literacy levels of the districts and taluk in Tiruchirappalli District have closer, stronger and positive association with the extent of rural NFE.
3. There may be other factors [whose influences are not captured in the secondary data] at village levels which are very contributing to the rise in the extent of NFE at village levels. In this respect, village level studies such as the present one, may give more insights of this process of ED in the rural sector.

Profile of the Study Villages

As already mentioned Vengur and Thayanur are almost similar in size of population, level of irrigation and distance from Tiruchirappalli town and extent of NFE. However, there are many bore wells; and sales and purchase of water are frequent in Thayanur, while they are almost absent in Vengur. Both the villages have Village Administrative Offices and Schools within the village. They are equally well connected by bus transport facilities and have good roads. However, differences do exist between them. Major differences are in cropping patterns, occupation, and caste compositions, land holding patterns and so on. More details could be observed by discussing the villages separately.

Vengur

Vengur and its hamlets are located in north eastern side of Tiruchirappalli and the western side of Kallanai, very close to Thanjavur district. All the buses going to Kallanai from Tiruchirappalli Junction Bus Stand and from Main Guard Gate touch this village. This village has got majority of the characteristics that are similar to that of old delta region of Thanjavur district. This is also closer to Thiruverambur where a large number of small scale industries and a giant industry called BHEL are located. Some of the BHEL employees working in the Water Pumping Station are also having their families in this village. Besides them, there are Scheduled Caste (SC) households in a separate hamlet, and they are mostly landless agricultural labourers. Almost 50 per cent of the households in this village are landless agricultural labourer households. The land owning backward community households, who are more in number, live in the main village, where, one could see very old houses, constructed more than 50 years back. These houses themselves could speak

that the owners are traditionally rich but now they do not give much attention to the maintenance of these buildings, for they are looking out to permanently migrate to other places. From the list of households, it is very clear that already some of them have left the houses. Hence, many houses are vacant and at moribund stage now. Perhaps they may belong to forward communities, who in Tamil Nadu have moved out of the villages in search of higher economic and political power. Now, there are only very few forward community households in this village. As seen in the primary data analysis, a high proportion of the residents are now employed in BHEL and in the engineering units located around villages.

The mono-culture cropping pattern (i.e. 87 per cent of lands under paddy crop) combined with higher and assured wage in the adjusting industrial estates have been the major reasons for these households seeking employment in industrial sectors. Though paddy is a very labour intensive crop, the labourers are mostly from the SC households within the village and from outside the village. The traditionally and relatively richer households, it seems, could educate their wards with the proximity to the township, and they do not want to work in the mud and clay. Looking at the present condition of the village economy and changes that are taking place around this village, it is hoped that this trend will continue and become stronger in the future. The paddy lands will gradually disappear and that shall be used for construction of houses and plants for, new industries will encroach upon the agricultural lands and agricultural operations by the residents shall decline in future.

Thayanur

This village is located in the South Western side of Tiruchirappalli town, well connected by road-transport. Though there are some similarities between the two study-villages in some respects, differences are also obvious. This village resembles the villages in New Delta Region of Thanjavur district. This village with multi-crop pattern, adding more and more lands for the cultivation of vegetables, appears to be relatively prosperous. Traditional crops are disappearing and new crops are coming in. People are confident of getting good revenue from vegetable cultivation. Paddy is mainly cultivated for domestic consumption. The other crops are raised for revenue purpose.

This village is also dominated by backward communities namely Muthiriyer [as they call themselves, but might belong to Ambalakarar communities, which is in the lower hierarchy of caste system in Tamil Nadu]. SC families and Yadava families are living in two separate streets. They are small and medium land holders with small houses, traditionally poor but now fighting strongly to succeed their misfortunes.

Exchange of agricultural labourers between the villages is common here. The reason for this kind of labour use pattern appears to be more of sociological. Economic gain is also implicit. The landless agricultural labourers do not want to work for their native masters regularly but want to show that they can work in other villages too. Thus, they

think, they could exhibit their independence and which in turn would increase their wages in the market. Whenever there is labour-deficit, contract wage system is undertaken, by which same number of labourers can work hard for longer duration, so that, they can obtain higher share in total wage. This is also in a way helpful to tackle the problem of labour shortage in the buy seasons. This kind of labour shortage is nowadays quite frequent and common as some of them move for NFE. The diversification of crops also helps to tackle the problem of shortage of labour, for different crops demand labour in different periods, and in different proportions.

The level of NFE here is almost as same as that in Vengur. Quarrying, painting and gem cutting are some of the major activities among them. It is very strange to see about 20 boys from SC community in this village to be working as painters regularly. Painting is their main source of income. As it is seen, more and more boys get into this profession. When the field work was going on in the village [during Dec.1995 and January 1996], two major political parties were organising their state level conferences [Dravida Munnetra Kazhaham on January 26, 27, and 28, 1996, and All India Anna Dravida Munnetra Kazhaham on February 7, 8 and 9, 1996 in nearby town viz., Tiruchirappalli] for which painting work had started right from December 1995 instant. One could easily see the paintings and writings in almost all the walls in Tiruchirappalli town. This required a lot of manpower and that helped some of the workers of this village to get training in painting from their elders and senior ones in this field.

Another interesting phenomenon which one could easily notice in this village is cutting and collection of fuel wood by men and women folk [mostly women]. For getting fuel for cooking purpose for an average family for four days [one head load] one man day has to be spent. This is collected from babul trees in *Porambokku* lands located one and five km away from this village. Heaps of these fuel woods are found in front of all the houses in this village. Though not at a greater scale, marketing of this fuel wood in small quantities is also observed here. However, this is not so visible in Vengur.

As far as education is concerned, though a middle school has come up in this village, the number of graduates and post graduates is very small. A majority of them are yet to get suitable jobs, hence, the followers are reluctant to proceed for higher education. The selected villages are different in many respects. Though the levels of irrigation are almost equal in the villages, the sources are different; soil and crops are also different. As far as agrarian and social structures are concerned, the villages are very much different. Though the extent of ED is almost uniform in the study villages, the patterns are different. Vengur appears to be outward looking economy. Agricultural operations are still given more importance in Thayanur.

There has been a significant shift in crop pattern in favour of commercial, short-duration and immediate cash fetching crops like sugarcane, banana, vegetables and flowers. This has resulted in the difference in the composition of agricultural income.

Though the changes have occurred in both the villages, this is more prominent, fast and diversified in Thayanur as compared to that in Vengur.

Animal husbandry appears to be one of the activities of almost all the households. However, the households appear to have their own preferences towards buffaloes, bullocks, sheep, goats; the direct contribution to household income by animal husbandry however, does not appear to be significant.

The extent of dependence of the households on outside village (particularly urban economy) both for the purchase of agricultural inputs, consumer goods as well as for sales of agricultural produce is substantial. To that extent, the village economic activities could be considered to be influenced by different kinds of markets and market forces. This would also be one of the reasons why the rural households are forced to take up non-traditional jobs. Thus, the rural economic activities have also been gradually coming under the controls of non-rural market forces. This could be stated as one of the achievements of the modern economic development. As far as working places are concerned, now a greater portion of the households have started moving out of the villages and mostly to the nearby towns. And many of them belong to the categories of landless labourers and marginal farmers. By community, most of them are from SC and MBC.

In the last five years, the number of households who depend on agricultural operation for major portion of their income has declined. More than 50 per cent of the households in each village draw some portion of their income from non-farm sector. However, the extent of ED is different for different farm size groups and caste groups. The SC and landless labourers are more in search of new jobs in the non-farm sector. A sizable portion of the big farmer households have also joined non-farm occupation in Vengur.

More than 50 per cent of the households who get income from non-farm sources get more than 50% of their household income from non-farm sources. Thus, the NFE is gaining its importance in the rural economies and help the rural poor to improve or at least maintain their economic status, whatever they have.

Conclusions

The importance of non-farm activity particularly in improving the economic status of the rural poor cannot be over emphasised. The rural poor are also now prepared to move out of the villages in search of better jobs. However, they are yet to be better equipped with modern skills to take part in non-farm activities, without which they might find it difficult to survive in the new economic policy regime, where protection measures are gradually withdrawn and only those who have sufficient purchasing power can lead a normal life. Under these circumstances, it becomes necessary on the part of the government to see that non-farm activities are created for people with different skills around the villages and also provide opportunities for the rural poor to improve their skills so that they can easily diversify their economic activities.

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ASSESSMENT OF SPATIAL VARIABILITY OF RAINFALL PATTERN IN COIMBATORE DISTRICT, TAMIL NADU USING GIS TECHNIQUES

Masilamani P.

Department of Geography, Bharathidasan University, Tiruchirappalli - 620 024
E-mail: masilamani.ap@gmail.com

Abstract

Rainfall is one of the most important climatic elements and its distribution differs from time to time, season to season and place to place, which determines the cropping pattern of an area. In India the farmers mainly depend on monsoon season for agricultural practices. Southwest monsoon and northeast monsoon together serves maximum rainfall to the nation. The present study deals with the rainfall characteristics of Coimbatore district which includes the spatial distribution of rainfall, rainfall variability and precipitation ratio, these three parameters are most important in Rainfall analysis. For this study 30 consecutive years (1983-2012) monthly rainfall data were collected and analyzed from 29 rain gauge stations. The long-term rainfall analysis reveals the gradual changes of rainfall of the study area. The long term mean annual rainfall of the study area is 1119.63mm, the maximum long-term mean annual rainfall recorded at Annamalai Nagar with 1412mm whereas minimum mean annual rainfall has been distributed over Kallipalayam with 411mm. In terms of mean seasonal rainfall of the study area northeast monsoon was received maximum amount of rainfall with 647.71mm followed by southwest monsoon, winter and summer season with rainfall 334.26mm, 95.52mm and 46.14mm respectively.

Keywords: *Climatic elements, Cropping pattern, Southwest monsoon, Northeast monsoon, Rainfall abnormality*

Introduction

All of the natural conditions, rainfall should be regarded as the fundamentals so far as progress of the society is concerned. Rather it has always been treated as a fundamental sector for the total development of the society A.R.Subramaniam (1992). Rainfall is a crucial agro-climatological factor in the seasonally arid parts of the world and its analysis an important perquisite for agricultural planning in India, Alak Gadgil (1986). In India, more than 75% of people directly or indirectly depend on agricultural sector for their livelihood; one of the significant characteristics of Indian agriculture is that, it depends on monsoon season. Southwest and northeast monsoon together contribute nearly 90% of

rainfall. Rainfall is one of the important climatic factor which deciding the success and failure of the crop in an area and its distribution determines the cropping pattern of a region. It is not evenly distributed it changes in terms of place and time. The unevenness in receipt of this monsoon over space and time thus make it an important parameter for thorough analysis (Jagannadhasharma, 2005). Although the subject of climate change is vast, the changing pattern of precipitation deserves urgent and systematic attention as it will affect the availability of food supply (Dore, 2005). Despite the problems, the most comprehensive studies so far, notably Groisman et al. (1999) and Frich et al. (2002), did find evidence for significant large-scale changes in temperature and precipitation extremes during the latter half of the twentieth century. The systematic study of long-term rainfall reveals the actual characteristics of the rainfall distribution in an area, which includes seasonal and annual trends, variability and its abnormality. All this information will help various agronomic activity. So, rainfall analysis has much more importance among countries like India. The present study made to understand the rainfall of the region, the highland receives more rainfall than nearby lowlands, especially in their wind ward sides as a result of orographic lifting characters of the region G.Vennila (2007). It discusses spatial distribution of rainfall, variability and its abnormality. For this study GIS techniques were used for analysis and preparation of appropriate maps.

Study Area

Coimbatore district is situated on the banks of river Noyyal between 11° 00' of north latitude and 77° 00' of East longitude. The total area of Coimbatore district is 254 km². Coimbatore is located at an elevation of about 398 meters. The mean maximum and minimum temperatures during summer and winter varies between 35°C to 18°C. The highest temperature ever recorded is 41°C and lowest is 12°C. Due to surrounding mountains on the west, with reserve forests on the northern side. The eastern side of the district, including the city is predominantly dry. Coimbatore is one among the industrially developed and commercially vibrant districts of Tamil Nadu. It has got high concentration of small scale industries medium and large scale industries. It is known as the Manchester of South India because of its well-developed textile industry and other industrial base. The third largest city of the state.

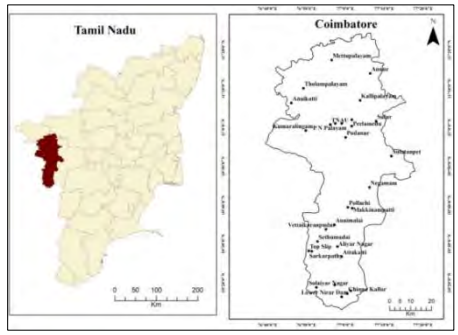

Fig. 1. Location of Coimbatore District

Database and Methodology

Twenty nine rainfall stations were chosen for the Study. Daily Rainfall data for 30 consecutive years have been collected for the years from 1983 to 2012. Rainfall data has been processed in excel and hence seasonal and annual rainfall pattern, co-efficient of variability and precipitation ratio of the study area has been found out. The collected data have been analysed and represented with appropriate maps using GIS software. Inverse distance weighting (IDW) method has been adopted for the interpolation of rainfall data. The point rainfall data collected from the statistical department of Coimbatore district has been analysed and average annual rainfall has been computed.

Results and Discussion

Mean Seasonal Rainfall

Winter

According to the rhythmical changes in the climatic element, the year is divided into four well-marked seasons. They are winter (Jan - Feb), summer (Mar - May), southwest monsoon (Jun - Sep) and northeast monsoon (Oct - Dec). The southwest and northeast monsoons are the two main seasons for agricultural activities. However, the southeast monsoon accounts for largest share in the total annual rainfall within short spell. The winter rainfall in the months of January and February. Highest rainfall in this season is recorded in the area Anaikatti and its surrounding area and the lowest rainfall is recorded in the Sulur region. The most of the parts of the study area is distributed by moderate rainfall. The spatial pattern of winter rainfall is unique and totally different from other seasons. Fig no.2 shows the spatial distribution of Rainfall during winter season.

Summer Rainfall

Summer receives more rainfall than the winter because the district is under rain-shadow region which is located in the leeward side of Western Ghats. Since the rainfall is confined to summer convection the variations in rainfall depend on purely local phenomena and the summer rainfall is associated with thunderstorm showers.

When compared with other parts of Tamil Nadu the summer rainfall is moderately high in the study area. A trough of high rainfall zone moves to the northeast in and around Upper Nirar Dam. The trend follows the mean annual rainfall distribution. On contrast to winter, Lower Nirar Dam receives the low rainfall. Figure 2 shows the spatial distribution of rainfall during summer season.

Southwest Monsoon

The study area receives 44.7% of rainfall during this season. It is mainly associated with southwest monsoon rain bearing winds and elevation of topography. Kripalani et al. (2007) predict an increase in monsoon precipitation associated with intensification

of pressure gradient during the establishment phase of the monsoon. The rainfall increases succeeding following the normal, moderate and high rainfall zones, notably in the southern part whereas the northern rim of the district with normal. Accordingly, the area under the lowest rainfall is also successively decreasing in the mid-portion of the study area. Fig no.2 illustrates the spatial distribution of rainfall in southwest monsoon.

Northeast Monsoon

The study area receives 34.5 % of the total annual rainfall during this season. The northeast monsoon followed almost the same trend of mean annual rainfall which exemplifies the dominance and intensity of northeast monsoon over the study area. The highest rainfall zone during this season concentrated over TNAU in the central part of the study area, which receives more rainfall. Rainfall increases towards east and extreme south of the study area comes under low and normal rainfall category. Fig no.2 illustrates the spatial distribution of rainfall in northeast monsoon. The lowest coefficient of variation observed during NEM indicates that this monsoon is a stable one as has been recorded by Dhar et.al, (1982).

From foregoing analysis on the spatial pattern of rainfall during annual, winter, summer, southwest and northeast monsoon, it is noted that Valparai taluk office is the breaking point station from where the rainfall increases or decreases on either side as the case may be. In general, as the study area is bordered by hills except the north-east opening of the valley portion, it receives the highest rainfall in the northern and southern boundary of the study area. In contrast, the interior part receives relatively low – very low amount of rainfall as the area lies in the rain-shadow region of the valley floor. It is inferred that during all seasons except winter, the spatial distribution of rainfall pattern is controlled by elevation of the terrain.

Mean Annual Variability

According to Trewartha, the variability of rainfall may be defined as the deviation from the mean. The coefficient of variability has been worked out by using standard deviation method for the series of years. The variability gives the stability of rainfall in the district.

Coefficient of Variability = SD/Mean x 100

where, SD = Standard Deviation = $\sqrt{\Sigma d2/n}$

The coefficient of variability of rainfall is the standard deviation from the mean expressed as percent of the mean annual rainfall. The isolines have been drawn on the basis of values compiled for 29 stations in order to bring out the spatial pattern (Table 2.).

Table 1. Mean Annual Seasonal Rainfall

Station Name	Mean Annual Seasonal Rainfall					
	Winter	**Summer**	**Swm**	**Nwm**	**Annual**	**Mean**
Aliyar Nagar	26	175	302	398	902	226
Anaikatti	47	306	268	610	1231	308
Anaimalai	34	382	2983	504	3902	975
Annur	15	126	177	283	600	150
Attakatti	34	272	405	589	1300	325
Chinna Kallar	18	88	260	398	764	191
Coimabatore Town	12	101	189	330	632	158
Kallipalayam	10	83	102	216	411	103
Kumaralingam	14	90	121	291	516	129
Lower Nirar Dam	13	78	154	321	566	142
Makkinampatti	44	182	167	403	796	199
Mettupalayam	33	135	187	402	758	189
Negamam	15	186	350	423	975	244
P N Palayam	26	154	227	533	941	235
Peelamedu	12	101	125	564	803	201
Podanur	18	131	134	300	583	146
Pollachi	18	111	125	423	677	169
Sarkarpathy	18	140	189	387	734	184
Sethumadai	16	143	354	398	911	228
Solaiyar Nagar	22	133	102	339	596	149
Sulatanpet	32	335	2909	498	3774	944
Sulur	9	158	165	294	627	157
Tholampalayam	10	159	136	453	758	190
TNAU	12	1243	173	1813	3242	810
Top Slip	28	123	1892	435	2478	620
Upper Nirar Dam	12	1702	445	398	2557	639
Valparai Taluk Office	30	335	3983	602	4950	1238
Varadharajapuram	36	349	2234	499	3118	780
Vettaikaranpudur	13	125	402	304	844	211
Mean	**22**	**264**	**664**	**462**	**1412**	**353**

Annual Variability

The annual variability varies from 23 to 42% in the study area. The lowest variability of 18% occurs at Sultanpet where the maximum rainfall is found in this district. The areas lie in the openings of the valley namely, Chinna Kallar, Sulthanpet and Aliyar nagar a receives low variability of 21.3, 22.5 and 25.9% respectively which shows high dependability.

Table 2. Rainfall Variability

Station Name	Rainfall Variability				
	Winter	Summer	SWM	NEM	Annual
Aliyar Nagar	125.38	77.4	49.21	43.58	25
Anaikatti	124.3	76.87	38.53	41.15	29.46
Anaimalai	134.5	65.03	75.5	48.76	29.08
Annur	140.35	55.87	37.12	41.99	26.2
Attakatti	143.5	67.11	46.92	29.63	29.86
Chinna Kallar	143.34	58.7	66.53	52.03	33.06
Coimabatore Town	186.3	67.18	61.79	81.89	49.9
Kallipalayam	198.5	88.46	77.48	65.4	53.24
Kumaralingam	110.23	67.29	77.61	51.77	30.66
Lower Nirar Dam	176.98	79.96	79.52	62.27	44.14
Makkinampatti	198.24	58.7	68.55	55.75	35.42
Mettupalayam	224.23	65.46	86.26	73.28	53.71
Negamam	205.3	65.88	46.23	58.13	34.06
P N Palayam	175.3	54.13	73.4	46.61	29.67
Peelamedu	198.2	60.16	35.16	60.16	30.69
Podanur	190.1	65.63	70.99	55.58	33.68
Pollachi	192.2	73.83	93.53	49.36	36.45
Sarkarpathy	110.32	64.92	35.53	48.82	27.56
Sethumadai	222.43	80.44	45.65	59.51	33.24
Solaiyar Nagar	198.2	57.03	41.69	66.43	28.36
Sulatanpet	186.2	65.34	31.56	55.74	22.59
Sulur	154.23	65.81	45.45	56.39	29.03
Tholampalayam	154.2	82.03	72.23	52.5	33.76
TNAU	221.1	66.11	63.59	60.94	43.95
Top Slip	189.2	46.42	47.13	50.06	26.37
Upper Nirar Dam	132.1	51.17	42.85	43.91	34.33
Valparai Taluk Office	143.3	64.4	34.56	51.77	28.3
Varadharajapuram	221.3	69.45	52.6	58.87	35.12
Vettaikaranpudur	135.4	74.96	44.87	61.92	41.12

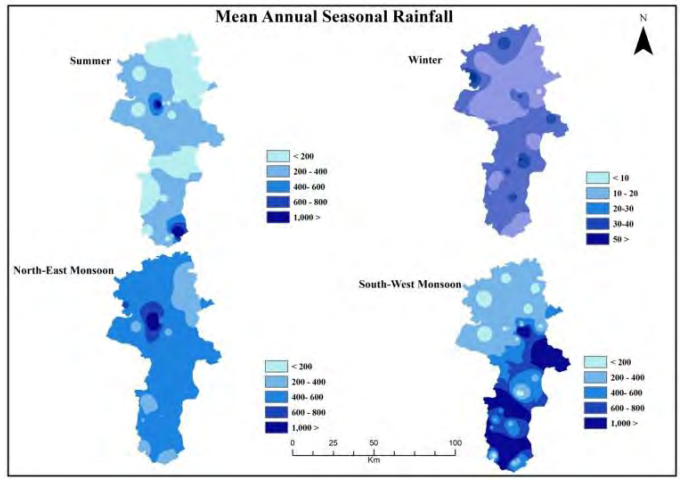

Fig. 2. Mean Annual Seasonal Rainfall

The stations located at the foot hills/vicinity of hills are under moderate-high variability. The highest variability found in Mettupalayam that is 53.71%. The stations located at the lower elevations adjacent to above experience normal variability in and around Coimbatore city. From here, the variability steadily increases towards southwest and northeast till beyond Coimbatore city again which steadily decreases till the end of the mouth of the valley portion. Accordingly, the dependability also follows the same trend as stated above. Fig 3 illustrates the spatial distribution of rainfall Variability.

Winter Variability

Among all seasons (Figure no 3), the winter variability of rainfall is high which ranges between 110.23 – 224.23%. During this season, the variability is triple fold than summer, southwest and northeast monsoon. Accordingly, the dependability of rainfall is also relatively very less. From the spatial distribution of winter variability, the eastern portion notably at the mouth of the valley and southeastern margin has very low and low variability fall under less than 50 and 50- 80% variability classes. The southern portion covering Sulur, Upper Niradam dam , Valparai areas fall under normal variability (80-150%) which increases to moderate (175- 200%) and high (>225%) extend on either side towards north as well as southeast. As the variability ranges between 60 to more than 180% indicates that the rainfall is scanty (> 40%). Hence the dependability is unreliable. However, cultivation practices like short-term crops are possible in and around Annur, Avinashi, Krishnapuram and Pollachi.

Summer Variability

During the summer season, the pattern of rainfall variability is from NE to SE in the order of very low (< 50%), low (50- 60%), normal (60-65%), moderate (65-80%) and high (>80%) which increases succeeding. The very low and high variability occupy almost equal. The rest of low, normal and moderate are equally distributed orienting SW-NE which passes middle of the study area. The variability during this season ranges between 51-88%. While comparing winter and summer the lowest variability class does not have much variation whereas the highest variability class is three fold less than winter which shows that there is a large variation in spatial distribution as well as trend.

Southwest Monsoon Variability

Among the 29 stations the variability is relatively low in Sulthanpet (31.56 %) which is located about 30 km away from southeastern rim of the Coimbatore city whereas the high is at pollachi (93.53), located at the northern part of Nilgiri hills near Mettupalayam. As far as the distribution of variability is concerned the district is divided into two halves, viz. northeastern and southwestern parts, which are separated by a line connecting Mettupalayam and southern margin of Coonor Nilgiri hills. In the southern portion, the low variability (< 50) starts from Valparai and Pollachi which increases towards southeast as much as above 50% that runs along the western margin till end of the northeast portion of

the study area. Another stretch of low variability class starts from Erasakkanaickanur hills and increases towards west till margin of the Pothanur region. Fig no.3 illustrates the Southwest Monsoon Variability

Northeast Monsoon Variability

The rainfall variability of northeast monsoon resembles almost the characteristics and the general pattern of mean annual rainfall variability. Owing to this nature, the annual rainfall variability reflects characteristics of NW monsoon season rainfall variability. This is the season gets more rain which is favorable for agricultural operation as the continuation of southwest monsoon rainfall. A band of area under moderate variability class passes through middle portion of the watershed from northern margin to southern margin. From this zone, the variability increases towards southwest and as well as northeast. From here, the variability decreases towards east along the lower valley portion until touches Coimbatore city. During this season, the rainfall variability lies within 40-60% which indicates less in its fluctuation. From the foregoing facts and figures, it is inferred that the variability fluctuation is less which ranges between 60-80% during both monsoon seasons, though summer touches the maximum of 118.2%.

However, summer rain is useful for preparation of land for agricultural activities and summer ploughing before sowing and seedling. In continuation of summer rainfall, the southwest and northeast monsoon rains are main causes for agricultural activities as the fluctuation of variability is less than interior part of Tamil Nadu. Therefore, the dependability for agricultural activities is relatively large during southwest and northeast monsoon seasons. Fig no.3 illustrates the north monsoon variability.

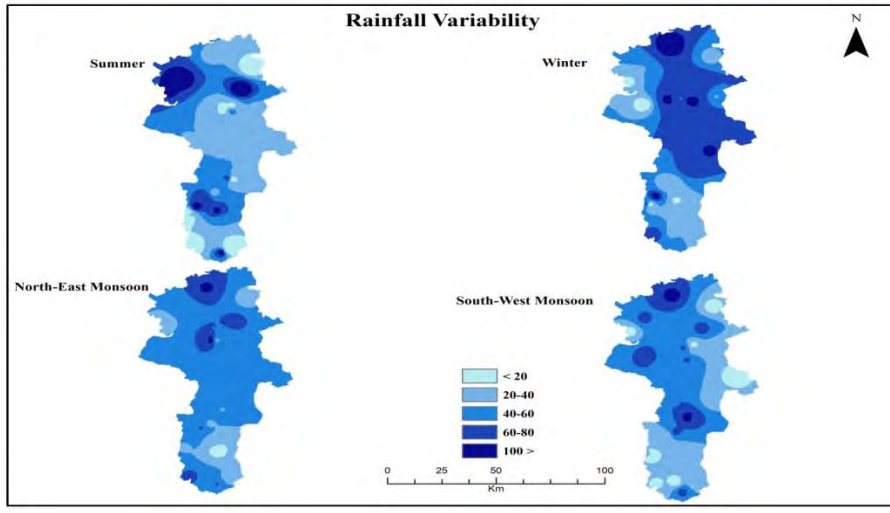

Fig. 3. Rainfall Variability

Results and Discussion

The annual rainfall for 29 stations is classified into five categories by using percentage criterion and evaluated by determining the abnormal condition for each station, and annual total rainfalls are plotted. It is also identified that topography plays an important role in the variability of rainfall. It is found that rainfall is lowest in mid of Coimbatore district and increases away from it in all directions from the Northeast monsoon season and South west monsoon seasons. The trends in spatial distribution of rain days are similar to that of the rainfall. The long term mean annual rainfall of the district is about 1119.3 mm of which the winter, summer, southwest and northeast monsoon contribute 1.9, 18.9, 44.7 and 34.5 of the annual rainfall respectively.

The seasonal or temporal rainfall distribution is of vital importance in human activities especially in agriculture and is a decisive factor in the struggle for sufficient food supply as agricultural activities each year are regulated according to its behaviour. According to the coefficient of variation, the lowest annual variability in rainfall is observed at Bhavani sagar 21.21% and the mid portion of the study area Coimbatore city with a value of 49.90. The highest variability is found in the core area of the region with a value of more than 53.37% at Mettupalayam.

The rainfall variability is greatest in the central area and it decreases away from it in all directions. Low variability implies that the mean rainfall at a given location is reliable while high variability implies wide fluctuations about the mean value. Generally, it is obvious that there is an inverse relationship between rainfall amount and rainfall variability. Annual rainfall is most variable in all the seasons. This is critical as it is the Bhavanisagar, Aliyanagar, Valparai that receives least rain and records highest variation, thus making it very vulnerable in terms of crop production. The study concludes that the Coimbatore district receives meager amount of rainfall over the last twenty years.

Conclusions

The present study reveals that the use of GIS in spatial analysis for rainfall variability analysed both spatial and temporal distribution of rainfall and its patterns, both annually and seasonally. The seasonal distribution of rainfall for 29 stations in Coimbatore district is graphed to analyze the seasonal regime. All the 29 rain gauge station locations are mapped using GIS technique. Variation in annual total rainfall for 29 stations is calculated and isolines are drawn on the map. The annual rainfall for 29 stations is classified into five categories by using percentage criterion and evaluated by determining the abnormal condition for each station, and annual total rainfalls are plotted. It is also identified that topography plays an important role in the variability of rainfall. It is found that rainfall is lowest in mid of Coimbatore district and increases away from it in all directions from the Northeast monsoon season and South west monsoon seasons. The trends in spatial distribution of rain days are similar to that of the rainfall. The long term mean annual

rainfall of the district is about 1239 mm of which the winter, summer, southwest and northeast monsoon contribute 1.9, 18.9, 44.7 and 34.5 of the annual rainfall respectively

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ASSESSMENT OF LANDUSE AND LAND COVER CHANGE FOR SUSTAINABLE DEVELOPMENT: A CASE STUDY OF PICHAVARAM MANGROVE ECOSYSTEM, TAMIL NADU, INDIA

Surendran D. and Jaganathan R.
Department of Geography, University of Madras, Chennai - 600 005
E-mail: rjnathan@gmail.com

Abstract

Land forms and landuse / land cover classification play a major role in the study of changes in the environment. Several scientific geographical studies indicate that the study of landuse /land cover changes is an ideal topic for any geographic research. Globally, land is being intensively and extravagantly utilized to meet the needs of the ever-growing population. The unsustainable and unplanned way of exploiting natural resources is a great concern of the present time. Landuse /land cover change has become an important component for monitoring and managing the changes in the environment and utilisation of natural resources towards sustainable development. In the recent years, the development of geospatial technology has played a crucial role in achieving the land/use land cover classification in a relatively more accurate and scientific manner. The present study attempts to explore the salient features of spatio-temporal changes in the complex system of landuseland cover system of Pichavaram Mangrove region. The datasets used for mapping such as topographic sheet, satellite images and socio economic data from Census of India (2011) were discussed in detail. The methods in which base map was prepared from georeferenced topo sheet, satellite images and the landuse/ land cover classes according to which the study area was classified were mentioned. The classified images were then interpreted. From the interpretations made, it was analysed and observed that the area under settlements have shown an increase of 4%. It is evident that agriculture has been the dominant economic activity in Pichavaram region. Agricultural lands have consistently declined from 1984 to 2013. Aquaculture showed a sharp rise to 3.6%. Mangroves showed a negative growth resulting in -1.7%. Mangrove plantations and sandy area showed a positive growth of 3.8% and 0.3%. The area under longitudinal sandbars, mudflats and decreased to an overall -0.7% and -6.8% respectively. Open scrubland also declined to -9.8%. Backwaters have showed an overall increase to 1.7%. Seawater intruded land increased to 2.5%, on the whole. The evaluation of the assessment is very important in the process of landuseclassification. Finally, for accuracy assessment 252 samples were randomly selected using error matrix technique. The results derived using the matrix were tabulated and the overall accuracy was calculated as 81.02 percent whereas kappa coefficient calculated for the year was around 78.99%.

***Keywords*:** Mangrove Ecosystem, Change Detection, Matrics, Sustainable Development

Introduction

Mangroves are a diverse group of plants which includes trees, shrubs, palms or ground ferns generally exceeding 0.5 m in height and grow above the mean sea level along the intertidal zones of marine environments (Duke et al., 1998), the zone where the salt and fresh water mixing takes place. The community of the mangroves that are found along the sedimentary shores of tropical and subtropical regions in association with intertidal flora and fauna has been termed by MacNae (1969) as Mangal. Mangroves are an assortment of tropical and subtropical trees and shrubs that are seen to acclimatize to the hostile zone between land and sea. Mangrove forests are architecturally simple, harbouring few species of trees that can withstand the mixture of land and sea. The uniqueness of mangrove ecosystems lies in the fact that mangroves have the ability to survive in the transition zone between land and sea and with characteristic adaptations of the ecological niche. Mangroves are xeromorphic (plants conserve water) and halophytic (survive in high saline conditions) in nature.

Mangrove forests are a part of marine coastal ecosystems and the most productive diverse ecosystems on the earth, which influence global climate, nutrient budgets and primary productivity (Twilley et al., 1992). Mangroves are quite old, possibly arising just after the first angiosperms, around 114 million years ago (Duke, 1998). The mangrove species are adapted to grow in saline habitats ranging from 3 ppt to 37 ppt of salinity. They are regularly or occasionally inundated and are capable of tolerating the stresses of salinity and flooding. Mangroves are important coastal habitats which comprise of immense nutrients. Interestingly the mangrove system supports a number of endemic and endangered species throughout the tropical coast. Mangrove ecosystems provide habitats for a wide range of marine and terrestrial species, act as a source of food, medicines and other forest products (Kristensen et al., 2008). Two hypotheses namely the Centre-of-origin hypothesis and the variance hypothesis are given for the origin of mangroves. They occur in the tropical and sub-tropical coastline. In India, they are found in nine states and three union territories. Mangrove forests are classified into five types – riverine, fringe, over wash, dwarf and hammock mangrove forests. The climatic changes in the recent past have become a potential threat to the existing mangroves and other coastal ecosystems along the Indian coastline. In addition, the loss of mangroves extend towards the adjoining mangrove ecosystems (Duke, 1998).

In India, mangroves are found with an aerial extent ranging from 6,81,000 ha (Sidhu, 1963) to 5,00,000 ha (Forest Survey of India, 1998). As one proceeds along the east coast from Sundarbans (in the North) to Pichavaram and Muthupet (in the south), the tidal amplitude as well the periodicity of fresh water flow decreases (Selvam et.al., 2002). Mangroves are a rich source of seafood. They also serve as shelter belts against storm surges and cyclones. Mangrove plants act as sponge and absorb flood water, reducing the disastrous effects of flooding. Mangroves have the capacity to remove carbon dioxide from the atmosphere and store it in the soil, in large quantities.

Thus they act as large carbon sinks and protect the environment from global warming. Mangroves are rich in biodiversity which includes flora and fauna and even the slenderest ecosystem imbalance will lead to a heavy toll in resources (Deshmukh, et.al 1994). Hence, mapping and assessment of mangroves using GIS and Remote Sensing techniques are needed for sustainable development and management of mangroves for the coastal communities.

The term landuse/ land cover implies the various purposes served by land that has been subjected to changes induced by physical factors such as geology, climate, soil and topography and anthropogenic factors such as population explosion, conversion of land for other uses and the like. Landuse/ land cover refer to the distribution of physical features on land and also the utilisation of land for different activities. The classification of landuseof a region is very essential to have a thorough understanding of the region which in turn helps in developing it. For this study, landuseclassification mapping and analysis are of paramount importance to study the extent of mangrove cover and anthropogenic activities in Pichavaram region, thereby help to suggest framework for conserving it in a sustainable manner.

Sustainable Development

Sustainable development of mangroves involves using the resources at a rate less than the rate of regeneration. It also means that the waste generated should not be more than the ability of the ecosystem to assimilate and to adapt. Sustainability on the whole encompasses ecological sustainability, economic sustainability and sustainability of the social system (Peter Saenger, 1993). The 2001 Earth Summit held in Rio de Janeiro listed certain suggestions for the protection of mangroves, protection of coasts, proper allocation of resources and preserving biodiversity. The proper management and protection of mangroves can be done only with the aid of the concept “Sustainable Development”.

Study Area

Pichavaram area is located near Chidambaram in Cuddalore District, Tamil Nadu, India. The study area lies between lat 11°22′N to 11°30′N and long 79°45′E to 79°52′E. The total area covered by the mangrove was about 1,400 ha (Tissot 1987). Pichavaram mangroves is located between two prominent estuaries, the Vellar estuary and Coleroon estuary in the north and south respectively. This mangrove forest is influenced by the seawater from Bay of Bengal, brackish water from Vellar, Coleroon estuaries. According to the system of classification the Pichavaram mangroves comes in the category of fringe type (Lugo & Snedaker, 1974). Pichavaram mangroves covering an area of around 61 sq.km which includes nine villages is taken for the study. According to Census 2011, the total population of the study area is 32,653 and villages like Killai, Pudhupattinam and Pichavaram have high population density. Geomorphology of the study area is mostly covered by young coastal plains with brackish water creeks and orgainsed deep coastal plains. Geologically, Precambrian Crystalline Rocks and cretaceous clay are found in the entire study area. Very deep sandy soils and marshy lands are the major soil types in the

region. The mangrove ecosystem is an open estuarine system drained by Vellar and Coleroon rivers which is rich in fluvio-marine deposits. The annual rainfall varies between 166 mm to 136 mm and the temperature ranges from 18° to 40° Celsius. Fisheries and Aquaculture are the dominant activity other than agriculture. The Pichavaram mangrove forest is well connected through Chidambaram a major urban centre in the area both by railways and road network. It is observed that the study area is found in rich deltaic plain of Cauvery basin. Periodic sediment transport from river sources and tidal water enriches the region for mangrove growth and sustenance.

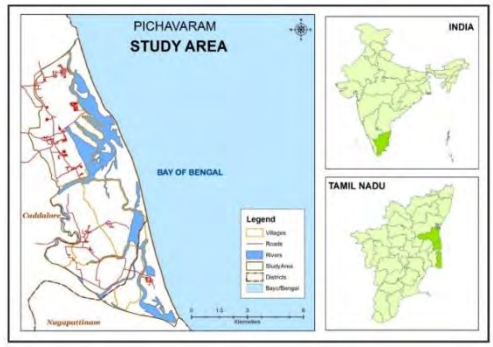

Fig. 1. Location of Pichavaram

Database and Methodology

Dataset

Basemap was created using Topographic Sheet 58M15 of Survey of India (SOI). Socio economic data was collected from Census of India for the year 2011. Primary data was collected from the local people by adopting interview schedule survey method. Remotely sensed data was used to map the resources of the study area. The following remote sensing images were used for the study.

Table 1. Datasets

Sl. No	Dataset	Organisation		Year	Scale / Resolution
1	Topographic Sheet	Survey of India		1970	1:50,000
3	Satellite Image	Landsat 3 MSS, USGS		1984	60 metre
4	Satellite Image	Landsat 5 TM, USGS		1994	30 metre
5	Satellite Image	Landsat 5 TM, USGS		2003	30 metre
6	Satellite Image	Landsat 8 OLI, USGS		2013	30 metre

(Source: Compiled by the Author)

Methodology

For the study, multi temporal Landsat images were acquired from United States Geological Survey (USGS) for landuseclassification. The landusechange and change detection was carried out using Landsat - Multi Spectral Scanner (MSS) having 60 m resolution, Landsat - Thematic Mapper (TM) with 30 m resolution and Landsat Operational

Land Imager (OLI) with 30 m resolution. The base map for landuse analysis was prepared using Survey of India topographic sheet (SOI), 1970. The landuse map was generated for four decades from the period between 1984 and 2013.

Using modified NRSC classification as a base, the landuse of Pichavaram region has been classified into settlements with vegetation, agriculture, aquaculture, mangrove plantation, mangrove forest, open scrubs, mud flats, sandy area, longitudinal sandbars, land with salt water intrusion and backwaters.

The Landsat imagery was further orthorectified and supervised classification & visual interpretation technique was carried out to classify the images into 11 categories based on ground truth verification and the classes were digitized to perform change detection analysis. For accuracy assessment, a standard method of error matrix was used for assessing the accuracy of landuse/ land cover classification. Finally, the overall accuracy, kappa index and kappa coefficient were assessed for 2013 imagery. Based on NRSC classification, the land under study is modified and classified into eleven classes and the remotely sensed data were interpreted and analysed to give the following results in form of thematic maps.

Results and Discussion

Change detection is the technique used in remote sensing to identify the changes in the landuse / land cover of a region with the help of geo referenced satellite images. In this study, change detection has been used to analyse dynamics for the extent of mangrove cover in the study area during the time period of 1984 to 2013. The results of mapping and analysis of mangrove ecosystem here is helpful in understanding the local ecosystem as a whole and also in framing suggestions to conserve it in a sustainable manner.

The landusedata of the year 1984 shows that settlements with vegetation occupy 0.32 sq.km, agricultural lands an area of 20.96 sq.km, aquaculture 0.29 sq.km of the total, mangrove forests in an area of 8.16 sq.km, mudflats a total of 9.89 sq.km, open scrubs a total of 9.16 sq.km, sandy area 0.76 sq.km, longitudinal sandbars along a stretch of 3 sq.km, backwaters 8.03 sq.km and land where seawater has intruded is found to be 0.49 sq.km.

The landusedata of the year 1994 shows that settlements with vegetation occupy 0.82 sq.km, agricultural lands an area of 24.57 sq.km, aquaculture 1.16 sq.km of the total, mangrove forests for an area of 6.42 sq.km, mudflats a total of 8.19 sq.km, open scrubs a total of 5.11 sq.km, sandy area 1.23 sq.km, longitudinal sandbars area in stretch of 2.47 sq.km, backwaters 9.64 sq.km and land where seawater has intruded is found to be 1.47 sq.km. Figure 2. portray the picture of landuseand land cover for the year 1984 & 1994 in Pichavaram area.

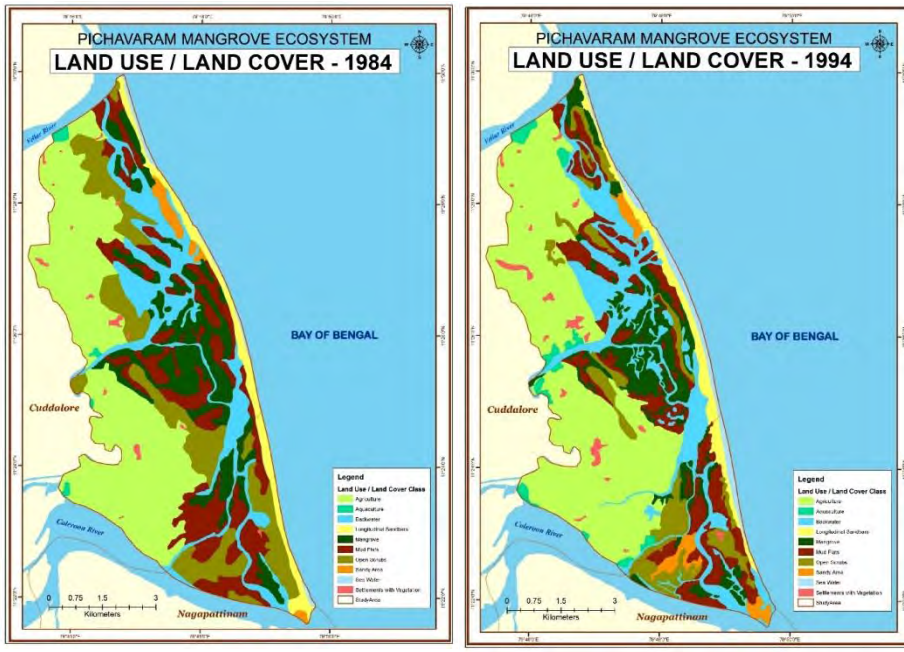

Fig. 2. Landuse and Land Cover - 1984 and 1994

From the year 1984 to 1994, the following changes have been observed. The area under settlements has increased from 0.5% to 1.3%. It is found that agricultural lands account for the maximum landusecover. The area has increased from 34.3% to 40.2%. Hence it is evident that agriculture continued to remain the dominant economic activity during 1994. Aquaculture has increased from 0.5% to 1.9% during this year. This shows increasing awareness among people about the importance of aquaculture. Area under mangroves has decreased from 13.4% to 10.5%. This may be attributed to the beginning phase of the anthropogenic activities leading to pollution of the ecosystem and hence a decrease in the forest covers. The absence of mangrove plantations suggests that people had less or no awareness about the importance of mangrove ecosystems. Open scrubs have decreased and sandy area has increased from 15% to 8.4% and 1.2% to 2% respectively. This may be due to the conversion of scrubland into settlement areas. Thus the degradation of mangrove forests and decrease of scrub land indicate the impact on the ecological conditions of the study area. The introduction of aquaculture has also induced contamination of waterbodies in the down streams.

The area under longitudinal sandbars has decreased from 4.9% to 4%. A major decrease in mudflats is observed from 16.2% to 13.4%. There has also been a significant increase in the lands intruded by seawaterfrom 0.8% to 2.4%. Hence it can be inferred that most of the longitudinal sandbars and mudflats got submerged under seawaterdue to its intrusion on land. Area under backwaters has increased from 13.1% to 15.8%. This may be because of high annual precipitation in the study area.

The landuse data of the year 2003 shows that settlements with vegetation occupy 2.04 sq.km, agricultural lands an area of 23.02 sq.km, aquaculture 2.51 sq.km of the total, mangrove forests for an area of 6.66 sq.km, mangrove plantations cover 1.67 sq.km, mudflats a total of 7.05 sq.km, open scrubs a total of 3.63 sq.km, sandy area occupies 1.30 sq.km, longitudinal sandbars area in a stretch of 2.70 sq.km, backwaters occupy 9.10 sq.km and land where seawater has intruded is found to be 1.41 sq.km. Figure 3. show the spatial patterns of landuseand proportionate share during 2003 respectively. Between the years 1994 to 2003, the following changes have been observed.

The area under settlements has increased from 1.3% to 3.3%. It is found that agricultural lands account for the maximum landuse cover (37.7%). However, the area has decreased from 40.2% to 37.7%. Though it is evident that agriculture continued to remain the dominant economic activity during 2004, considerable agricultural lands have been converted for settlements or other activities. Aquaculture increased from 1.9% to 4.1% during this year. This shows the increasing awareness among people about the importance of aquaculture and also that most of the population started shifting from agriculture to aquaculture. There is a big jump in aquaculture use.

Area under mangroves has increased from 10.5% to 10.9%. This may be attributed to the beginning phase of awareness among people to conserve mangroves. An important fact is that mangrove plantations occupied an area of 2.7% thereby suggesting that people started to know about the importance of mangroves and hence conserved it. Open scrubs have decreased and sandy area has increased from 8.4% to 4.9% and 2% to 2.1% respectively. This may be due to the conversion of scrubland into settlement areas.

The area under longitudinal sandbars has increased from 4% to 4.4%. A decrease in mudflats is observed from 13.4% to 11.5%. There has also been a decrease in the lands intruded by seawater from 2.4% to 2.3%. Hence it can be inferred that most of the longitudinal sandbars re-emerged due to the decreased seawater intrusion. Area under backwaters has decreased from 15.8% to 14.9%. This may be because of low annual precipitation and high rate of evaporation in the study area.

The landusedata of the year 2013 shows that settlements with vegetation occupy 2.73 sq.km, agricultural lands an area of 22.82 sq.km, aquaculture 2.55 sq.km of the total, mangrove forests for an area of 7.15 sq.km, mangrove plantations 2.30 sq.km, mudflats a total of 5.83 sq.km, open scrubs a total of 3.16 sq.km, sandy area 0.93 sq.km, longitudinal sandbars area in a stretch of 2.56 sq.km, backwaters 9.02 sq.km and land where seawater has intruded is found to be 2.03 sq.km. The spatial pattern pertaining to 2013 landusecan be visualized from Figure 3. From the year 2004 to 2013, the following changes have been observed.

The area under settlements has increased from 3.3% to 4.5%. Though it is found that agricultural lands account for the maximum land use cover (37.4%), the area has

decreased from 37.7% to 37.4%. It is evident that agriculture continued to remain the dominant economic activity during the year 2013. However, some of the agricultural lands have been converted for settlements or other activities. Aquaculture increased from 4.1% to 4.2% during this year. This shows increasing awareness among people about the importance of aquaculture and also that most of the population started shifting from agriculture to aquaculture.

Area under mangroves has increased from 10.9% to 11.7%. This may be attributed to the awareness among people to conserve mangroves. Mangrove plantations increased from 2.7% to 3.8%, thereby suggesting that people started to know about the importance of mangroves and hence conserved it. Open scrubs have increased and sandy area has decreased from 4.9% to 5.2% and 2.1% to 1.5% respectively. The increase in open scrubland may be due to the moisture shortage in the study area because of low annual precipitation and high evaporation.

The area under longitudinal sandbars has decreased from 4.4% to 4.2%. A decrease in mudflats is observed from 11.5% to 9.5%. There has been an increase in the lands intruded by seawater from 2.3% to 3.3%. Hence, it can be inferred that most of the longitudinal sandbars and mudflats submerged due to the intrusion of seawater. Area under backwaters has decreased from 14.9% to 14.8%. This may be because of low annual precipitation and high rate of evaporation in the study area.

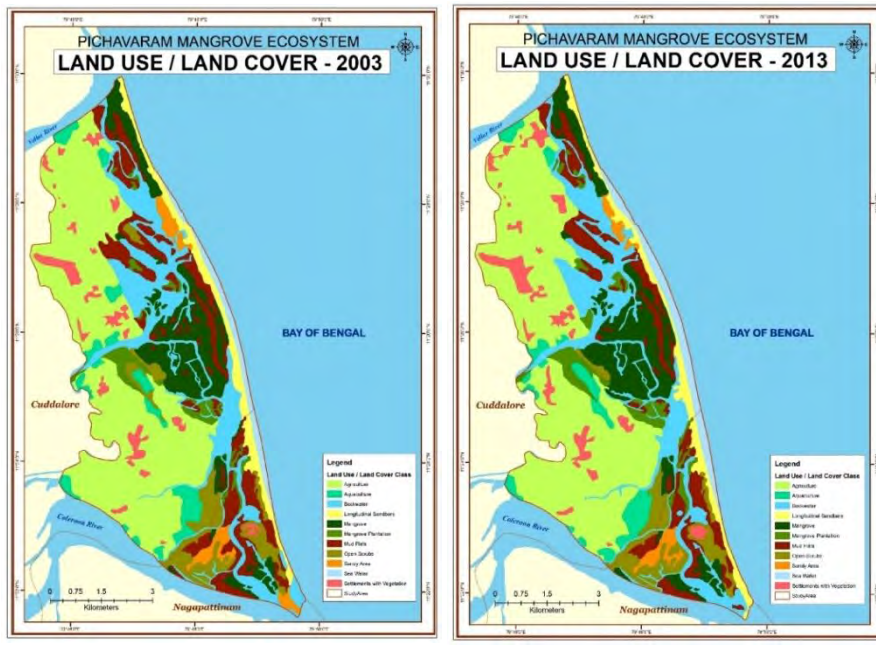

Fig. 3. Landuse and Land Cover - 2003 and 2013

Table 2. Landuse / Land Cover Absolute Change 1984 - 2013 (in Hectares)

Sl. No	Landuse / Land Cover Class	1984	1994	2003	2013
1	Agriculture	2,096.3	2,456.7	2,301.9	2,282.2
2	Aquaculture	29.0	116.1	250.9	255.1
3	Backwater	803.3	964.5	910.3	901.7
4	Land with seawater intrusion	49.2	146.8	141.4	203.5
5	Longitudinal Sandbars	300.1	246.9	269.7	255.8
6	Mangrove	816.1	642.4	665.7	715.1
7	Mangrove Plantation	0.0	0.0	167.3	229.7
8	Mud Flats	989.4	818.7	705.2	583.1
9	Open Scrubs	916.0	510.6	362.5	315.7
10	Sandy Area	76.2	122.9	129.8	92.8
11	Settlements with Vegetation	32.0	82.2	204.0	272.8

Source: Compiled by the Author

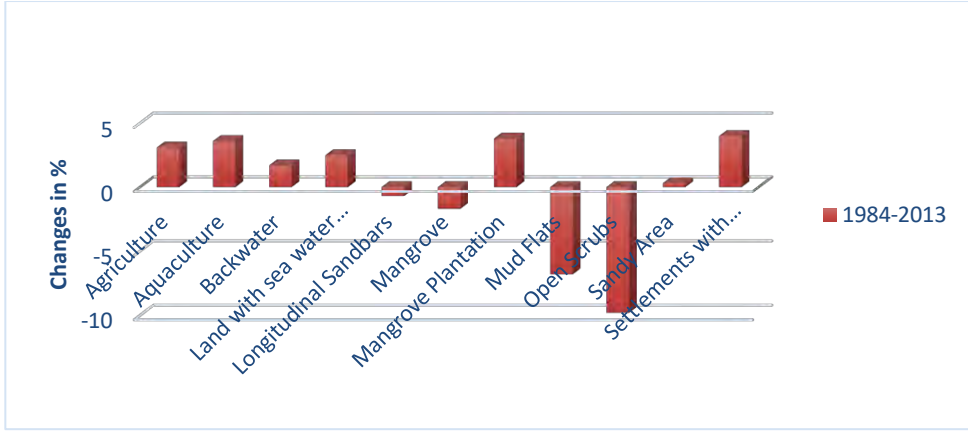

Fig. 4. Landuse and Land Cover Change Dynamics (in %)

Accuracy Assessment - Error Matrix

The evaluation of the assessment is very important in the process of landuse/ land cover classification. For the accuracy assessment 252 samples were randomly selected to assess the accuracy using error matrix technique. The couple coefficient has been used to measure the accuracy of the result derived using the matrix. The results derived using the matrix has been tabulated and the overall accuracy is calculated as 81.02 percent whereas kappa coefficient calculated for the year is around 78.99%. It may be observed from the accuracy assessment that the user accuracy ranges between 75% and 88% and the producer accuracy between 53.7% and 100%. The accuracy variation is high in case of open scrubs, mud flats and backwater measurements. Thus the dynamics has led to differences in accuracy levels in the above landuse / land cover categories.

Table 3. Error Matrices

Classification	AG	AQ	BA	BB	LS	MA	MP	MF	OS	SA	SV	Row Total	User Accuracy %
AG	32	0	0	0	0	0	0	0	7	0	4	**43**	74.4
AQ	0	16	4	0	0	0	0	0	0	0	0	**20**	80
BA	0	0	18	0	0	0	0	2	0	0	0	**20**	90
BB	0	0	2	10	0	0	0	0	0	0	0	**12**	83.3
LS	0	0	0	0	12	0	0	2	0	0	0	**14**	85.7
MA	0	0	0	0	0	58	0	7	5	0	0	**70**	82.9
MP	0	0	0	0	0	5	28	2	0	0	0	**35**	80
MF	0	0	0	0	0	4	0	26	3	0	0	**33**	78.8
OS	2	0	0	0	0	0	0	2	22	2	0	**28**	78.6
SA	0	0	0	0	0	0	0	2	0	14	0	**16**	87.5
SV	0	0	0	0	0	0	0	0	4	0	16	**20**	80
Column Total	**34**	**16**	**24**	**10**	**12**	**67**	**28**	**43**	**41**	**16**	**20**	**311**	
Producer Accuracy %	94.1	100	75	100	100	86.6	100	60.5	53.7	87.5	80		

(Source: Compiled by the Authors)

WHERE,

1. AG- Agriculture
2. AQ – Aquaculture
3. BA – Backwater
4. BB – Bay of Bengal
5. LS – Longitudinal Sandbars;
6. MA- Mangrove
7. AQ – Aquaculture
8. MP – Mangrove Plantation
9. MF – Mud Flats
10. OS – Open Scrubs
11. SA – Sandy Area
12. SV–Settlements with Vegetation

Accuracy Assessment: Total Accuracy

$$\text{Accuracy Total} = \frac{32 + 16 + 18 + 10 + 12 + 58 + 28 + 26 + 22 + 14 + 16}{311}$$

$$= 252 / 311$$

$$= \mathbf{81.02}\ \%$$

Kappa Value

Where N = total number of sites in the matrix, r = number of rows in the matrix, x_{ii} = number

$$\kappa = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}$$

of rows I and columns I, x_{+i} = Total for row i, and x_{i+} = Total for column i (Jenson, 1996)

$$N\sum_{i=1}^{r} x_{ii} = 32 + 16 + 18 + 10 + 12 + 58 + 28 + 26 + 22 + 14 + 16 = \mathbf{252}$$

$$\sum_{i=1}^{r}(x_{i+} \times x_{+i}) = 43(32) + 20(16) + 20(18) + 12(10) + 14(12) + 70(58)$$
$$+35(28) + 33(26) + 28(22) + 16(14) + 20(16) = \mathbf{9402}$$

$$k = \frac{311(252) - 9402}{311^2 - 9402} = 0.7899 = \mathbf{78.99\ \%}$$

Summary and Conclusions

From the remotely sensed data, the area under settlements has shown an increase of 4%. It is evident that agriculture has been the dominant economic activity in Pichavaram region. However, there has been a consistent decline in agricultural lands from 1984 to 2013. Aquaculture showed a sharp rise to 3.6%. Mangroves showed a negative growth resulting in -1.7%. Mangrove plantations and sandy area showed a positive growth of 3.8% and 0.3%. The area under longitudinal sandbars, mudflats and decreased to an overall -0.7% and -6.8% respectively. Open scrubland also declined to -9.8%. Backwaters have showed an overall increase to 1.7%. Seawater intruded land increased to 2.5%, on the whole. Landusechanges have been observed between 1984-2013 and the change analysis results are presented in Figures 2 and 3 as absolute area of change in terms of hectares. In Figure 4 it is noticed that the form of columnar diagrams in trends of landusechange in each landuse.

It is noticed that, in the year 1984, agricultural land continued to dominate the landusepattern of the study area. The area under mangroves increased and the area under longitudinal sandbars and backwaters decreased. Mangrove plantations were absent. During the year 1994, agricultural lands covered maximum area, mangrove cover started decreasing implying the beginning of anthropogenic activities and continuous absence of mangrove plantations. During 1994 - 2013, settlements, aquaculture and mangrove plantations increased thereby implying the spread of awareness among people about the importance of mangroves. However, the area under agriculture has decreased. Using change detection analysis, it was observed that the settlements with vegetation increased steadily from 1984-2013, agricultural lands increased from 1984-1993 and started declining thereafter; there is a rapid increase in aquaculture and mangrove plantations from 1994 onwards, mangrove forests increased till 1994, after which there was a negative growth and then started increasing from 2003, the area under sandbars increased from 1984 to 2003, sandy area increased from 1984 to 2003, mudflats and open scrubs suffered a continued decrease throughout the period of study, backwaters increased from 1984 – 1994 and then decreased from 1994 to 2013, the land under seawater intrusion increased from 1984 – 1994, suffered a decrease during 1994 to 2003 and again increased from 2003 to 2013. By applying error matrix to 252 randomly selected samples, the overall accuracy is calculated as 81.02% and the kappa coefficient for the year is found to be 78.99%.

Based on the study, it is observed that the mangrove environment is in endangered level. Population in the surrounding mangrove environment is getting increased time to time. But the livelihood of the local people is not much supported. So their livelihood is questioned. As their socio-economic conditions is not so adequate they are in need to utilize their surrounding environment, which lets the mangrove environment degraded. The study reveals that the mangrove environment has an enormous potential for further development of its natural resources through remedial measures. Sustainable measures must be taken up to fulfill the basic livelihood / socio economic conditions of the local people which indirectly helps in conserving the mangrove environment. Public awareness

by all means is the possible way to safeguard the natural resources of mangrove environment.

Geographic Information System (GIS) and Remote sensing helps in obtaining information and analyzing the changes regarding species diversity, density and areal extent of each species of mangrove ecosystems. Furthermore, there is a need to predict the future scenarios of the mangrove ecosystem with the aid of spatial models to take suitable measures for sustainable development.

Acknowledgement

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Archives - 1

PROCEEDINGS OF THE 4th GEOGRAPHICAL CONFERENCE OF THE MADRAS GEOGRAPHICAL ASSOCIATION, TRICHY SESSION

Formerly Known as The Journal of The Madras Geographical Association
(Volume 8, July 1933, No. 2)

The Fourth Conference of the Madras Geographical Association commenced its sittings on the afternoon of Tuesday the 16th May 1933 at the Lawley Hall, Trichinopoly, under the presidency Mr. K. A. Nilakanta Sastri, M.A., Professor of Indian History and Archaeology in the University of Madras.

Besides the following members of the Association, there was a large gathering of visitors:- Messrs. A. K. Krishnaswami Iyer (Madras), T. S. Suryanarayana (Madras), K. Rangaswami Iyenkar (Madras), V. Saranath Iyengar (Trichy), K. A. Nilakanta Sastri (Madras), E. S. Radhakrishnan (Trichy), T. S. Anantanarayanan (Lalgudi), M. S. Sabesan (Madras), George Kuriyan (Madras), B. M. Thirunarayanan (Madras), S. T. Ramanujam (Trichy), S. Ramakrishna Avadhani (Trichy), R. Agoram (Tanjore). G. Narayanaswami (Madras), C. S. Rajagopalan (Madras), V. K. Sourirajan (Madras), N. P. Ramanathan (Namakkal), M. Krishhnamurthi (Trichy), V. K. Rajagopalan (Chidambaram), N. S. Narasimham (Trichy), S. Natesa Iyer (Pudukottah), P. Natarajan (Pudukottah), R. Krishnaswami Iyer (Pudukottah), V. K. Rajagopalan (Pudukottah), Srinivasa Iyengar (Pudukottah), R. Rangaswami Iyengar (Periyakulam), V. S. Ramaswami Iyenger (Madras), J. N. Paramasivan Pillai (Coimbatore), S. Natarajan (Madras), V. Krishnan (Madras), T. S. Sundaram Iyer (Ambasamudram), S. K. Devasikamoni (Trichy), N. Subrahmanyam, Secretary (Madras), P. K. Ramanatha Rao (Chittoor), S. S. Krishnaswami Iyer (Secunderabad), A. L. Sundaram (Karur), R. S. Srinivasa Iyengar (Karur), V. Pitchu Iyer (Negapatam), N. Achutharaman (Erode), S. Ananthanarayanan (Trichy), K. N. Krishnaswami Iyer (Srirangam), R. Ramakrishn (Andiyur), N. Rangaswami Iyer (Kumbakonam), S. Srinivas murthi (Kurnool), C. G. V. Subbiah (Nandyal), N. Divakar Rao (Coonoor), J. Sugirtha Raj (Tuticorin), G. Mahadeva Iyer (Madras), V. Sivasubrahmanyam (Madras), D. Narasimhachari (Madras), R. Srinivasan (Madras), R. Seshagiri Rao (Madras), N. Sitaraman (Batlagundu), C. Visvanadhan (Manamadura), S. Raghunadhan (Madras), G. V. Rama Iyer (Kumbakonam), Vaithinathaswami Iyer (Chidambaram), T. G. Panchapagesa Iyer (Perambalur), V. Garudadri (Devakottah), Seetharama Gupta (Madras), K. S. Seetharama Iyer (Kattuputhur), V. Ramakrishnan (Vizag), A. R. Srinivasa Iyer (Madras), A. S. Ramaswan Iyengar (Srirangam),

K. N. Rangaswami Iyer (Srirangam), M. S. Paul (Udayarpalayam), T. D. Govindaswami Pillai (Lalgudi), Lakshmikantham (Vridhachalam), M. Gopala Iyengar (Chidambaram), A. N. Ardhanari (Bhavani), K. N. Subramania Chetty (Edappadi), B. H. Krishna Rao (Vizag), T. K. Kothandaraman (Namakkal), V. Guruswami Sastri (Tirukkattupalli), A. N. Schwartz (Madras).

Welcome Address

Mr. Khan Bahadur P. Khalifullah Sahib, M.A., B.L., M.L, Chairman of the Reception Committee, delivered the welcome address in the course of which he said that man was a creature of environment, and History is but a study of the activities of man placed in the peculiar geographical conditions of his country and its environment. He was sure that Trichinopoly was not a great puzzle geographically and would give ample scope for study. As far as he was aware, in parts of Perambalur taluk, they had deposits of stone slabs which proved beyond doubt that the area must have been submerged under the sea at one time or other and he learnt on reliable authority that there were clear traces of petrol depesits in the northern part of this district and it was an admitted fact that there were rich mineral deposits in parts of Perambalur and Ariyalur, well worth investigation and research.

They were meeting at a time when there were several change and alterations of a sweeping character in contemplation by the powers that be. It behoved them to think deeply and deliberate on every one of those questions and convey in no unequivocal terms the views of this Conference thereon. It was a matter for deep concern that while subjects of great human interest like History, Geography and Science were accorded a prominent place in the curriculum of studies in several civilised countries of the world, in this country alone due prominence was not attached to the study Science and Geography. They must be given a place in the 'A' group of subjects, in the S.S.L.C. Scheme, so as to stimulate the interest of the students in their study during at least the Secondary School years.

Mr. S. K. Devasikamani, Headmaster, Bishop Heber High Beel, proposed Professor Nilakanta Sastri to the Chair. He said that Mr. Sastri was a great educationist of Southern India and a sound critic. They required such a critic to guide their deliberations especially at a time when Geography is about to be disowned.

A time there was, he said, when Geography was like the Cindrella in the story. About three years ago it came to its own in the High School. It was grouped along with History. The circular recently issued by the Director of Public Instruction marked a new era in the study of Geography. Perhaps it may again go down; and they therefore wanted somebody like Mr. Nilakanta Sastri to champion their cause. He was lucid in his speech, had a capacious understanding and incomparable intellect and his wide knowledge of History and Archaeology eminently fitted him preside over the Conference.

Mr. George Kuriyan of the Department of Geography, Madras University, seconded the proposition. He said that History and Geography had been closely allied subjects for many years; and Professor Nilakanta Sastri as the Head of the Department of Indian History and Archaeology deserved to fill the chair of their Conference.

Mr. M. R. Rangaswami Iyengar, Headmaster, Board High School, Periyakulam, supported the proposition which was duly carried. Professor Nilakanta Sastri then delivered his presidential address

Presidential Address

Less than two years ago, in his retrospect of geographical studies in Britain the Rt. Hon'ble Sir H. J. Mackinder said:

"About half a century has elapsed since the Council of the Royal Geographical Society came gradually and with some controversy to the conclusion that if it would succeed in reforming geographical education it must transfer its attention from the Schools to the Universities. It was at Oxford, our senior University, that a beginning was made. My memory goes back to my first lecture as University Reader there forty-four years ago. I had an audience of three, one man and two women. The man was a Don who told me he knew the geography of Switzerland for he had just read Baedeker through from cover to cover. The University of Oxford is now at long last to complete the work of my successors by electing a Professor of the subject with full status and emoluments. In the interval every University in the country has set going the teaching of Geography. Thus, the decision to establish the Oxford Chair comes as the endorsement of a general movement and crowns a national development." (Scott. Geogr. Mag. 1931. Vol. 47, p. 321.)

Geography as an independent subject of study is thus a new creation, and its place in the curriculum of studies and as a subject for research still provides matter for argument.

As a school boy I had a little to do with Geography. I recall that Geography was then, as it still is, an annexe of History: in the early stages, Geography was almost entirely a string of names, of continents, countries, peninsulas, mountains, peaks, rivers, tributaries, towns, and, last but not least, exports-imports: later, there was some talk of seasons, eclipses, tides and so on, and I belonged to a school which made a name for its enterprise in cultivating the newest methods and obtaining the best teaching appliances for Geography. I am afraid these opportunities were wasted on me, and the only thing I recollect of the most advanced Geography classes I attended is my having heard some fine descriptions of natural scenery read out to the class by my teacher. But I do not believe that many students of my generation had equally good opportunities of geographical education: speaking generally, it was the era when exports and imports made up Geography, and dates and events constituted the whole of History.

Geography has been gaining better recognition amongst us in recent years and the work of this Association is to serve as a clearing house of the latest researches in the subject. One of the features of the annual conference of the Association is to take up the detailed regional study of the locality of the meeting, and I have it no doubt that, presently, you will be invited to discuss a number of interesting and instructive papers on the Geography of the Trichinopoly Region.

A geographer may feel that the recognition accorded to his subject is still slow, meagre, and half-hearted: it is still History and Geography, much to the detriment of the second member in unequal combination. In the drama of human evolution, the geograper argues, the theatre has been of equal importance with the actor, the prevalent partiality for the study of History as against that of Geography is somewhat irrational. I remember the brave efforts our geographers made some time ago to produce a syllabus of Geography for the S. S. L. C. which could hold its own by the side of the histories of England and India taken together; they succeeded better than they knew, and the result is seen now in the disaster that threatens to befall both History and Geography in our secondary education course. The same plan was followed by the enthusiasts for Elementary Science and the consequences are similar.

"Though cultivated almost from the beginning of recorded history, Geography has always hovered between a hobby and a science. Parts of it, Cartography and Mathematical Geography for instance, were from the beginning characterised by a great amount of accuracy and certitude and have been steadily improved by generations of workers: the rest was superficial observation and vague descriptions. The new Geography which aspires to the position of an independent science is, as Mackinder has pointedout, a creation of the last half a century.

To one who is not a geographer, some puzzling questions inevitably present themselves on the nature and content of geographical studies. He is tempted to ask if Physical Geography is really more than a loose leaf album of strips torn from the natural sciences and manipulated by each geographer after his own fashion; if Mathematical Geography is not more Mathematics than Geography, and if Human Geography again is not a patchwork of data more systematically treated in Economics, Politics, Medicine and other sciences. Geography in his view, seems to lack the unity which characterises the subject matter of other science, and consequently the geographer, being forced to be the Jack all Sciences, is master of none.

To such enquiries and doubts the geographer must produce a convincing answer, or the future of his science is imperilled. He may indeed point out that criticism is easier than defence, that defence even though well founded is often difficult. Of the positive contribution of Geography to human knowledge in one sphere, there can be no question. The task of describing the earth accurately by means of scientifically constructed maps based on travels, surveys, observations and so on is preeminently the work of Geography, and if the geographer had not done it, and done it so well, someone else would have had to do it. Then, the true relation of Geography to the other sciences cannot be understood without realising that the central aim of Geography is the study of the earth as the home of man, of 'the human habitat', of how it affects man and his work and is in turn transformed by these. Mackinder illustrates the position thus: "When I was in Africa" he says, "I remember seeing before me a great billowing slope, clothed with dense forest, dark green and burnished in the sun shine. I entered and traversed that forest for a long day. When I emerged and looked back there was the same forest, and yet my vision it was not the same, for I could now appreciate its texture: I had not merely sight of it, but insight. So it is

with the trained geographer: he starts on the shoulders of the scientific specialists, he traverses his natural regions, and emerges with a new grasp and insight of the world as a whole." (Scott. Geog. Mag. Vol. 47. 1931, pp. 328-9.) But having said this, he is modest enough to add: "This, if I mistake not, will be his essential contribution to the shaping of our human destiny in the not far distant future." Geography to-day resembles Economies in this, that no two Professors will agree on their estimates of the relative importance of the various factors at work in individual cases, with this difference, that Geography has never yet attained even the thin core of doctrine and method on which the economists of the world are generally agreed. Much hard thinking will be needed to effect the synthesis by which the two great branches of Modern Geography, Physical and Human, can be integrated into a united whole: but even here there is no lack of fertile suggestion. It has been pointed out, for instance, that both Physical and Human Geography are essentially "concerned with the carriage and storage of energy on the surface of this earth, and the vehicle is the Protean element, water. Even the lightning is incidental to the cloud and broadcast music depends on steam or water-power." (Scott. Geog. Mag., p. 334.) This perhaps sounds very much like poetry but does it not sometimes happen that the poetry of today is the science of tomorrow?

I wish to say a word on the relation of Geography to History. Historical Geography is wider than what a historian like Freeman understood by that expression. To him it was only historical topography, in particular the shifting of political frontiers. The new conception of Historical Geography is that of a study of the effects surface relief upon political and racial boundaries, upon the whole course of civilisation. While the theoretical conception of scope of Historical Geography is thus stated easily enough, there is not available as yet any scientific method of working out in detail the positive effects of geographical environment on History. That is the reason why, to the chagrin of the geographer, books on History open with vague, but respectful references to the influence of the Geography of a country on its History, and with more or less satisfactory descriptions of the Physical Geoography of the countries to which they relate and for the rest of it, all about Geography, except when a battle or a campaign clamours for its mention once again. It is no use blaming the historian for this so long as geographers themselves do not speak with settled convictions or evolve a consistent method of study. So far the historian has not been much impressed by the attempts made by geographers and others to explain the course of History by the geographical environment and changes in it, with the result that he still prefers to build on the surer foundation of archaeology and literature.

Take, for instance, Huntingdon's theory of pulsatory changes in climate. It is a theory which has passed through many changes itself, and I shall sketch its outline from the most recent edition available to me of his *Civilisation and Climate* (1924). Climate, Race and Culture are "the three great factors in determining the conditions of civilisation. As to which of the three is most important it is impossible to say." (p. 387.) In historical times, climate "seems to have undergone a pronounced series of pulsations which have varied in character from one part of the earth to another" (p. 6.) and the effects of these changes have depend on the extent of the resulting departure from the optimum conditions of climate (p. 6.), which vary according to a nation's stage of civilisation, and perhaps also

from race to race. (p. 17.) The mechanism of these changes consists in variations in storminess and rainfall, rather than in temperature: a shifting of the areas of cyclonic storms alternately toward and away from the equator. (pp. 9-10.)

Criticism and reflection have led Huntingdon to formulate this theory which is so very different from Koropotkin's simple hypothesis of progressive desiccation. But one may ask if in introducing so many refinements into his theory of the climatic basis of History, Huntingdon has not greatly obscured the issue. Even if one concedes the pulsatory hypothesis without argument, and 3 will not be forgotten that several geographers do not concede either this hypothesis or the 'blanket theory of climate' used to cover such widely different facts as polyandry in Ladakh and the decline of Ancient Greece, one is at a loss to see what it all means. The effects of climatic changes depend not on the amplitude of such changes, but on the deviations they cause from the optimum climatic conditions. And these latter depend on the stage of civilisation reached and perhaps also on Race. I have a habitual distrust of positive arguments based on the conception of the optimum, for the optimum in the social sciences is not definitely ascertainable, and not definable except in relation to results. And where these very results form the subject of debate, the concept of the optimum can afford no help. Huntingdon is rather impatient with the historians who say that climatic changes are not needed in order to explain the historical facts. He argues that the primary question is whether climatic changes have taken place in historical times, and if they have, the historian is bound te take note of them and enquire into their effect, just as he inquires into the effects of barriers like Alps or of great men like Socrates. (p. 342.) But his own statement that the effects of climatic changes depend on the deviation from optimum climatic conditions caused thereby, that, in plain words, the effects of climatic changes may be great or small according to the circumstances of each in dividual case, makes it seem less worth while for the historian to pursue so elusive a game.

The historian cannot also help reflecting how little the conditions of physical climate seem to have with such world-historic events like the Reformation or the French Revolution, the Great War or the Russian Revolution, and how much more important the moral and spiritual climate is in explaining these great occurences. And if from what he sees more clearly, he makes an inference in relation to what is not so clearly recorded, and concludes that either there were no important climatic changes in historical times, (the case of Geological periods stands on another footing), or if there were, they had not such consequences as to merit the historian's attention, he is probably only following the best course that is yet open to him. His presumption that in the history of civilisation the "Social heritage" counts far more than the physical environment remains unshaken.

I think it was Buckle who first made an elaborate attempt to explain the history of India by the rice-eating propensities of her people. The modern geographer makes a more general effort and has a theory regarding the civilisation of the rice-fields. One of the most remarkable statements of this theory is the chapter on "The Civilisation of Rice Lands" in Huntingdon's *The Human Habitat*. It is not a mere description of the characteristics of rice-civilisation, but an attempt to explain the history of rice-lands in Weems of their geographical environment. I have not the time to examine here in detail the amazing

contentions and the highly imaginative excursions into pre-history calculated to arrest our attention, but this I will say, that when we come to historical times, it is no longer a case of Geography explaining History and bringing fresh light to it, but of History controlling the thought of the geographer. The chapter concludes with the remarkable statement: “Our purpose here is merely to point out that in the past, and perhaps in the future, the conditions that favour the greatest density of population and the greatest aggregations of human beings are those which make rice cultivation feasible for people with tropical appetites, desires and modes of living, and yet with a high degree of culture according to tropical standards.” The climate, in other words, which is good for rice, also necessarily makes for low economic standards and a conservative social system. To me this looks more like propaganda and less like science. It is quite possible to explain much of the present backwardness of the tropics in terms of human action which has nothing more to do with climate than with the Binomial theorem; and Huntingdon makes not the slightest attempt to allow for these factors and to determine the residue that may, if at all, be attributed to climate, which at one time did not stand in the way of some countries in the tropics reaching a relatively high culture, not merely according to a tropical, but by a more absolute standard.

Let me point to another instance of the alliance between Geography and propaganda. This time I choose my example from definitely propagandist book. For the benefit of an America audience whom he addressed in 1930, Lord Meston began his discourse on the origin and growth of Hinduism: “permeating our general conceptions of bygone India must be that of a country singularly isolated and absorbent, with few entrances and practically no exits. In Europe the ancient world was one of much racial movement and migration; the mediaeval world was busy with the comings and goings of soldiers and adventurers, travellers and scholars, for whom national boundaries were of small account. Not so with India. There was no continental interchange of men and thought. Almost a continent in itself, its land frontiers were great mountain masses, the loftiest and densest of this globe, while elsewhere the unknown terrors of the ocean guarded it. Into this pocket on the earth’s surface there flowed wave after wave of human race - not to recede again - but to soak into the soil. It lived in seclusion, in itself and for itself, churning over and over for centuries, under enervating skies, its own speculations on life and eternity. No cleansing winds of outside thought swept through the galleries of the mind”.* In this tirade on India’s isolation, Lord Meston grudgingly admits that there was some commerce by sea with the west and that we hear of occasional missions of western courts; but this intercourse with the outer world was all, according to his Lordship, very partial and spasmodic.

A mountain and a sea frontier are not the monopoly of India, and in sober truth they did not act as barriers to foreign intercourse more than they did in other countries, Italy for instance, and in the eyes of the historian, the isolation of India was never so pronounced as in recent historical times after the advent of the European nations on her soil. Much recent work in archaeology, philology and anthropology is calculated to show with increasing distinctness the place of Indian culture in a belt of closely related and freely communicating cultures spreading across the whole of Southern India and the Pacific ocean, and to bear

down the superficial estimate of India's isolation held by the last generation of India's historians. A perusal of works like Hudson's *Europe and China* or Ferrand's *Textes Arabes* etc., bearing on the trade of the Indian ocean for many successive centuries will show how regular and important were the contacts India maintained with the countries to the West and East of her. Stein's explorations on the one side, and the work carried out by the Dutch and French archaeological departments in the East Indies and Indo-China reveal the wide range and firm hold of Indian influence on the cultures of foreign lands.

Now my object in dwelling at some length on the limits of Historical Geography is not to argue that the historian has no interest in geographical studies or that the geographer should make no attempt to explain historical facts from geographical environment. Geography is a young science and it is perhaps difficult for any science in its adolescence to resist the temptation to be flighty and meretricious. Geography must beware of going too far, and asserting much more it can, with the data in its possession, prove to the satisfaction of fellow-workers in other fields. When all is said, Geography is a science of things and at the other end of the pole is Man; the geographical outlook is apt to stress the influence of the environment too much, and unduly neglect the various human influences at work to transform the environment and overcome obstacles presented by it. Any suggestion that this privilege of humanity depends upon Latitude or Longitude cannot be received with too much caution. Geography is no stranger to exact and scientific methods in some of its branches and no one dreams of calling into question the great achievement of Geography on these lines. But in all that relates to human character and History, the geographer has perhaps unconsciously, been too often the plaything of accident or prejudice. With patience, a scrupulous regard for objective data, and readiness to for the play of extra-geographical influences on the problem on hand, better results will no doubt be reached. Historical Geography is an exacting study; the continuous action and reaction between environment and human progress is the most difficult aspect of dynamic human geography; and the problem is always complicated by the presence of the imponderable considerations attaching to race.

Of the teaching of Geography in our schools I cannot hope say much, or indeed anything, that is likely to interest you. With your leave, however, I wish to make one general observation. I am tempted to make it for two reasons. First, I believe that there is a real need for a radical change in our methods of teaching not only of Geography, but of most of our school subjects.

It seems to me that our practice makes education too much of a process of stuffing the mind and too little of what it should be, a process of drawing out the latent capacity of the mind. We must put a stop at the earliest opportunity and as completely as possible to the phenomena of the teacher who lacks a full view of his subject and gets up 'notes' from day to day on the successive heads of a heavy syllabus, and of the pupil assiduously 'getting up' these notes for the examination. Secondly, the question the content of our secondary education course is becoming a serious problem, and the authorities in charge of the secondary course appear to me to be embarking on a reform which, in the name of

“freedom in education”, seems calculated to maim the secondary course hopelessly. Geography loses heavily in the change so does History.

We have short memories. Not many years ago, the cry was against the premature specialism of the old S. S. L. C. course and for an all round general education. I believed in that plea then, and nothing has happened to change my belief. I must say this, however, that when we came to grips with the details, we saw that the enthusiasm of specialists outran the pupils’ capacity for assimilation; and the demands of the men of science, that the pupils who seek scientific education in the university must have a special preparation for it at the school stage, had to be met somehow. We got a somewhat overloaded group of five compulsory subjects, and a single optional subject, literary or scientific for pupils seeking entrance to the University, that is, in practice, for every pupil, for there is none so mean has not to aspire for a University degree. Now the pendulum swings back to the old position, three compulsory subjects and two options. I am afraid that this course, if decided upon, would leave our secondary education course still in a position of unstable equilibrium, and we may be up against the whole problem in the course of a few years; for in this country, public opinion has a way of being somnolent at the proper time when reforms are on the anvil, and of beginning to kick against them just a little too late.

With the rapid increase of the factual knowledge on all hands, the problem of the content of the school course is becoming increasingly difficult of solution in all countries of the world. Ours is not by any means the only country where the school curriculum is the battle ground of specialists, each sincerely actuated by the firm conviction that no education can be complete which does not give a good grounding in his subject. But we have other difficulties besides. Our elementary schools are hopelessly backward, and in one word, we do not get our money’s worth even for the small expenditure on this branch of our educational system; our second secondary schools do not recruit pupils coming out of well managed schools, and we have no system of efficient and compulsory education to the age of fourteen on which the high school course may be built. And despite the option to teach through the mother tongue, our teachers still prefer the English medium for the bulk of their work, a medium which does not conduce to the comfort of either teacher or pupil.

It seems to me that to attain a proper balance in our high course, we must not cut down the content so drastically as to confine the compulsory part of the course to the three R’s and then give the choice of any two odd bits from a wide range science and arts subjects. The better method seems to be to do away with the single optional subject and use the time so released not to intensify the training in the general subjects, but to introduce the much needed variety and interest in the school programme in the form of options with a vocational and technical bias. In the general and compulsory part of the course, there must be worked out a reasonable syllabus in each subject and an attempt made to diminish the strain of the examination. The aim of the syllabus in each subject must be to bring the pupil into intimate contact with a selected part of the subject; and equip with the capacity and the desire to carry his studies further on his own. For this, more than the syllabus, the method of its treatment in the class-room counts. The teachers must be able to furnish skilful guidance through the subject-matter which lies before the pupil and teach him to put his

time to the best use. And the type of examination must be such as will test, not the capacity to memorise and repeat facts at proper notice, but the general ability of the pupil and the extent to which he had been able to assimilate the subjects in his course and make them part of his permanent mental equipment.

I believe that experts in Geography, if they feel that there is something in what I have said, can and will contribute their quota towards improvements along such lines. It is with some diffidence that I commend to your consideration the method suggested by following description of the teaching of Geography in a German school of to-day: “A class of twelve-year-old boys has recently returned from a journey to the island of Sylt in the North Sea. There the thirty-eight lads spent two weeks with their teacher who is continuing to use those common experiences in class work. On the walls of the room are many maps, sketches, and paintings made by the pupils during or after the trip. A picture-map of the journey down the Elbe River, a topographical map of the island, and other diagrams showing the region and route followed were made at home by the pupils after they had been given some instruction in the technique of enlarging maps accurately. There are many drawings and paintings of fish seen in the markets and in the waters around the island. A record of the tidal stages was kept during their stay at the seashore. A number of stories of camp life and descriptions of the trip have been written voluntarily.”

Secretary’s Report

After the Presidential Address was over, Mr. N. Subrahmanyam, Secretary of the Association, then presented his report. He said: - It has been usual for the last three or four years at each Conference for the Secretary just to make a short retrospect of the work of the Association and speak about its progress. In the District of Trichinopoly in which our Conference is now being held we have sometimes plenty of members; sometimes there is a paucity in membership; at any rate for the public, the Geographical Association and its work may not be as well known as it ought to be.

The Association is now beginning its eighth year of existence; and it has been running its journal these eight years as a quarterly with a variety of aims and objects. The objects of the Association as published in the rules are: (1) to promote geographical knowledge, (2) to secure for Geography its proper place in the High Schools, the University and its constituent and affiliated colleges, (3) to help to improve the methods of teaching Geography, (4) to work for a School of Geography being started and (5) to promote regional studies about South India from various points of view.

All the foregoing aims and objects had been kept in view these years and some of them have borne fruit in fair measure. To promote geographical knowledge and to promote regional studies of South India have been the two most prominent, however, and with these aims before us we have had a number of papers published in the journal of the of the Association from time to time; and for the ;past four years we have been having conferences of this kind. Probably this year we will be having a short business session also. But till now it has been purely an academic conference. It was four years ago that we started this new activity of the Association at Coimbatore under the protecting wings of the

S. I. T. U. as well as to those of the Madras Geographical Association to meet more or less simultaneously.

The main aim of the Conference has been to make a regional study of the particular district in which the S.I.T.U. Conference meets. The second Conference was held in Malabar, the third in Medura and this is the fourth.

The other aim, to help to improve the methods of teaching Geography, was kept steadily in view all these years and Summer Schools have been conducted - the fifth of which was held during the last two weeks at this very place under the joint auspices of the Geographical Association and the Provincial Educational Conference.

To secure for Geography its proper place in the Universities and their affiliated colleges, there has been a good deal of propaganda done both on the platform and in the Press as well as through the Journal of the Association. But there is once more need for doing such propaganda to avoid what we may regard as another calamity that threatens the position of Geography in the Secondary School.

The aim of starting a School of Geography has also been kept in view from the outset, and the University was persuaded directly and indirectly so that we have now a Department of Geography established in the Madras University. Though it is now kept on a temporary basis, it is hoped that this Department will soon be placed on a permanent footing.

As usual, we have received this year also quite a number of papers and I do not know how many of them could be read and discussed; but all will appear in a special number of the Journal, however, containing the proceedings of the Conference.

A message from M.R.Ry. Rao Sahib T.S. Subramania Aiyar, wishing the Conference every success, was next read by the Secretary.

A paper on *The Population of the Trichinopoly District* by Mr. B. M. Tirunarayanan, B.A. Hons. (London), was then read and discussed. (All the papers on the Trichy District with the discussions will be published in the next number of the Journal.) The Conference then adjourned for the day.

It reassembled on the afternoon of the second day (17-5-33) at the Saraswathi Hall, National College, and devoted well-nigh two hours in the reading of papers and discussions thereon.

The papers read in this session were the following:- The Meteorology of the Trichinopoly District by Mr. B.G. Narayan B.Sc., of the Kodaikanal Observatory; The Influence of the Physical Features of the Trichinopoly District on the History, Commnications and Economic Conditions of the area by Mr. C.A. Krishnamurthi Rao, M.A., of the Madura College; The Urban Geography of Trichinopoly and Srirangam by Mr. R. Dann, Director of Town Planning, Madras; Fairs, Festivals and Shandies by Mr. V. Krishnan, M.A., Dip. in Geo.

In the intervals between the sessions members went on excursions in separate parties to the Golden Rock Railway Workshop, Grand Anicut, Upper Anicut and other places of importance in the neighbourhood.

The concluding session of the Conference was held at the Saraswathi Hall on the afternoon of Thursday the 18th May, when the following three papers were read and discussed:- *Mediaeval Town-Planning in India* by Mr. C. A. Krishnamurthi Rao; *Place Names of the Trichinopoly District* by Mr. S. K. Devasikhamani, B.A., L.T., Headmaster of the Bishop Heber College; and a paper on *Human Geography* by Mr. T. S. Sundaram Aiyar, B.A., Geography Assistant of Ambasamudram High School.

For want of time, the following papers were taken as read:- *Physical Geography of the Trichinopoly District* by Mr. T.N. Muthuswami Aiyar, M.A. L.T., of the Engineering College Guindy; *Soils and Products of the Trichinopoly District* by Mr. P. R. Anantarama Aiyar of Board High School, Lalgudi; *Economic Geography of Udayarpalayam Taluk* by Mr. M. S. Paul of Board Secondary School, Udayarpalayam; *The Agricultural Geography of the Trichinopoly District* by Mr. A. S. Rajamanikam M.A., University Research Fellow in Geography; *Communication - lines and Town-sites of the Trichinopoly District* by Mr. N. Subramanyam, M.A., L.T., F.R.G.S.; *Lalgudi and its Environs* by Mr. T. S. Anantanarayana Aiyar, B.A., L.T., of Board High School, Lalgudi;- The Urban Geography of Karur by Mr. A. L. Sundaram, B. A., LT., of Municipal High School, Karur; and The Cauvery delta and the Kallars by Mr. J. S. Ponniah, M.A., of American College, Madura.

Resolutions

Two resolutions were then placed before the Conference for adoption. Mr. Sastriar took the opinion of the House, after reading the resolutions, as to whether or not they were non-controversial and having found the House agreed that they were non-controversial and with the approval of the House moved them himself and they were carried unanimously. The resolutions were in following terms:-

"This Conference is of opinion that Geography should not be deleted from the compulsory A Group in the S.S.L.C. course, as in any system of sound Secondary Education Geography should find place as a natural link between the Sciences and the Humanities."

"With a view to help the growth of scientific study of Geography in all its aspects in this Presidency, this Conference recommends that each High School in this Province should make arrangements to record the daily temperature, pressure and rainfall and direction of wind in its locality and report the same every month to the Madras Geographical Association for consolidation and report in the Journal of the Association.

Chairman's Concluding Remarks

In bringing the proceedings to a close, the Chairman made a few remarks on the work of the Conference and the possible lines of improvement. But before doing so, he said he must give expression to his feelings of gratefulness and thanks to Mr. Subramania Aiyar

and the Geographical Association for the opportunity given to preside at that session and to learn so much that was of profit and pleasure to him.

There was an advantage as well as also some disadvantage, Mr. Sastriar proceeded to say, in a conference of that kind being held at the same time as other conferences of a similar nature. Both the advantages and disadvantages were very obvious. Advantage was that the Conference did not stand by itself but became one of a group of like conferences and the chances of social and intellectual intercourse were secured to them. But the disadvantages were that they had to suit their sessions very carefully, time them so as not to trench on the time taken up by other conferences. And in that matter the Geographical Conference which was quasi-technical in character suffered a real disadvantage because the chances of discussion got considerably minimised. He had felt the inconvenience himself. But he did not wish to be understood to say that the disadvantages outweigh the advantages of the arrangements under which they were now working. He hoped it would be possible for them in the coming years to device some means by which they could retain the advantages which they now had and go very far to minimise the disadvantages and handicaps. One of the main things required for that was that papers to be read at the Conference should be submitted to the Secretary by the prescribed date and the Secretary also would have to make it a rule to insist on that rule being observed. And then the Secretary will get an idea of the resources of the Conference and secondly it was also desirable that contributors should make it a point to attend the Conference also and participate in the discussions,

Mr. Sastriar regretted that as a Conference in the present session they had devoted so little to problems of Geography teaching, of which there remained so many that called for answer and solution. But he did not want to dwell only on their shortcomings. He did so obviously with a view that the Conference, as it was, was good, and that he only wished it to be better. He had no doubt that in the coming years the sessions would improve in the directions he had indicated and each session of the Conference would mean a substantial addition to the stock of knowledge of the Geography of the Province. The papers that were being published year after year, they would see, constitute very valuable studies of the Regional Geography of the area in which the Conference assembles. He hoped that in the coming years there would be real, brisk and lively intellectual exchange so to say of ideas and thoughts such as could be had only on such occasions.

He had nothing more to say, Mr. Sastriar concluded, except to congratulate Mr. subramania Aiyar on the excellent success - which had attended the work as the organiser of the Geographical Association and the successive Geographical Conferences. Just at the moment, perhaps, Mr. Subramania Aiyar was not as cheerful as he might be because there was some fear of Geography being thrown into the background in the S. S. L. C. course. But he would promise Mr. Subramania Aiyar and he was sure Mr. Dewasikhamani would do likewise with him that they would do their best to stand by him and avert the danger. (Cheers.) He must also underline here, Mr. Sastri humourously remarked, the undertaking which Mr. Subramania Aiyar gave and that was that on his part he would co-operate with them in producing a reasonable Geography syllabus; for it was not a secret that a heavy

syllabus was a handicap and the present S.S.L.C. Scheme has been criticised very much on that score and it needed looking into.

Mr. K. R. Avadhani, Vice-Chairman of the Reception Committee, proposed a vote of thanks to the President who he said had guided their deliberations with patience, tact and humour which came to the rescue of tense situations. He also proposed a vote of thanks to Mr. Subramania Aiyar who had proved himself to be the soul of the organisation and without whose sage advise and guidance the Reception Committee could not have performed their task with success. He also thanked the authorities of the St. Joseph's College and the National College for placing their buildings at the disposal of their Conference members.

Mr. N. Subramania Aiyar, Secretary of the Association, added his thanks to the President and to all those others who contributed not a little to the success of the present session. It was gratifying to note that as many as 75 members of the Geographical Association attended the present session as against only 30 that attended the Madura Conference last year. Members had come from Vizagapatam, Kurnool and Nandyal. It was also pleasing to note that the Mysore Government itself had deputed a representative to attend the Conference. He could not just then say where their next Conference would be held. The choice seemed to lie with three places, Tanjore, Salem and Anantapur. But whichever it was, it did not matter; for any place was welcome for making geographical studies; and he would in conclusion only assure their President that he would take his suggestions and work accordingly.

Mr. Nilakanta Sastriar was garlanded amidst cheers, and the Conference concluded.

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Archives - 2

THE GEOGRAPHY OF THE PAST

Formerly Known as The Journal of The Madras Geographical Association
(Volume 8, July 1933, No. 2)

By

Dr. B. SAHNI
Lucknow University, Lucknow

Under the auspices of the of the Vizagapatam Athenaeum Dr. Birbal Sahni of the Lucknow University, delivered an interesting lecture on the "Past Geography of the World". Sir C. V. Raman Presided.

Sir C.V. Raman, in introductory remarks, humorously observed that the Punjab was so much associated with a fierce, bold, stalwart people, with manly vigour, that if the public expected to find in Dr. Sahni, a typical Punjabee of the conventional type, they would be disappointed. Dr. Sahni was a greatly reputed Doctor of Sciences. Dr. Sahni was full of expert suggestions on every subject concerning knowledge that Sir C.V. Raman wondered what Dr. Sahni did not know. Dr. Sahni came to seen the place for a few hours, he made a splendid suggestion that the place would be excellent as a first class station of marine biological research.

Origin of the Continents

Dr. Sahni said that he chose as the title for his lecture of the evening, "Reconstruction of the Geography of the past", because it had a great fascination for him. It was a subject that was of immense interest to the geologist, the geographer, historian, biologist, physicst, chemist and every other "ist" as well as the philosopher. The philosophy of science was not the conventional philosophy with which the majority of them were familiar; it did not allow unbounded, unbridled licence to the imagination, but was directly controlled by observed facts and experience.

Proceeding, Dr. Sahni said that if they looked at the map of the Atlantic Ocean they would find the opposite sides of Africa and South America, if brought sufficiently close to each other, fitted together almost exactly as if forming one piece of land. A like similarity was to be found between the eastern coast of Africa the Island of Madagascar. He then explained that various hypotheses had been made regarding the similarity of the fauna fora and the stratographical structure of land on both sides the oceans where the sinuosities of

coastline almost fitted into each other. According to one theory, the continents were like icebergs floating on a mass of lesser density, and that, at some remote past, what was one great mass of land consisting of Africa, Asia, Australia and Antarctica, covered over to a great extent by an enormous ice-sheet, had broken by rifts in the crust of the earth's surface and drifted away leaving the gap now occupied by the Indian Ocean. That India was once covered by ice was discovered in the early eighties of the last century by signs of glaciation found near Talcher about 200 miles north-west of Berham pore (Ganjam). In those far off days South India was said to have been in the same latitude as South Africa, and the eastern coast line of Africa and the western seaboard of India almost hugged each other. But by the process of 'continental drift', India had receded north-eastwards and in the same process the Himalayas were raised out of the bed of the sea by forcing up the strata in a series of movements. This drift of the continents, its extent and direction, had been recorded by observatories in various parts of the world by calculating the time of transit of the stars over particular spots.

Theory of Lost Continents

A different theory was that, while the continents had always occupied their present positions with the similarity of the fossils found and of the fauna and flora, there existed in those very remote periods land bridges connecting these great masses of land that these bridges were now supposed to have gradually sunk the sea-bed. According to this theory, two great masses of land that once existed in what were now called the Atlantic and Indian Oceans, i.e., Atlantis and Lemuria, had been lost and attempts were being made from time to time to discover these lost Setinents. Dr. Sahni stated that the great mass of evidence was in favour of the theory that the continents drifted away. The Nile Valley in Africa was supposed to be another great rift in surface of the earth's crust which, in the distant future, would separate a big slice of north-east Africa by the inlet of the sea.

Sir C.V. Raman said, in his concluding remarks, that Dr. Sahni's description of the Poles wandering about, continents moving up and down on a walk, and the prospect of Egypt some day going under the sea making two more continents of Africa and the Nile becoming a huge ocean, made his head real with the stupendousness of the prospect. He insisted that it was the duty of a scientist to be meticulously correct in his calculations. The difference of a few thousands or millions of years in calculations on a speculative subject as the Geography of the Past didnot matter very much. But a scientist must muster sufficient courage necessary to propound such profound matters.

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Archives - 3

PROPOSED EXTENSION OF THE MYSORE RAILWAYS

- Shorter Route to South Indian Towns

Linking of Agricultural and Commercial Centres

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(Volume 9, July 1934, No. 3)

The Government of India and the Mysore Government are considering a proposal to connect the Mysore Railway system with the South Indian Railway via Chamarajanagar and Satyamangalam, as stated by Dewan Bahadur N. N. Ayyangar, Chief Engineer of the Mysore Government, at the recent session of the Mysore Legislative Council, The projected line will be 56 miles long. It is estimated that the total cost of the scheme will be approximately Rs, 2 crores. The section connecting Chamarajanagar and Satyamangalam has to pass through the ghats which separate the Mysore plateau from the plains in the Madras Presidency to its of the high cost of construction, the traffic survey made by the authorities shows that the railway will be profitable and that return of 6 per cent. on the capital outlay may be expected within five years after the opening of the railway.

The outstanding features of the proposed railway, from the point of view of engineering, are: There will be no less than 28 tunnels on the ghat section of 21 miles between Chamarajanagar and Kottamangalam.

There will be a fall in gradient of 2,172 feet in 31 miles.

The total length of the tunnels will be nearly three miles.

The line will run through primeval forests in the *ghats* almost rivalling in richness and beauty the forests besides the ghat railway in Travancore.

The establishment of direct connection between the metre gauge of the South Indian Railway and the Mysore Railways has been under consideration for over 30 years. Originally, it was proposed to extend the Mysore railway line so as to make a junction with the South Indian Railway at Erode. This was before the Trichinopoly-Erode section was converted from metre gauge into broad gauge.

A Continuous Line

On the conversion of this section into broad gauge, however, original idea was abandoned and proposals were mooted to connect the Mysore Railways with the South Indian Railway at Tiruppur via Satyamangalam. This idea has been strengthened the proposal for construction of a metre gauge line connecting Dindigul, Palani, Pollachi, Tiruppur and Satyamangalam. When this connection is completed it will provide a continuous metre age line between northern and southern India and from western dia through Mysore. The various projects have been surveyed difference times by the Mysore Railways and the South Indian way. According to the present proposal, the existing Mysore-Chamarajanagar metre gauge line is to be extended to Satyamangalam in the Madras Presidency. The distance between Chamarajanagar and Satyamangalam by the proposed route is 56 miles, of which 11 miles will be within the Mysore territory and 45 miles in the Madras Presidency.

The Mysore section of the extension is estimated to cost Rs. 8.36 lakhs, while the British section will cost about Rs. 163 lakhs. The extension will also necessitate radical improvements to the existing line between Mysore and Chamarajanagar and these will cost an additional Rs. 8.5 lakhs. These estimates are exclusive of the rolling stock required for the construction.

The construction of the line will be an engineering achievement, as there are various natural obstacles to be overcome. As the Mysore plateau is, on an average, 2,000 feet higher than the level of the plains below the ghats any line connecting the two areas has to negotiate a steep incline. The whole range of hills surrounding the Mysore District has been investigated for railway outlets at various times, and the alignment now proposed has been chosen as the best. In fact, it is stated that hardly any alternative is possible.

The Route

The alignment of the proposed link will be as follows: The line, after leaving Chamarajanagar station, will skirt round the eastern side of the town and run parallel to the Satyamangalam road for five miles, reaching the site of the Hardanahalli station Thence it will cross the road and run south-west to Talavadi station, crossing the Mysore frontier at the 11th mile from Chamarajanagar. At the 27th mile the line will reach Talamalai, a station on the top of the ghat. Over this section of 27 miles, between Chamarajanagar and Talamalai, the line will take an up-gradien, rising 660 feet between the two points named.

The descent of the ghat will begin at Talamalai (2,958 feet above sea level). Between this point and Kottamangalam, on the plains below, a distance of 22 miles, the line will lose 2,100 feet in height and another 56 feet in the eight-mile run between Kottamangalam and Satyamangalam. It is the middle section of the line. Which has a fall of about 100 feet per mile, that is estimated to cost most.

A ruling gradient of 1 in 45 will be adopted for this ghat Section and there will be 28 tunnels, varying in length from 100 feet to 1,820 feet, their total length being 14,320 feet (nearly three miles).

The proposed connection will bring the numerous towns and cities in South India and Mysore much closer, benefiting trade, commerce and intellectual and social intercourse.

For example, the distance between Mysore and Ootacamund by railway will be reduced from 398 to 153 miles. Similarly a great reduction will be effected in the railway distance between Mysore and other towns like Coimbatore, Erode, Tiruppur, Trichinipoly, Madura and Tuticorin, and the public will benefit by the reduced fares.

Traffic Survey

Detailed surveys have been made of the commercial possibilities of the proposed extension and all reports on the subject contain the assurance that the new link will prove a commercial success and that the net return on the capital outlay will be about 4 per cent. in the first two or three years after completion of the line, increasing to about 6 per cent. after five years. ”

The extension of cultivation in the Cauveri valley and the rapid growth of sugarcane cultivation and sugar manufacture in the Irwin Canal area are arguments in favour of the railway extension. There is also the fact that the cotton areas in the Coimbatore District will be brought much nearer to Mysore with its cheap electric power. Without any expansion of the existing agricultural and industrial activities in the State the proposed link will more than pay its way, considering the traffic now available, and the advantages are greater when the extension of trade and commerce, following the opening of the line, is taken into account.

Promising forecasts of the passenger traffic have been made on account of the fact that such well-known places of pilgrimage as Rameswaram, Palani, Madura, Kumbakonam and Srirangam will be brought much nearer to Mysore by the proposed link.

Among the seaports which will benefit by the proposed connection are, of course Tuticorin and Cochin. Traffic to Cochin will have a break of guage at Tiruppur, but there will be an unbroken metre gauge connection between Tuticorin and Mysore. From Mysore there will be a break of guage both to Madras and Cochin, but Cochin will be nearer than Madras.

Thus the shortening of the distance between many places if South India and Mysore, the stimulus to trade and commerce between such centres the avoidance of the inconvenience which traffic between such centres is experiencing now, and the fact that there will be an unbroken metre gauge connection between north and south India through

Mysore (from Poona to Tuticorin) are the principal arguments in favour of the proposed metre gauge ink between Chamarajanagar and Satyamangalam.

A Madras Proposal

It would appear that the Government of Madras have called for an estimate for the construction of a light broad gauge line from Kottamangalam to Tiruppur via Satyamangalam. But the construction of such a line would deprive the country of the contiuity of a metre gauge long distance connection between Poona and Tuticorin - a single gauge continuity which will prove advantageous also from a strategic point of view, should necessity arise. The object of the proposed light broad gauge line is not so apparent, while its disadvantages, viewed in the light of the proposed extension of the Chamarajanagar line to Satyamangalam, are obvious. On these grounds, therefore, the Government of Mysore have, I understand, protested against the proposed guage for the Kottamangalam-Tiruppur railway and pointing out the desirability of having a metre gauge line over this section. It is hoped that the question will be considered from the wider point of view presented by the Government of Mysore and that a continuous metre gauge connection between north and south India, through Mysore will be made possible.

Extension to Kollegal

Allied with the proposed connection between Chamarajanagar and Satyamangalam, there is a proposal for the construction of a branch line between Chamarajanagar and Kollegal, which is situated in Gobichettipalayam taluq, Coimbatore District. Th distance of this line is about 22 miles and the scheme is estimated to cost about Rs. 15.75 lakhs. The Government of Mysore have been permitted to construct and work the entire length of this line, the last four miles of which will run in the Madras Presidency.

-"The Madras Mail."

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY

Department of Geography, University of Madras, Chennai - 600 005

UG & PG Results of 3rd Talent Test - 2013

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 3rd Talent Test - 2013		
Name	**Institute**	**Rank**
Gopinath S.	Department of Geography, Periyar E.V.R. College (Autonomous), Tiruchirappalli - 620 023.	**1**
Keerthiga	Department of Geography, Sri Meenakshi Government Arts College for Women (Autonomous), Madurai - 625 002.	**2**
Jasikala	Department of Geography, Bharathiyar University Arts and Sciences College, Gudalur - 643 212.	**3**

PROF. A. RAMESH AWARD

With the Cash Prize of Rs. 15,000/-
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PG Results of 3rd Talent Test - 2013		
Name	**Institute**	**Rank**
Jijin P.V.	Department of Geography, Madurai Kamaraj University, Madurai - 625 021.	**1**
Priyadersini B.	Department of Geography, University of Madras, Chennai - 600 005.	**2**
Reshma H.	Department of Geography, Government Arts College (Autonomous), Coimbatore - 641 018.	**3**

Please Note:

1) The Winners are requested to send their passport size photograph, postal address and contact phone number by email (kkumargeo@gmail.com / geobalas@gmail.com)
2) The Winners are requested to make arrangements to attend the award ceremony function being arranged in the *88th IGS Annual Conference to be held at Department of Geography, Bharathidasan University, Tiruchirappalli on 02.03.2013.*
3) For any queries, kindly contact the Coordinator Dr. K. Kumaraswamy (94421 57347) / Co-coordinators Dr. G. Bhaskaran (94444 14688) / Mr. K. Balasubramani (99440 60319) / Dr. S.R. Nagarathinam (98941 10585) / Dr. P. Ilangovan (94426 43430) / Prof. G. Jagadeesan (94432 02011).

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REGIONAL VARIATIONS IN DISTRIBUTION OF AGRICULTURAL WORKERS IN TAMIL NADU - A SPATIO - TEMPORAL ANALYSIS BASED ON AGRO-CLIMATIC ZONES

Lazar A.

Directorate of Census Operations, Chennai - 600 090
E-mail: lazar.gis@gmail.com

Abstract

The contribution of agricultural sector to overall GDP may continue to fall as Indian economy in the aftermath of globalisation process continues to move towards non-agricultural sector nevertheless the sector is still vital for development in the rural India where greater number of people live (68.2%). Since prevailing agro-climatic condition in a region can vastly influence the cropping pattern, successful harvest and viable agricultural production, agriculture continues to act as a major economic activity covering around seventy per cent of Indians. This study by computing basic demographic data especially the proportion of agricultural workers derived from census at agro-climatic zonal level may help us to understand the impact on the people at agro-climatic zonal level as the variability in climatic conditions may directly affects the rural people for whom the primary income is from agricultural productivity.

Keywords: Agro-Climatic Zones, Agricultural Workers, Regional Variations, Population Distribution

Introduction

The distribution of agricultural workers has been influenced by many factors and primarily by the favourable agro-climatic conditions, availability of cultivable land with adequate rainfall and employment generation. Over time, these dependencies are further impacted by the level of modernisation adopted in the agricultural practices and development in other sectors of economic activities. It is evident from the fact that during 1950-51, the Indian agricultural sectors accounted for over 75 per cent of work force and contributed more than fifty per cent share in GDP (CSO Statistical Report, 2013). The scenario in 2011-2012 is complete contrast to that as the primary sector contributes mere 14.1 per cent but still employs over 50 per cent work force (Census 2011). During 2011-2012, the industry and services sectors together contributed more than 75 per cent to GDP (at factor cost of 2004-2005 prices). Over emphasis on industrialisation, open market policies, changing agro-climatic conditions and rainfall variability are primary causes for the lack of growth in the agricultural sector. These impediments are pulling rural workers to non-agricultural sector where the employment is guaranteed around the year with a steady income.

However this is not uniform across the country and depends on various other socio-economic conditions as well. Since agro-climatic conditions have direct influence on the agricultural productivity and generation of employment in rural areas, analysing the basic demographic indicators at agro-climatic regional level is an important step to understand the changing scenario in the agricultural labour market.

Agricultural Sector in Tamil Nadu

Although Tamil Nadu is one of the highly industrialised States in India yet agriculture sector provides employment to over 42 per cent of workers (Census of India, 2011). Each passing year, the State produces record output in food grains and also is the highest producer of oil seeds. The 12th Plan outlay for agricultural sector in Tamil Nadu has been increased by 153 per cent compared to 11th Plan. There are also changes in agricultural practices and produces as more farmers are shifting to high value agricultural commodities for realising higher income (Vijay Paul Sharma and Dinesh Jain, 2011). But yet the sector has been under severe stress due to rapid urbanization, demand for land and labour for non-agricultural sector. This resulted in consistent decline of total cultivable area, higher labour cost, low productivity per unit of labour in most of the regions and vast seasonal variations.

Further the sector consists predominantly of small and marginal farmer households with a large percentage of tradition loving farmers (State Agricultural Plan, Tamil Nadu, 2009). Close to 3/4th of marginal farmers (< 1 ha) in Tamil Nadu is in indebtedness (NSSO, 59th round, 2003). It is evident from the statistical reports that the proportion of land put to non agricultural purposes had gone up from 9.8% in 1950's to 21.6% in 2007-2008 (Dept. of Economics and Statistics). This increase may be attributed to conversion of agricultural land for non-agricultural purposes.

The State, which accounts for 6% of population (7.21 Crore) and 4% of land area (1,30,060 sq.km) of the country, is endowed with only 3% of water resources in India (SAP, 2009). As such Tamil Nadu is not only a water starved State in India also majority of its agriculture is rain fed or irrigated by well. This resulted in tapping of groundwater potential on an increasing scale, leading to the depletion of groundwater table. The number of wells in the State has increased from mere 14,400 in 1951 to 18.32 lakhs in 2007-08 (Tamil Nadu State Perspective & Strategic Plan).

Scope of the Study

In this study it is envisaged to analyse the regional level variation in the distribution of agricultural workers in 2001 and 2011 using Census data for Tamil Nadu. The State has been divided into seven agro-climatic zones (ICAR and State Agricultural Plan-Tamil Nadu) based on rainfall pattern, altitude and irrigation sources. The data pertaining to agricultural workers for 2001 and 2011 have been compiled using GIS for these agro-climatic regions

and analysed. These analyses would be focusing on regional distribution of agricultural workers.

Study Area

The State of Tamil Nadu (Madras) was created on the 1st November, 1956 by the State reorganisation act. The geographical extent of the State is between 8° 5' and 13° 35' North Latitudes and between 76° 15' and 80° 20' East Longitudes. The State consists of 39.6 per cent of Plains (out of which 8.3 per cent are Coastal), 23.5 per cent of Uplands, 19 per cent of Forested Hills and the remaining 4.9 per cent is of Valley (ORGI, 1991). Total population of the State as per 2011 Census is 7,21,47,030 out of which 48.4 per cent live in Urban areas. In post-Independence, the State witnessed highest growth of population during 1961-71 (22.3%) and the lowest (11.7%) in 1981-91. During the last decade, the State witnessed 15.6 per cent growth in population.

Analytical Frame for the Study Area

The agro-climatic zones have been used to compile and infer the data pertaining to agricultural workers in Tamil Nadu. An agro-climatic zone is a land unit uniform in respect of climate and length of growing period (LGP) which is climatically suitable for a certain range of crops and cultivation (FAO, 1983). The Planning Commission of India (1989) delineated the country into 15 agro climatic regions based on homogeneity in rainfall, temperature, topography, cropping and farming systems and water resources. The entire State falls in three such agro-climatic regions namely ***Southern Plateau and Hills, East Coast Plains and Hills and West Coast Plains & Ghats.*** On the basis of ICAR suggestions, areas falling within the State have further been divided into 7 sub-zones as listed below,

1. North Eastern
2. North Western
3. Western
4. Cauvery Delta
5. Southern
6. High Rainfall
7. High Altitude and Hilly

North Eastern Zone

This zone consists of Kancheepuram, Thiruvallur, Vellore, Viluppuram Districts and Cuddalore District excluding Chidambaram and Kattumannarkoil taluks and Ariyalur taluk from Ariyalur District. The total geographical area of this zone is 30,360.67 sq. km (on the basis of GIS computation by the Author) and is the largest with a percentage share of 23.34. The major rivers are Palar, Ponnaiar, Cheyyar, Vellar, Thenpennai, Manimuthar and Komugi. The major crops cultivated here are paddy, cholam, cumbu, ragi, groundnut, sugarcane and cashew nut.

North Western

The north western zone comprising the districts of Dharmapuri (excluding hilly areas), Salem and Namakkal (excluding Tiruchengode Taluk) and has an area of 10,763.4 sq. km equivalent to 8.3 per cent of the State area. The zone has been surrounded by Shervaroy hills, Kalrayan hills and Kolli hills. The climate in the zone ranges from semi-arid to sub-humid with frequent occurrence of drought and the annual rainfall ranges from 560 to 1080 mm and the hilly regions enjoy rainfall of above 1300 mm.

Western Zone

The western zone comprises of Erode and Coimbatore Districts, Tiruchengode Taluk of Namakkal district, Karur Taluk of Karur district and northern part of Dindigul and Madurai Districts. The zone has undulating topography sloping towards east. The western and northern parts of the zone are bounded by the Western Ghats bordering Kerala and Karnataka States. The climate in the zone ranges from semi-arid to sub-humid with frequent occurrence of droughts. The annual rainfall of the zone varies from 524 to 1428 mm with an average of 780 mm.

Cauvery Delta

The Cauvery delta zone has diverse climatic conditions as the zone includes coastal belt as well as inland area. The entire terrain is an open plain sloping gently towards east and devoid of any hills or hillocks. The mean annual rainfall is 1,192 mm. The North-east monsoon alone contributes about 52.5 per cent of the total followed by south-west monsoon with 30.5 percent. Being an interior region, the diurnal variation in temperature is large particularly in the dry and hot seasons.

Southern Zone

This zone is the second largest with an area of 23.1 per cent comprises of flat plains and intermittent hills. The topography is undulating with the gradient sloping towards the east. The major river systems are Vaigai, Manimuthar, Sarguni, Gundar and Arjuna nadhi. The climate of the southern zone is generally semi-arid and only a small portion comes under - sub-humid. Thus, frequent drought occurs. The zone falls under rain shadow area. North-east monsoon accounts for 54.9 per cent of total rainfall and forms the main cropping season.

High Rainfall Zone

The High rainfall zone of Tamil Nadu consists of only 0.98 per cent of the State area and consists of a major part of Kanyakumari District. The zone has two distinct physiographic regions viz., the hills and coastal plain. The climate is sub-humid influenced by both the south-west and north-east monsoons, because of the proximity of sea and the Western Ghats.

High Altitude and Hilly Zone

This zone consists of hilly tracts of the Nilgiris, the Shervaroys, the Yelagiris, the Anamalais and the Palani hills and account for 17.5 per cent of the State area. The rainfall varies from 1000 mm at the foot of the hills to 5000 mm at the peaks. The major crops are vegetables, potato and tropical and temperate fruit crops.

Data Compilation using Geographic Information System (GIS)

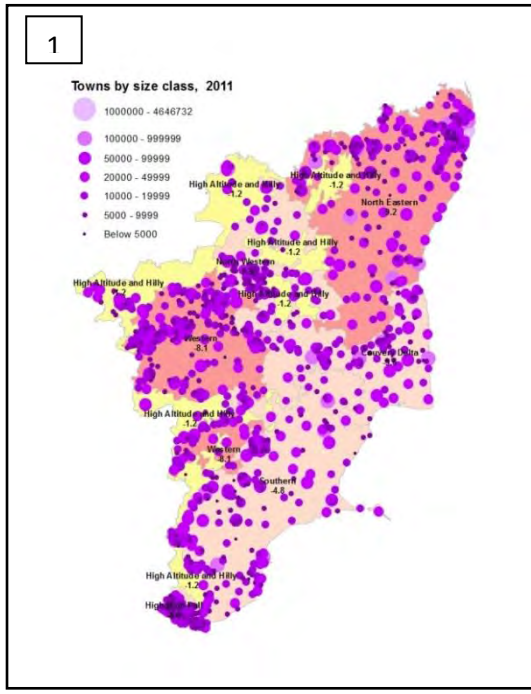
Since the data pertaining to Primary Census Abstract published at Village / Town level, The Census indicators used in this paper were compiled using GIS application (ArcGIS) on the basis of seven agro-climatic zones for census years 2001 and 2011. The tables consisting of Village / Town level Primary Census Abstract indicators have been imported into GIS application and linked with village / town locations (Point Shape file). Based on Spatial relationship, the agro-climatic zone boundaries (Polygon Shape file) and the village / town locations (Point Shape file) have been assigned with appropriate zone codes using spatial join method. The output file was then exported into MS Excel for required tabulation and analysis.

Results and Discussion

Population Characteristics

- Among the agro climatic zones, the North Eastern zone have the highest share of population concentration (34.1 %) followed by Southern zone. The least populated zone is High Rainfall zone, which is relatively very small in terms of proportion of area.

- Two zones, namely North Eastern (0.9%) and Western (0.3%), have increased their share of population in 2011 compared to 2001. It is important to note that these two zones have relatively high number of towns. The North Western zone recorded a negligible change while the rest of the four zones have declined. Significant among them are Cauvery delta (-0.6%) and Southern (-0.3%) zones.
- Literacy across all the zones has increased on an average of 6.6 per cent. The High Rainfall Zone has the highest literacy (91.8%) followed by Cauvery Delta (82.3%). The zones of High altitude and Hilly (72.8%), North Western (73.2%) and Western have recorded below the State literacy (80.1%). The highest increase in literacy could be seen in North Western Zone (7.7%) and the least is in High Rainfall zone (4.2%).
- About 40 per cent of Scheduled Caste population lives in the North Eastern zone which has also increased of its share of SC by 1.5 per cent compared to 2001. The High Rainfall (0.5) has the least share of Scheduled caste population followed by the High Altitude & Hilly (4.7%) and North Western zones (8.3%).



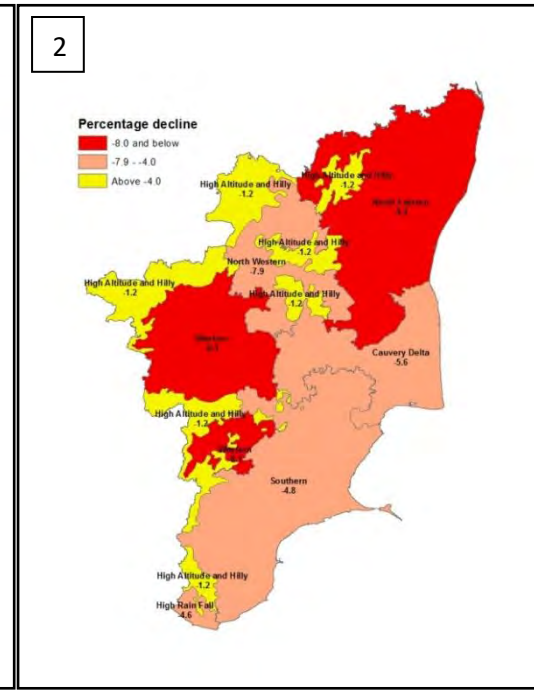


Fig. 1. Change in Share of Agricultural Workers, 2001-2011 (at Agro Climatic Zone level)

Fig. 2. Tamil Nadu Agro Climatic Zones and Distribution of Towns, 2011

Distribution of Agricultural Workers

- The share of agricultural workers (Cultivators + Agricultural Labourers) is 42.1 per cent in the State. This share has declined by 7.2 per cent. In fact all the agro climatic zones have recorded a decline in the share of agricultural workers in the State. The Cauvery delta zone which is called “Rice bowl of South India” employs the highest percentage of work force in agricultural sector though there is a decline of 5.6 per cent. The least percentage of agricultural workers is found in the High Rainfall zone (Kanniyakumari District) which is the most urbanised district (82.3%) in Tamil Nadu other than Chennai (100%).
- There is a significant decline in the share of agricultural workers to total workers across zones and the highest decline is in the North Eastern (-9.2%) and Western (-8.1%) zones. The least could be seen in High Altitude & Hilly zone (-1.2%).

The share of cultivators in agricultural workers has declined by 6.5 per cent in the state. The highest decline of cultivators is in the high altitude and hilly zone (-10.3%) followed by southern zone (-8.1%). Significantly the share of cultivators has increased by 2.5 per cent

in the High Rainfall zone which employs the highest share of agricultural labourers in the State (82.2%).

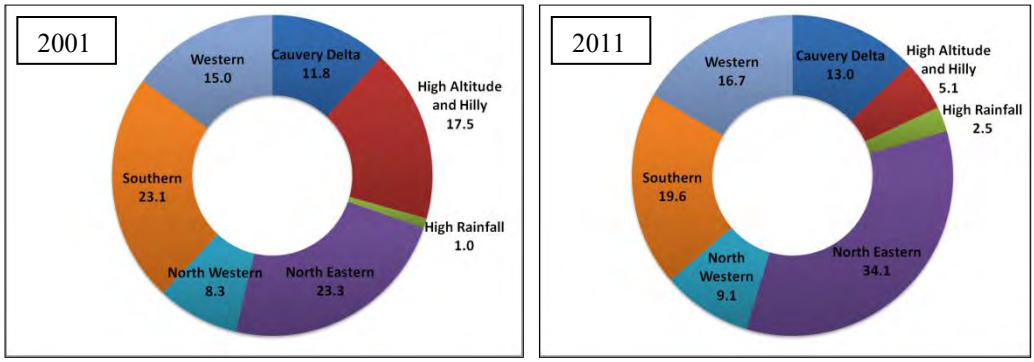


Fig. 3. Percentage Share of Population 2001 and 2011

Tamil Nadu: Demographic data by Agro Climatic Zones*, 2001

Table 1. Tamil Nadu Demographic Data by Agro Climatic Zones, 2001

2001							
Agro Climatic Zones	Households	Population	Scheduled Caste	Literates	Workers	Agricultural Workers@	Cultivators
Cauvery Delta	19,59,625	84,88,630	19,20,717	56,82,357	35,98,891	22,47,942	6,20,206
High Altitude and Hilly	7,68,062	33,12,624	6,17,466	19,05,536	16,01,088	8,77,940	4,42,930
High Rainfall	3,61,880	16,14,414	63,066	12,60,878	5,26,565	89,945	13,734
North Eastern	46,18,111	2,06,99,612	45,16,917	1,35,48,522	85,83,403	40,70,370	15,37,251
North Western	13,67,351	56,47,546	9,83,528	32,62,159	28,29,089	16,17,102	7,30,383
Southern	29,50,682	1,24,47,265	20,79,501	83,10,895	56,28,728	25,00,728	10,05,616
Western	26,40,272	1,01,95,588	16,76,309	65,54,198	51,10,518	23,49,642	7,65,919
Grand Total	1,46,65,983	6,24,05,679	1,18,57,504	4,05,24,545	2,78,78,282	1,37,53,669	51,16,039

2001

Agro Climatic Zones	Percentage share of Population	Work Participation Rate	Percentage of Agricultural Workers to Total Workers	Percentage share of Cultivators in Agricultural Workers	Sex Ratio	Literacy	Percentage share of Scheduled caste
Cauvery Delta	13.6	42.4	62.5	27.6	1011	75.9	16.2
High Altitude and Hilly	5.3	48.3	54.8	50.5	970	65.8	5.2
High Rainfall	2.6	32.6	17.1	15.3	1014	87.6	0.5
North Eastern	33.2	41.5	47.4	37.8	979	74.2	38.1
North Western	9.0	50.1	57.2	45.2	942	65.5	8.3
Southern	19.9	45.2	44.4	40.2	1022	75.8	17.5
Western	16.3	50.1	46.0	32.6	971	71.8	14.1
	100.0	**44.7**	**49.3**	**37.2**	**987**	**73.5**	**100.0**

** Zones are as devised and reported in the State Agricultural Plan (SAP), 2009 by Tamil Nadu Agricultural University.*

@Agricultural Workers = Cultivators + Agricultural Labourers

Tamil Nadu: Demographic data by Agro Climatic Zones*, 2011

Table 2. Tamil Nadu Demographic Data by Agro-Climatic Zones, 2011

Agro Climatic Zones	Households	Population	Scheduled Caste	Literates	Workers	Agricultural Workers	Cultivators
Cauvery Delta	23,75,588	93,50,305	22,13,571	69,21,402	40,28,592	22,91,358	5,36,410
High Altitude and Hilly	9,24,429	36,69,812	6,79,129	23,85,875	18,02,353	9,67,135	3,88,113
High Rainfall	4,66,823	18,07,573	70,356	14,97,766	6,55,919	82,067	14,617
North Eastern	60,24,853	2,45,91,398	57,11,872	1,77,67,366	1,07,73,732	41,18,176	12,71,429
North Western	17,00,661	65,39,953	11,98,527	43,07,984	31,98,852	15,76,135	5,93,089
Southern	36,64,912	1,41,65,426	24,90,443	1,04,04,056	64,71,422	25,64,280	8,14,471
Western	33,67,716	1,20,22,563	20,74,547	85,53,058	59,53,811	22,55,853	6,30,328
Grand Total	1,85,24,982	7,21,47,030	1,44,38,445	5,18,37,507	3,28,84,681	1,38,55,004	42,48,457

Agro Climatic Zones	Percentage share of Population	Work Participation Rate	Percentage of Agricultural Workers to Total Workers	Percentage share of Cultivators in Agricultural Workers	Sex Ratio	Literacy	Percentage share of Scheduled caste
Cauvery Delta	13.0	43.1	56.9	23.4	1021	82.3	23.7
High Altitude and Hilly	5.1	49.1	53.7	40.1	985	72.8	18.5
High Rainfall	2.5	36.3	12.5	17.8	1020	91.8	3.9
North Eastern	34.1	43.8	38.2	30.9	992	81.0	23.2
North Western	9.1	48.9	49.3	37.6	961	73.2	18.3
Southern	19.6	45.7	39.6	31.8	1007	82.0	17.6
Western	16.7	49.5	37.9	27.9	995	78.4	17.3
Grand Total	**100.0**	**45.6**	**42.1**	**30.7**	**996**	**80.1**	**20.0**

Tamil Nadu: Agro Climatic Zones with Density, 2001-2011

Table 3. Tamil Nadu Agro-Climatic Zones with Density, 2001-2011

Agro Climatic Zones	Area (in Sq.Km.)[#]	Percentage share to Total Area	Density 2001 (Per. Sq. Km.)	Density 2011 (Per. Sq. Km.)	Change
Cauvery Delta	15407.55	11.85	551	607	56
High Altitude and Hilly	22743.44	17.49	146	161	16
High Rainfall	1274.09	0.98	1,267	1,419	152
North Eastern	30360.67	23.34	682	810	128
North Western	10763.39	8.28	525	608	83
Southern	30008.19	23.07	415	472	57
Western	19502.71	15.00	523	616	94
Grand Total	**130060.04**	**100.00**	**480**	**555**	**75**

[#]Area calculated using Geographic Information System with UTM WGS 1984 43° N Projection system.

Conclusions

It is evident from the data compiled at agro climatic zonal level that across these zones there is a decline in the share of agricultural workers. This decline is not uniform across the zones as each zone consists of varying degree of employment generation in the agricultural sector. There is a strong correlation between the level of urbanization and literacy within these zones. The zones of North Eastern and Western have strong presence of Non-Agricultural sectors providing attractive and steady income throughout the year. Among the scheduled list of employment reported in Tamil Nadu, minimum wage ensured (as on 31.12.2012) for agricultural related works is Rs. 100 (Min. of Labour and Employment report, 2012) which is comparatively lower than other sectors. This could possibly the reason for shift of agricultural workers towards non-agricultural sectors. The shift in employment pattern across agricultural sector needs to be further researched to

understand the roles played by the variables such as changes in cropping pattern, agricultural wage structure, attractiveness of non-agricultural sectors which can provide greater mandays of work and wage with social security.

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STATUS OF TRIBAL LAND HOLDING IN MAHARASHTRA: A GEOGRAPHICAL ANALYSIS

Pawar S.K. and Ramotra K.C.

Department of Geography, Shivaji University, Kolhapur - 416 004
E-mail: skp_geo@unishivaji.ac.in, kcr_geo@unishivaji.ac.in

Abstract

There is a strong relationship between tribal population and land as; their entire livelihood depends on land, which they possess. The concept of land holding has come up among the tribes since then they have shifted from shifting agriculture to sedentary agriculture. The present paper intends to focus on tribal land holding and their status. The tribals in the state of Maharashtra or elsewhere are mainly confined to hilly and forest areas, which are relatively less fertile and productive. The subsistence agriculture system is the common practice that exists in the tribal society. More than one-third (34.18%) of the tribal households, on an average in the state were owning 9.9 per cent land. The proportion of tribal household with less than one hectare land was highest (54.29%) and they owned in all 5.47 ha of land. The proportion of tribal households with less than one hectare land was 21.48 per cent in 1990-91 and land they owned was 18.12 per cent in the state At the village level as per our sample studies, on an average, more than 40 per cent (40.56%) tribal households were identified as landless. It is found that landlessness has been increasing among the tribals in general but in the study area in particular.

Keywords: *Tribal population, Land holding, Livelihood, Shifting agriculture, Landlessness, Households, Land alienation*

Introduction

The term 'Tribe' originated around the time of Greek city-state and the early formation of the Roman Empire. The Latin term, 'Tribe' has since been transformed to mean, a group of persons forming a community and claiming descent from a common ancestor (Oxford dictionary). It is also called as a social division of a people, defined in terms of common descent, territory, culture etc. In tribal societies the relations are homogeneous, whatever the mode of production followed, whether hunting, gathering or primitive agriculture, there is no conspicuous separation of social categories on the basis of their differential position in the system of production; it means that tribal societies are unstratified. It is also important to mention that the tribal economy is underdeveloped,

where the specialisation is generally absent except the division of labour on the basis of sex that is too to some extent only. Earlier the tribal economy is a non-monetised economy but barter system in some very remote areas is still in existence. It is mostly domestic economy where the producers are themselves are consumers. Therefore, exchange through money does not exist (Beteilly, 1977).

India has the largest tribal population in the world perhaps next to Africa. As per the 1991 Census the scheduled tribe (5.7%) population in India was 6.78 crore which constituted about 8.01 per cent of the total population. The largest concentration of scheduled tribes is in central India particularly in Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Zarkhand, Orissa, and Bihar. In Maharashtra the scheduled tribe population as per the 1991 census was 73.18 lakh, which constituted 9.27 per cent to the total population of the state. Their population has increased to 85.77 lakh in 2001 and the proportion was 8.85 per cent. It is also noticed that the growth rate of the tribal population between1981 and 1991 was 26.87 per cent, which declined to 17.20 per cent between 1991 and 2001. In absolute terms, the tribal population has increased by 12.59 lakh between 1981 and 2001. Even in terms of absolute growth, it is found that the tribal population increased by 15.46 lakh between 1981 and 1991 but it has declined to 12.59 lakh in 1991- 2001. It means the decline in tribal population was due to under enumeration and some other socio-cultural regions, because of wrong registration by the Census of India. The checking of tribal and caste certificates, de-notification of some tribal communities, high mortality rate especially of tribal children in 0-6 age group, due to malnutrition, etc. are some of the main reasons for the slashing down of tribal proportion in the total population as well as their growth rate.

There is strong relationship between tribal population and land, their entire livelihood depends on land, which they possess. The concept of land holding has come up among the tribes since then they have shifted from primitive to shifting and now to sedentary agriculture (Ramotra, 2010: UGC Major Research project). Their economic status depends upon the size and quality of land, which they hold and cultivate. It is mostly realised from the fact that, tribals in the state of Maharashtra or elsewhere are mainly confined to hilly and forest areas, which are relatively less fertile and productive. This is what a practice of subsistence agriculture system still exists in the tribal society.

The history of tribal land in general is quite complex. By the end of the nineteenth century, step was taken for survey and settlements of land revenue, under section 73 of land Revenue Code, in the tribal areas directly governed by the British. Wherever scarcity condition prevailed due to natural calamities; the tribal found it extremely difficult to maintain themselves in absence of any sources of livelihood. The scarcity-hit people were not able to pay land revenue in such hard days and even when the assessment was revised to a lower level, they opposed it tooth and nail (Trivedi, 1998).

The data on tribal land holding is hardly available below district level; hence, without this it is not possible to bring out the real situation. It is evidenced from the fact that, their land ownership is much higher than the tribals. It is realised that they have been cultivating the land since long but has not so far been registered in their, in terms of ownership of land and (till this time they were more than 91% landless-Daily Sakal 23/5/2011). Now the government of Maharashtra has also realised that the land which they cultivated or possessed, have been de-possessed by the non-tribals, which has some cases in the same area. It is assumed that the villages in which tribals are in majority, they should possess a major share of agriculture land.

Study Area

The state of Maharashtra is located in the western part of the country, lies between $72^0$36'E to $80^0$54' East longitude and $15^0$45' N to $22^0$6' North latitude. The State is expanded from west to east in conical shape with extending and increasing height from sea level (Deshpande, 1971). The tribals in general are found in geographically backward parts of the state, for instance, in the north-western part and north-eastern of the state that is comparatively less developed. These pockets are particularly known as tribal pockets of the state, where more than 65 per cent tribals are concentrated.

The field survey conducted in fourteen tribal villages viz; Chandikapur, Bhanwad, Bhatode, Borvan, Phopsi, Koch, Ghatkarpada, Nyahale, Karamba, Sulyachapada, Kankala, Itwai, Pohara, and Kakarpada from 2006 to 2010. These villages are located in the north-western part of the state. In this study, as many as 498 households were surveyed, which constituted about 32 per cent of the total households in these villages and tribal population surveyed constituted about 30 per cent that could bring out the ground reality of tribal state of living.

Table 1. Surveyed Tribal Population and Households to Total in Sample Villages, 2006 - 2010

Sl. No.	Name of Village	Name of Tahsil	Name of District	Total House holds	Surveyed Households	Total Population	Surveyed Population	% of Surveyed Households to Total Households	% of Surveyed Population to Total Population
1	Chandikapur	Dindori	Nashik	144	22	849	111	15.27	13.07
2	Bhanwad		Nashik	239	52	1,500	346	21.75	23.06
3	Bhatode		Nashik	266	22	1,546	131	30.33	8.47
4	Borvan		Nashik	89	27	593	159	30.33	26.81
5	Phopsi		Nashik	132	76	960	410	57.57	59.42
6	Koch	Mokhada	Thane	261	34	1,454	189	13.02	12.99
7	Ghatkarpada		Thane	48	27	230	113	56.25	49.13
8	Nyahale	Jawhar	Thane	287	50	1,582	247	17.42	15.61
9	Karamba		Thane	47	24	246	118	51.06	47.96
10	Sulyachpada		Thane	67	27	349	138	40.29	39.54
11	Kankala	Akkalkuwa	Nandurbar	178	38	875	201	21.35	22.97
12	Itwai		Nandurbar	64	24	303	104	37.50	34.32
13	Pohara		Nandurbar	98	33	458	159	33.67	33.26
14	Kakarpada		Nandurbar	153	42	767	230	27.45	29.99
	Total			**2,073**	**498**	**11,712**	**2,656**	**32.38**	**29.76**

(Source: Fieldwork, 2006-2010)

Ekta (1976) attempted a study of the occupational structure and the levels of economic diversification in the tribal villages of Chotanagapur. Hassan (1978) evaluated the nature of the agricultural economy of the Santals of Bihar who were having problems of primitive agricultural techniques. Patel (1982) listed the agro-economic problems faced by the Indian tribes in the wake of diffusion of new agricultural technology and the transformation of their traditional agrarian relations. Samanta (1982) noticed that a considerable number of 'Jhum' farmers have switched over to modern settled cultivation, particularly in Tripura. Srivastava (1977) discussed the regional variations in the types of shifting cultivation as practiced by the tribes in different parts of India. Mitra (1978) discussed the general problems of the tribal groups of West Bengal. Rao (1981) explored the nature of the processes of ecological adaptation among the jalaris of coastal Andhra Pradesh, whose economy is crucially dependent on fishing. Bose (1977) analysed the problems of the tribes of eastern India. The study makes a particular reference to the economic mode of life of these tribes and its variety is found in the region. Gosal (1960) has studied the occupational structure of India's rural population with regional perspective and Kohli and Kothari (1996), studied occupational structure of population in Rajasthan with spatial perspective.

In the present paper, it is endeavored to assess the pattern of tribal population land holding and their land ownership in the state of Maharashtra.

Database and Methodology

In order to meet these objectives the study is mainly based on primary data, which have been collected by conducting an intensive fieldwork in the selected fourteen tribal villages of north western part of Maharashtra, from 2006 to 2010. Near about 498 households, which constituted about 32 per cent of the total households were surveyed by employing systematic sampling technique. The secondary data collected from census of India has helped us to understand the status of land holding. The marginal (less than 1ha), Small (1-2 ha), semi-medium (2-4 ha), medium (4-10 ha), and large (above 10 ha) land holding status have been calculated.

Tribal Land Holding at District Level, 1990-1991

With the exception of some small communities of hunters and food gatherers of all tribal population of Gonds, Kolams, Koyas, Bhils etc. are slash-and-burns cultivators and cultivate by using the traditional equipments like, axe, hoe, and digging stick. Some of the developed and who are having their own land, they are using some of new equipments for cultivating the land (Haimendorf, 1982). Here, the discussion was continuing about the condition of land owning among the tribal who are living in the extreme condition of the

state like North-western and the Eastern parts of the Districts and also discussed the tribal case study village land owners.

Table 1 reveals that more than one third (34.18%) of the tribals on an average in the state were owning 9.9 per cent land. All these tribals were having land less than one hectare (ha), they are marginal landholders or were marginalised in terms of land ownership. The proportion of tribals with less than one hectare land was highest (54.29%) and they owned in all 5.47 ha of land. In other districts like Nashik and Dhule also, the proportion of households was much higher than the land they own. But it is noticed that in Dhule District the proportion of concentration of tribal population was relatively very high (above 40%), the proportion of tribal households with less than one hectare land was 21.48 per cent in 1990-1991 and land they owned was 18.12 per cent, which shows relatively better condition of the tribals as compared to Thane and Nashik in the category of marginal land holding (below 1 ha). Their position in terms of land holding in the state as a whole was also not good, because there were 27.49 per cent tribal households with the marginal land holding of less than one hectare and in all they possessed 6.41 ha of land but the non-tribals in this respect have not shown their superiority in terms of land holding in the state as a whole. This is because of the fact that in 1991, 35.20 per cent non-tribal households in the state were holding only 8.05 per cent land, which means that per head land ownership was much less than the tribals in this category. It does not mean that these non-tribals are poorer than the tribals. They are engaged in non-agriculture pursuits and having good links with the urban centers in and around them as their children are mostly studying in the urban areas. Some of the tribals also have good economic condition and have also sent their children to the urban areas for study purpose but their proportion is negligible.

It is found from the Table 2 that as the land ownership increases (beyond 2 ha), the proportion of households decreases, which is not common in case of marginal and small land holdings in the state of Maharashtra. More than 32.27 per cent tribal households were having ownership just little above 20 ha (20.12%) of land and that of the non-tribals 28.86 per cent households were owning nearly 20 ha land. In this case at state level the position of tribals was relatively better. But on an average the tribals in the area of study, were also having more or less the same status. About 29.50 per cent tribal households were with ownership of land of 1 to 2 ha and in all they were holding 19.88 ha land. In this case the tribal households were having land between 1 and 2 ha, in the district of Thane (26.21%), Nashik (18.15%), Dhule (22.25%), Chandrapur (15.91%) and Gadchiroli (22.54%) more or less closer to the average of landholding in the state. It does not show much difference between the semi-medium (2 to 4 ha) and above land holding category. In the semi-medium (2 to 4 ha) category, the proportion of land holders was relatively less than the proportion of land ownership. For instance, on an average 23 per cent (23.10%) tribal households were holding more than 27 per cent (27.56%) of land in this category. The minimum landholding found in this category was in the district of Jalgaon (4.19%), and

maximum in Aurangabad district (39.51%).The tribal concentrated in districts like Dhule (31.13%), Nashik (28.97%), Thane (31.63%), Chandrapur (28.60%), and Gadchiroli (32.20%) owned on an average 28.68 per cent of land which is near to the state average (27.56%).

In the medium (4 to 10 ha) land holding category 12.94 per cent tribal households were with 32.69 per cent land in the area under study, i.e. in the state, as per the 1990-91 agricultural census. It is noticed that in the district of Thane hardly 8.29 per cent households were with 41.01 per cent land. It shows relatively better position of tribals as compared to non-tribals in Nashik, Dhule, Chandrapur, and Gadchiroli districts. In Nashik about 14 per cent households owned about 34 per cent (33.82%) agriculture land from the total land under cultivation with tribal population, in Dhule 14.21 per cent households were with land 34.18 per cent, Chandrapur district 15.73 per cent households herewith more than 37 per cent land and in Gadchiroli owned 28.34 per cent ha of land holds as land was owned by 9.83 per cent households. The position of tribals in the state in terms of land holding from 4 to 10 ha category was slightly better than the tribals in the state as whole, because on an average 12.38 per cent households were holding 32.55 per cent land in this category and the average values in the state were 12.94 per cent households and 32.69 per cent area owned, in 1990-1991. It does not show much difference but comparatively the status in the state is better. Among the non-tribals in the same category 12.01 households owned 82.59 per cent land. It vindicates that the non-tribals more or less are at par with the tribals in land ownership. This is the only category (i.e. 4-10 ha) in which it is found that a large proportion of land is with the tribals. These are the some tribes whose position is economically better than the marginal and small land holders.

Table 2. Maharashtra: Scheduled Tribe Land holding - 1990-1991

Sl. No.	Districts	Marginal Land Holding (Less than 1.00 ha)		Small Land Holding (1.0 to 2.00 ha)		Semi-medium Land Holding (2.0 to 4.0 ha)		Medium land holding (4.0 to 10 Ha)		Large Land Holding (Above 10.00 ha)		All Size Classes	
		HH %	AO %	HH %	AO %	HH %	AO %	HH %	AO %	HH %	AO %	HH	AO
1	Thane	54.29	05.47	21.84	26.21	13.79	31.63	8.29	41.01	1.49	23.81	100	100
2	Raigarh	34.28	12.88	21.84	18.58	13.79	22.48	8.29	29.14	1.8	16.92	100	100
3	Ratnagiri	47.33	7.23	17.56	10.79	17.47	21.09	13.44	35.98	3.65	24.91	100	100
4	Sindhudurg	61.82	11.46	14.84	13.00	12.47	21.49	8.65	31.70	2.22	22.35	100	100
5	Nasik	28.97	6.38	29.80	18.15	25.28	28.97	13.83	33.82	2.07	12.68	100	100
6	Dhule	21.18	5.73	36.19	22.25	27.23	31.13	14.21	34.18	1.19	6.71	100	100
7	Jalgaon	25.25	9.51	36.10	31.70	24.96	4.19	12.58	44.17	1.11	10.40	100	100
8	Ahmednagar	35.10	9.53	31.53	23.41	23.25	32.32	8.97	26.05	1.15	8.09	100	100
9	Pune	39.30	8.46	25.20	16.71	21.50	27.28	11.83	31.87	2.17	15.68	100	100
10	Solapur	21.09	4.07	27.82	13.78	28.72	26.88	18.70	37.51	3.67	17.73	100	100
11	Satara	57.55	17.39	23.39	24.60	13.23	27.54	5.17	21.80	0.66	9.58	100	100
12	Sangli	48.64	12.18	23.51	19.05	17.62	26.36	8.72	28.89	1.51	12.34	100	100
13	Kolhapur	66.74	23.86	18.92	24.98	10.36	34.72	3.59	18.96	0.38	5.84	100	100
14	Aurangabad	24.40	6.35	34.76	22.41	27.23	39.51	12.38	31.21	1.23	7.31	100	100
15	Jalana	24.31	6.36	35.51	22.79	25.60	36.36	13.35	33.64	1.14	6.70	100	100
16	Parbhani	23.08	5.79	32.54	19.82	27.95	34.37	15.43	36.40	1.0	5.44	100	100
17	Bid	30.46	7.85	31.75	21.23	24.21	32.54	12.28	32.21	1.30	8.15	100	100
18	Nanded	26.49	7.62	35.13	24.29	26.70	27.15	11.02	29.45	0.66	4.27	100	100
19	Osmanadbad	16.73	3.57	31.15	15.42	28.97	29.69	20.36	40.56	2.81	3.30	100	100
20	Latur	16.93	4.19	32.93	17.29	29.56	28.06	18.49	38.98	2.09	9.85	100	100
21	Buldhana	22.88	5.83	34.23	19.75	25.71	26.11	18.17	35.46	2.01	10.90	100	100
22	Akola	19.50	4.92	34.26	18.06	26.25	26.15	17.07	36.84	2.92	14.04	100	100
23	Amravati	23.24	6.72	37.19	21.83	23.38	28.63	14.06	33.70	2.13	11.60	100	100
24	Yavatmal	4.14	0.87	35.70	16.08	34.33	28.08	22.22	39.72	3.54	14.70	100	100
25	Wardha	13.43	3.30	32.80	15.81	30.46	29.16	20.40	39.71	2.85	13.10	100	100
26	Nagpur	19.57	4.80	33.75	18.63	27.75	26.74	16.95	37.01	1.98	10.32	100	100
27	Bhandara	56.04	21.20	26.61	29.19	12.63	24.74	4.35	18.95	0.36	3.92	100	100
28	Chandrapur	29.23	6.57	27.77	15.91	25.72	28.60	15.73	37.26	2.09	11.63	100	100
29	Gadchiroli	34.43	9.32	30.79	22.54	23.86	32.20	9.83	28.34	1.09	7.60	100	100
Maharashtra		**31.94**	**8.51**	**29.50**	**19.88**	**23.10**	**27.56**	**12.94**	**32.69**	**1.81**	**11.36**	**100**	**100**

(Source: Report on Agricultural Census, 1990-1991 Part I & II)

The land holding above 10 ha (25 acres) is a rare case among the tribals as well as among the non-tribals, but these people (above 10 ha) in this category are well off and they are the land lords among the tribals and it also holds true in case of non-tribals large. The large land holders among the non-tribals are mostly from Marathas and Malis caste, because a major share 3/4th (74%) of land in the state is with the Marathas and Malis caste (Dikshit, 1986: p.65). Suhas Palshikar's study also found that comprising 32 per cent of states Maratha population. The share of Maratha's in agricultural land is above 70 per cent (www.first poster politics News). Nearly 1.66 non-tribal households were such who were having land above 10 ha; about 11.24 per cent land of the total land belonged to this landlord category. Similarly, 1.81 per cent tribal households in the state were land lords of large land holding and they owned more than 11 per cent (11.36%) of the total land of tribal community in 1990-91. But it is very surprising to note that in the district of Thane nearly 1.5 per cent tribal households were land lords of this sort, as the each household in this category owed more than 10 ha of land. This 1.8 per cent household, in all owned 23.81 per cent of the total land in Thane district. In Nashik District 0.85 per cent, less than 1 per cent households owned 12.68 per cent, in Dhule 0.50 per cent owned 6.71 per cent, Chandrapur 2.09 per cent owned 11.63per cent and in Gadchiroli 1.09 per cent owned 7.60 per cent land respectively in 1991. Here the land. Ownership has created a very sharp disparity in the land distribution among the tribals as well as non-tribals in the state, less than 1 per cent (0.99%) tribals owned more than 14 per cent land. The territorial or regional land ownership determines the overall social and economic status of tribal as well as of non-tribal.

Land Householding Status Among the Tribals at Village Level, 2006-2010

As per the survey conducted in the sample villages of the study area in 2006-2010 about 14 villages were covered in the field study and in that 1,065 households were surveyed. On an average, more than 40 per cent (40.56%) tribal households were identified as landless. It is found that landlessness has been increasing among the tribals in general but in the study area in particular. Out of the 14 sample villages, as many as six villages viz. Phopsi (52.63%) in Dindori Tahsil of Nashik district, Koch (58.82%), Ghatkarpada (53.85%) in Mokhada Tahsil of Thane District, Nyahale (54.00%), Karamba (62.50%) in Jawhar Tahsil of Thane District, and Kakarpada (67.44%) were such where more than 50% of the tribal households were landless. It ranges between above 52% to above 67%. It is very surprising to note that about 43% of villages were with more than 50% landless tribals as per our field survey 2006-2009. In Bhanwad (46.15%) in Dindori Tahsil of Nashik District, and Sulyachpada (44.44%) in Jawhar Tahsil of Thane District where the landless was between 40 per cent and 50 per cent. In the remaining Tahsil, it was less than 40 per cent. The landlessness among the tribals has increased if we look into comparative figures since 1991.

Marginal Landholding (Less than 1 ha)

On an average more than 25 per cent of the tribal households were marginal landholders who owed less than one ha (hector) land. All these marginal landholders were possessing hardly 23.86 per cent of their total land in the sample study area. In about 7 out of the 14 villages the proportion of marginal landholding households was above 20 per cent. In these 7 villages, the highest proportion of marginal landholding was in Pohara (45.90%) in Akkalkuwa tahsil of Nandurbar district. It was closely followed by Bhanwad (42.64%) in Dindori tahsil of Nashik District, Ghatkarpada (42.93%) in Mokhada tahsil of Thane district, Kankala (42.10%), Itwai (35.90%), in Akkalkuwa Tahsil of Nandurbar district Kakarpada (27.10%), and Karamba (24.08%) in Jawhar tahsil of Thane District. The serious condition was observed in some villages, for instance in Koch, Bhatode and Sulyachapada where landless and marginal landholders constituted more than 80% and like this there are some other villages also where marginal landholders were also more or less landless because the land, which they possessed was not suffice to meet their both the ends. Therefore, their position is really a pitiable.

Small Landholding (1-2 ha)

The small and marginal landholders constitute about nearly 42 per cent of the tribal householders in 14 villages and were owned more than 28 per cent land. The marginal landholders and landless house holds constitute more than 69 per cent. As many as six villages were owned less than 29 per cent to more than 40 per cent landholdings, and remaining were in bellow average; their economic position is very poor. The marginal landholders are not in a position to get the yield from the land, which can be sufficient for the farmer and his family. Therefore, these marginal landholders have to work as agricultural labourers for the supplement income to the household. They have been reduced to small landholders because of land alienation or land dispossession, which has been taken place since long. In some cases tribals have been compelled to migrate to other areas to earn their livelihood. This sort of process, which is separating them from the land, is the land alienation that has already began.

Semi-Medium Landholding (2-4 ha)

In the area under study nearly about 11 per cent tribal landholders were having 2-4 ha of land in 2006-2010 and all these tribals were possessing about 29 per cent of total tribal land in the case study villages. From semi-land through medium to large landholding the position of tribals was comparatively better than the marginal and small land holders because the proportion of land holders was relatively less than the proportion of land them possesses. It is noted that in the village like Chandikapur 18.18 per cent households were possessing 44.53 per cent land in the semi-medium category, where grape-wine cultivation is popular. Similarly, followed by Borvan and Phopsi village of Dindori tahsil, Koch of

tahsil and Sulyachapada and Karamba of Jawhar tahsil, more than 47 per cent households were having more than 30 per cent land in the semi-medium category. In about eight villages, the proportion of land owning between 2 to 4 ha was bellowing the average (28.64%). In general, it is found that tribals or non-tribals holding 2 to 4 ha of land are comparatively better than the marginal and small landholders. The major proportion of the land is lying with the farmers in the semi-medium category.

Medium Landholding (4-10 ha)

The proportion of landholders in the medium and large land holding was relatively very small but the land which they held was very large. It means lower the proportion of land holders larger is the proportion of land ownership. It is hardly 3.65 per cent on an average households possessing 13.58 per cent in medium land holding (4-10 ha). There are five villages, for example, Bhatode and Phopsi in Dindori tahsil of Nashik district, Ghatkarpada in Mokhada tahsil of Thane district, Itwai and Pohara in Akkalkuwa tahsil of Nandurbar district where no one was found with medium land holding. Some of the villages like Kakarpada and Kankala of Akkalkuwa tahsil, where 10 or more than 10 per cent households were having medium landholding, otherwise the proportion was far less than 10 per cent but holding 4-10 ha of land. Now the tribal in this category are relatively much better and they mostly depend on agriculture. Since the land is enough, they are able to meet their both the ends from the yield from this piece of land.

Table 3. Distribution of Tribal Landholding in Sample Villages, 2006 - 2010

Sr. No	Name of Village	Surveyed H.H	Land Less H.H %	Marginal Landholding (Less than 1 ha) %		Small Landholding (1-2 ha) %		Semi- Medium (2 - 4 ha) %		Medium (4-10 ha) %		Large (above 10) %		Total Percentage	
				No. H.H	A.O	No. H.H	A.O	No. H.H	A.O	No. H.H	A.O	No. H.H	A.O	HH %	A.O %
1	Chandikapur	22	27.27	27.27	11.76	22.73	25.90	18.18	44.53	4.55	17.82	0.00	0.00	100.00	100.00
2	Bhanwad	52	46.15	38.46	42.64	9.62	24.34	3.85	18.66	1.92	14.36	0.00	0.00	100.00	100.00
3	Bhatode	22	18.18	27.27	6.44	31.82	21.89	13.64	14.64	0.00	0.00	9.09	57.03	100.00	100.00
4	Borvan	27	29.63	25.93	12.91	25.93	30.81	14.81	42.56	3.70	13.72	0.00	0.00	100.00	100.00
5	Phopsi	76	52.63	18.42	18.47	14.47	25.19	13.16	38.03	0.00	0.00	1.32	18.31	100.00	100.00
6	Koch	34	58.82	2.94	1.17	14.71	21.12	17.65	42.38	5.88	35.33	0.00	0.00	100.00	100.00
7	Ghatkarpada	26	53.85	30.77	42.93	11.54	37.37	3.85	19.71	0.00	0.00	0.00	0.00	100.00	100.00
8	Nyahale	50	54.00	18.00	14.00	18.00	41.01	6.00	19.28	4.00	25.71	0.00	0.00	100.00	100.00
9	Karamba	24	62.50	20.83	24.08	4.17	9.10	8.33	36.42	4.17	30.40	0.00	0.00	100.00	100.00
10	Sulyachpada	27	44.44	18.52	9.19	18.52	35.14	14.81	37.12	3.70	18.56	0.00	0.00	100.00	100.00
11	Kankala	39	15.38	38.46	42.10	26.64	20.19	10.26	25.27	09.26	12.44	0.00	0.00	100.00	100.00
12	Itwai	24	37.50	41.66	35.32	12.50	38.42	8.33	26.24	0.00	0.00	0.00	0.00	100.00	100.00
13	Pohara	33	39.39	39.39	45.90	9.09	39.24	12.12	14.86	0.00	0.00	0.00	0.00	100.00	100.00
14	Kakarpada	42	67.44	11.63	27.10	4.05	29.85	9.30	21.23	13.95	21.82	0.00	0.00	100.00	100.00
	Total	**1,065**	**43.37**	**25.68**	**23.86**	**15.99**	**28.54**	**11.02**	**28.64**	**3.65**	**13.58**	**0.74**	**5.38**	**100.00**	**100.00**

(Source: Fieldwork, 2006-2010)

Large Land Holding (Above 10 ha)

Barring three villages like Bhatode and Phopsi in Dindori tahsil of Nashik District where the land holders were having land about 10 ha. The largest number was in Bhatode where more than 9 per cent tribal households were having more than 10 ha land and in all they were having 57 per cent of total land and in Phopsi 1.32 per cent were having more than 18 per cent land. On an average 0.74 per cent tribal households were having 5.38 per

cent land in the category of large landholding. In these villages grapevine cultivation is being done to a large in extent because of favorable climatic condition and better in irrigation facilities provided by the state government. Some of them being economically batter have developed on their own.

Conclusions

It is inferred that there is a very sharp inequality in the land distribution both among the tribals as well as non-tribals. It is also suggested that here the process of redistribution of land should be initiated so as to bring equality by making the provision of land distribution to the landless and marginal and small land holders so that their overall condition can be improved, it will also enhance their accessibility to the resources with which they can raise the standard of living.

It is also concluded that tribals have been loosing their own land to non-tribals in their own land. More than 43 per cent tribal households were landless as per our sample study of 14 villages in 2006 - 2010. Six villages Phopsi, Koch, Ghatkarpada, Nyahale Karamba and Kakarpada were identified where majority of tribals were landless. The landless among the tribes is on increase, 42 per cent tribal households were marginal and small landholders owned 52.40 per cent land.

About 11 per cent tribal households were semi-medium landholders (2-4 ha) and were possessing nearly 29 per cent land. The proportion of medium and large landholders (4.39%) is lesser than the land (13.58%) they possess. The inequality in land possession and ownership even among the tribals is very sharp and wide. It creates dominances of a few over the majority.

It is inferred that the tribals who have more than 2 ha to above 10 ha of land, their position was comparatively better but the share of large land holders was insignificant but their position is much better off and hence, they have been controlling the other resources of the villages being economically better off. Among the non-tribals in the state as a whole the proportion of large landholders were 1.66 per cent and were holding more than 11 per cent of land as per the 1991 agricultural census.

In the state as a whole one-third of the tribals (in 1990-91) were marginal landholders and owned only 9.10 per cent land. In Thane District (54.29%), majority of tribals were marginal land holders. It is also found proportion of large land holders (1.49%) with 24% land is also largest one. Higher the proportion of land with large land holders higher is the proportion of households with marginal land holders. Considering all size classes about 35 per cent tribals owned about 36 per cent land in the study area and more or less the same holds true at state level. In village Bhatode about 9 per cent tribals in large

land holding category were holding above 57 per cent land and in Phopsi 1.32 per cent owed more than 18 per cent land.

The land lost to non-tribals by the tribals under the precarious economic compulsions should be returned to them so that they can earn their livelihood by tilling their own land. The schemes or programs of a forestation should be implemented with which the economic position can be improved. Selling of land by tribals to non-tribals should be seized so that further exploitation can be stopped. If at all the tribal occupancy land has to be sold, opportunity ha to be given to tribal family in the same area or within 5 km from the same area on the consideration of payment to the tribal occupancy holder as per the existing rule and price of the land. Irrigation provision and better seeds should be made available. High level of corruption in forest departments is also the strong base of exploitations of tribals.

It is suggested that the problem of landless and marginal land holders need to be addressed through re-distribution of land or by making the provision of land for them to raise their overall position, So that, they can improve their accessibility to other resources, which are essential for their development.

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AN ANALYSIS OF LANDUSE AND LAND COVER CHANGES IN CUDDALORE DISTRICT, TAMIL NADU - A GEOMATIC APPROACH

Ravikumar P.[1] and Bhaskaran G.[2]

[1]Department of Geography, Presidency College (Autonomous), Chennai - 600 005
[2]Department of Geography, University of Madras, Chennai - 600 005
Email: ravi6780@yahoo.com

Abstract

Landuse / land cover are essential components in understanding the interaction of human activities with nature, and thus, it is necessary to monitor and detect the changes to maintain a sustainable environment. The study aims to find landuse/land cover features of Cuddalore District of Tamil Nadu. The total area is 3,564 sq.km. The study has made using Landsat Images. The landuse and land cover analysis in the Cuddalore District have been attempted based on thematic mapping of the area consisting of built-up land, agriculture land, water bodies, forest and wasteland using the satellite image.

***Keywords**:* LU/LC, Remote Sensing, GIS Techniques, Urbanisation

Introduction

In the fast-developing society knowledge on landuse and land cover is one of the essential factors, to study planning and management activities, which are considered as an essential element for modeling and understanding the earth as a system. Land cover maps have presently developed from local to national to global scales. The use of panchromatic, medium-scale aerial photographs to map landuse has been as accepted practice since the 1940s. More recently, small-scale aerial photographs and satellite images have utilized for landuse/land cover mapping (Thomas M, 2004). Land-use information, coupled with the hydrologic characteristics of soils on the land surface, can also provide measures of expected percolation and water holding capacity. Recently land-use change mainly deals with the land conversion from one type to another and land cover modification through human intervention has altered a large proportion of the earth's land to satisfy their immediate demands. (Meyer and Turner 1992; Vitousek et al. 1997; Foley et al. 2005). Landuse/land cover of the earth is changing dramatically because of human activities and natural disasters (Muttitanon 2005). The rapid industrialization and urbanization of an area require quick preparation of actual landuse / land cover maps in order to detect and avoid overuse and damage of the landscape beyond the limits of sustainable development. (Fulleret 2003). Cuddalore District falls under the disaster-prone zone; disaster mitigation is

a major focus of the government. Landuse and Land cover helps in identifying these impacts.

Study Area

Cuddalore District is bounded in Latitude 11°11" and 12° 5"N Longitude78° 38" and 80° 00" E covered in an area of 3678 sq.km. It is bounded on the north by Villupuram District, east by the Bay of Bengal, south by Nagapattinam District, and west by Perambalur District. Cuddalore District was a part of the South Arcot District which was bifurcated into Cuddalore and Villupuram Districts in September 1993. As per the 2001 census, Cuddalore had a population of 2,285,395 of which males were 1,150,908, and the remaining 1,134,487 were females. With the setting up of the Neyveli Lignite Corporation, the district has acquired an essential place in the economy of the State. This vast industrial complex is the primary industry in the district. The project provides us lignite, electricity, fertilizer, loco, and washed clay. The sugar industry is the next major primary industry in the district (Fig.1).

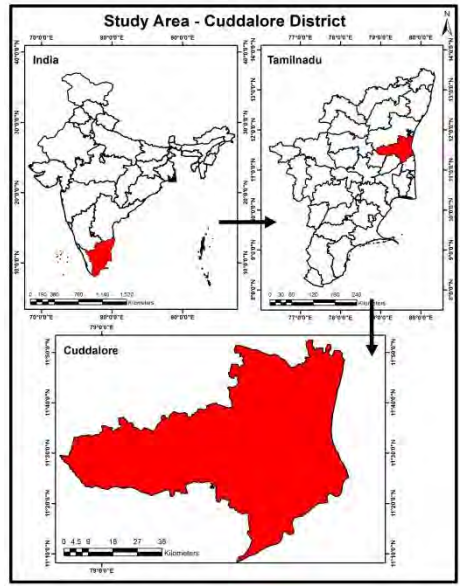

Fig. 1. Location of Cuddalore District

The District was under the rule of Nawab of Arcot during the first decade of the 18th century. This division has come to be called South Arcot to distinguish it from the northern division of Arcot (Cuddalore Handbook, 2001). The aim and objectives of the study is to study the pattern of Landuse and Land cover changes in the high flooded year of Cuddalore District and to study the Landuse and Land cover changes for the years 1991, 2005, 2008 and 2010.

Database and Methodology

Multi-temporal satellite data of Landsat TM 1992, Landsat 5 - 2005, 2008, and 2010 images were used to generate landuse / land cover map. This Landsat satellite images were downloaded freely through the global land cover facility. The use of multi-temporal satellite data at a large scale possesses several challenges including geometric correction error, noise erasing from atmospheric effect, instrument errors etc. In this study, the geometric and radiometric errors were rectified through image pre-processing techniques. Images were geometrically corrected using ground control points (GCP) and were taken from the SOI toposheets (1972) with an RMS error of less half a pixel value by using the nearest neighbourhood resampling method. The images were registered with Universal Transverse Mercator projection, WGS 1984, and area of interest was selected and was subsetted using ERDAS Imagine software. The FCC was created for differentiating the landuse/land cover features. Different land-use features were mapped such as settlement, cropland, river, land with and without scrub, vegetation, salt pan, waterlogged area, mudflat and industries, and also their changes were analysed with the help of GIS (ArcGIS 9.3) software environment.

Landuse and Land Cover Changes

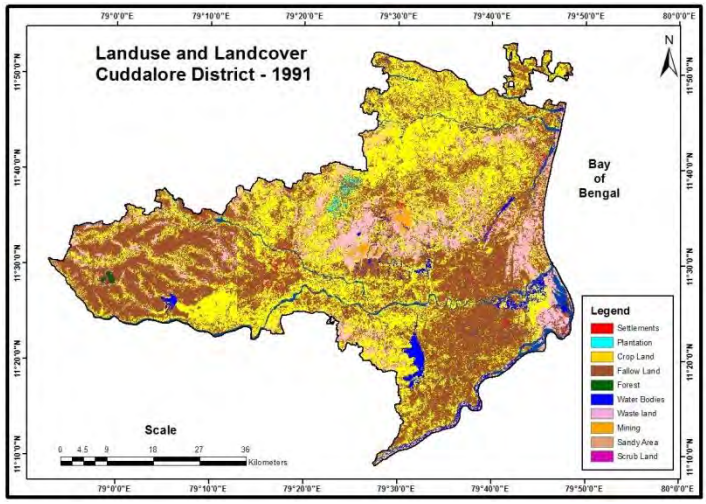

Fig. 2. Landuse and Land Cover, Cuddalore – 1991

In the year 1991, the cropland continued to rule the majority of the area with 56%, followed by fallow land 29%, water bodies with 8%, wasteland with 4% and settlements with only 1%. Cuddalore District depends on agricultural activities, also in Tamil Nadu Cuddalore District is one of the flood prone zone in Tamil Nadu, contrary to this in the year of 2005, crop land was slightly increased to 2,060.42 km^2, fallow land was decreased to 1021.29 km^2 due to its economic credits.

Noticeably, there is a further enhancement that was found in the forest due to M.S. Swaminathan Foundation who planted many varieties of Mangrove species. At the same time, lands with the scrub region were increased to 17.67 km^2 in 2005. There were three major types of land-use changes conversion evidenced from the figure (Figure 2 & 3) as; agricultural land to settlement areas, water bodies to fallow land due to low rainfall (Table 1).

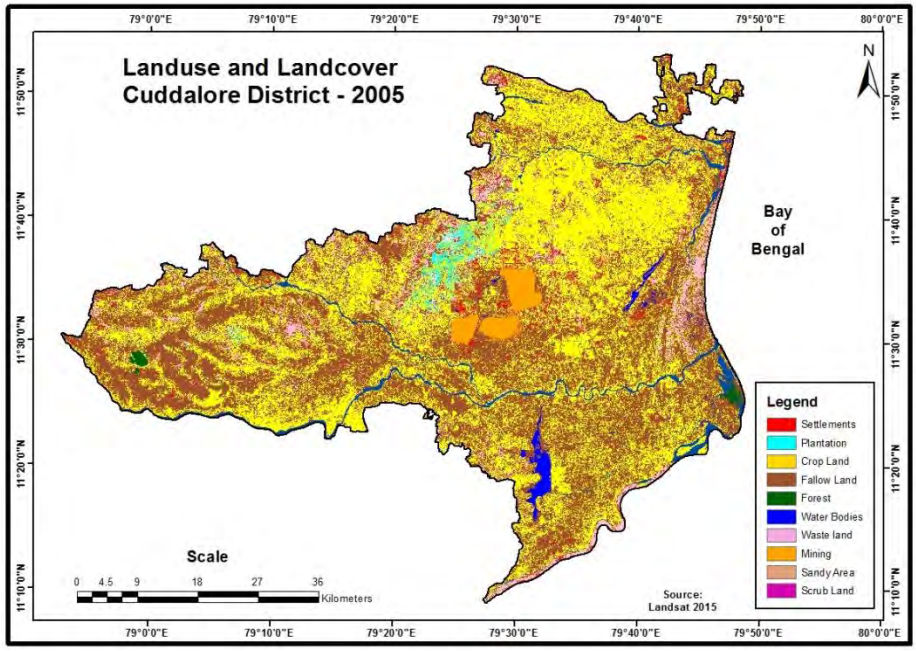

Fig. 3. - Landuse and Land Cover, Cuddalore - 2005

Table 1. Landuse and Land Cover - 1991 and 2005

Landuse and Land Cover - 1991				Landuse and Land Cover – 2005			
Sl.No	Landuse and Land Cover	Area sq. km	%	Sl. No	Landuse and Land Cover	Area sq. km	%
1	Settlements	50.6	1%	1	Settlements	90.6	1%
2	Plantation	40.6	1%	2	Plantation	60.9	1%
3	Crop Land	2043.1	56%	3	Crop Land	2060.4	56%
4	Fallow Land	1071.6	29%	4	Fallow Land	1021.3	29%
5	Forest	15.6	0%	5	Forest	17.5	1%
6	Water Bodies	276.2	8%	6	Water Bodies	236.5	8%
7	Waste Land	144.3	4%	7	Waste Land	150.7	4%
8	Mining	13.4	0%	8	Mining	16.2	0%
9	Sandy Area	7.9	0%	9	Sandy Area	6.4	0%
10	Scrub Land	15.6	0%	10	Scrub Land	17.7	0%
	Total	**3,678.0**			Total	**3,678**	

The plantation has increased due to awareness by the government, and the presence of port has made the sandy area of Cuddalore showed only minor variation with unstable areas, as the northern part of the port region will be eroded. The increase in Mining activities has affected the region's contaminated groundwater and neighbouring areas. The above image's information on landuse/land cover also provides a better understanding of the cropping pattern and spatial distribution of fallow lands, forests, grazing lands, wastelands and surface water bodies, which are vital for developmental planning.

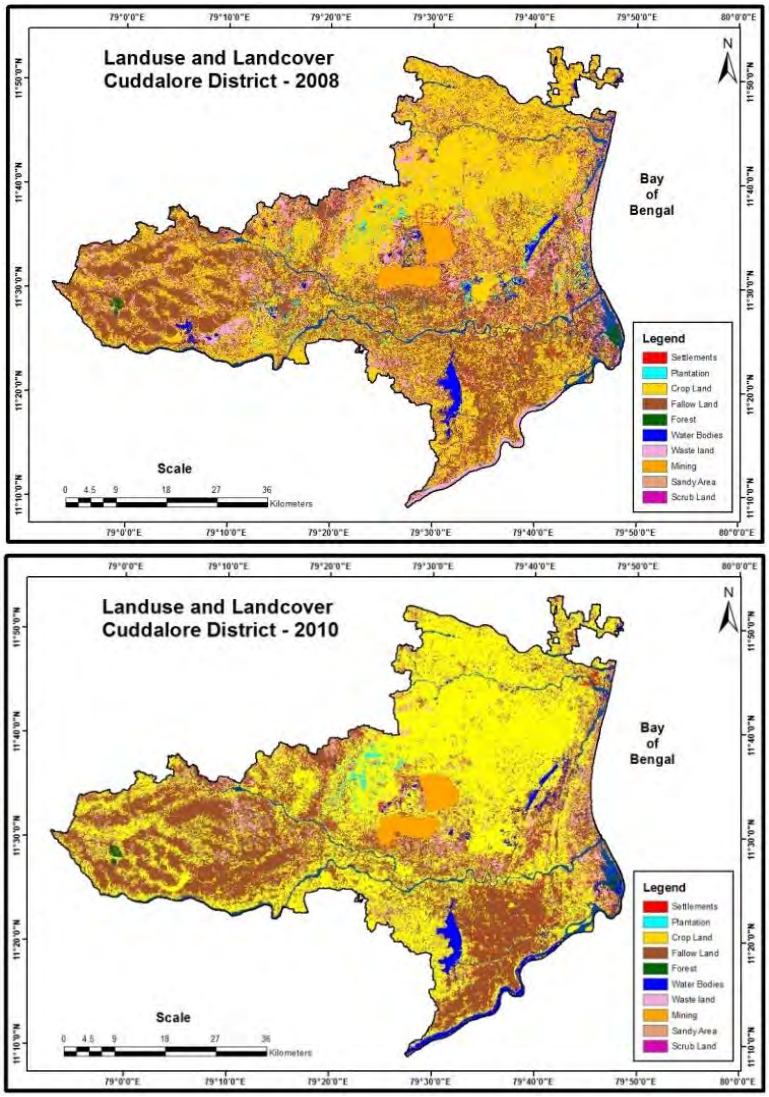

Fig. 4. Landuse and Land Cover for Cuddalore District, 2008

Fig. 5. Landuse and Land Cover for Cuddalore District, 2010

The present study reveals that the Cuddalore coastal zone and its surroundings still retain more agricultural land when compared to all other landuse / land cover features, though the rate of conversion of agricultural land for other purposes like industries and building construction were increased alarmingly for the past few years(Table 2). In the year 2008, the Cropland continued to rule the majority of the area with 55%, followed by fallow land 31%, water bodies with 4%, waste land with 4% and settlements with only 1%. Cuddalore District depends on agricultural activities, which is one of the Flood Prone Zone of Tamil Nadu.

Table 2. Landuse and Land Cover, 2008 and 2010

Landuse and Land Cover - 2008				Landuse and Land Cover - 2010			
Sl. No	**Landuse and Land Cover**	**Area sq. km**	**%**	**Sl. No**	**Landuse and Land Cover**	**Area sq. km**	**%**
1	Settlements	123.5	3%	1	Settlements	125.5	3%
2	Plantation	63.1	2%	2	Plantation	64.6	2%
3	Crop Land	2,012.6	55%	3	Crop Land	2,019.6	55%
4	Fallow Land	1,128.6	31%	4	Fallow Land	1,130.9	31%
5	Forest	9.0	0%	5	Forest	9.0	0%
6	Water Bodies	139.2	4%	6	Water Bodies	123.2	3%
7	Waste Land	161.4	4%	7	Waste Land	163.4	4%
8	Mining	17.3	0%	8	Mining	18.0	1%
9	Sandy Area	5.9	0%	9	Sandy Area	5.5	0%
10	Scrub Land	17.6	1%	10	Scrub Land	18.6	1%
		3,678				**3,678**	

Contrary to this in the year of 2010, cropland was slightly increased to 2,019.57 km^2, fallow land was Increased to 1130.93 km^2 due to its economic credits. Noticeably, there is a further enhancement that was found in the forest due to M.S. Swaminathan Foundation who planted many varieties of Mangrove species.

At the same time, lands with the scrub regions were increased to 18.56 km^2 in 2010. There were three major types of land-use changes conversion evidenced from the figure (Figure 4 and 5) as; agricultural land to settlement areas, water bodies to fallow land due to low rainfall.

Conclusions

When compared to all other landuse/land cover features, the rate of conversion of agricultural land for other purposes like fallow land and building construction have increased alarmingly in the past few years. The baseline information generated on landuse/land cover pattern of the area would be of immense help in the formulation of policies and programs required for developmental planning of the District. As the region falls in Disaster Prone Zone, the industrial activities in the district need to be regularised. From the year 1991 to 2005 it has shown drastic changes, when compared to 2005, 2008 and 2010 respectively.

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AFFORESTATION AS A TOOL TO PREVENT DESERTIFICATION PROCESS - A CASE STUDY OF TALAKAD POINT BAR RIVERINE DEPOSITS OF CAUVERY RIVER OF SOUTHERN INDIA

Arun Das S.[1], Purushothamma[2], Venugopal V.R.[3], Sawant Sushant Anil[4], Chandrashekara Y.P.[5] and Harsha B.S.[6]

[1]Department of Studies in Geography, University of Mysore, Mysore - 570 006
[2]Government of Karnataka, Mysore - 570 005
[3]Emerald, Enclave, Mysore - 570 018
[4]JSS Academy of Higher Education and Research, Mysore - 570 015
[5]Karnataka Open University, Mysore - 570 006
[6]Vidyavardaka First Grade College, Mysore - 570 021
E-mail: arundas109@hotmail.com

Abstract

Afforestation program is taken up for many reasons mainly to protect the environment and also for commercial purpose. The case here is different and the afforestation program is taken up to safeguard one of the oldest capital cities of Ganga (320 - 1000 AD) dynasty called 'Talakad' This town was situated on the bank of Cauvery river, a major river of southern India. The meandering loop of the river in this junction and the wind gap that falls exactly perpendicular to the loop is the cause for the shifting as well as the rising sand over the existing monumental buildings burying the entire ancient capital city. The afforestation program has been sought to check the advancing sand material brought by the river. Over these buried monumental structures, the afforestation program has been taken up as a good measure to prevent further expansion of sand material to the adjoining newly shifted town and the agrarian land. From this paper one can understand how the nature pose a onslaught on mankind, where the entire human machinery (Government bodies and other organizations) has become a silent spectator. An adjoining village to Talakad called Kukuur also share the same geomorphological features and it is in the process of burying. The main objective of the study is to highlight the usefulness of the afforestation program in checking the sand expansion and the damaged thus controlled in agriculture production. Secondly, this paper also briefly discusses the threat of desertification in the surrounding land in the near future, if not, afforestation program is expanded to the places mentioned herein. Thirdly, the authors have evolved to suggest a new strategy in recommending how to stop the desertification process adopting afforestation as a remote-control tool.

Keywords: Afforestation, Desertification, Sand bars, Wind gap, Wind breaker

Introduction

Afforestation today has become like instant meal for many environmental problems. Afforestation means bringing a land under forest cover where the land was not under forest since last 50 years or more. The main aim and the intention of afforestation vary as per the local need. In cities, the afforestation program is chalked out with the intention of greening the land and to meet the environmental standards to prevent atmospheric pollution. Social forestry has been geared up in some towns and across countryside with the intention to prevent the land transforming into semi-arid condition by enhancing the evapotranspiration. Afforestation done adjoining to the forest cover is to expand the forest area and to improve the territory of the animal habitat. Another motive of introducing the afforestation is to meet a particular goal such as to prevent the eolian effect or rapid soil erosion or the mud flow or landslide etc (Hoffmann & Jackson, 2000).

Some of the studies revealed that the afforestation has taken up as one of the best tools to promote the land value and also to acclaim the set aside land (Scott & Lesch, 1997). In Finland to boost the rural landscape and to add scenic beauty to the land, afforestation has been adopted. The set aside land has now been converted into one of the hot tourist centres.

Here are few extracts taken as it is from the internet to substantiate how useful the afforestation in various situations.

> *The speed and scale of afforestation in China both rank first in the world. In the past two decades, volunteers participating in the national tree-planting movement throughout the country have planted over 35 billion trees. The pace of afforestation has quickened. At present, the total area afforestation by aerial sowing has accumulated to 8.68 million ha, and the area of hillsides closed to facilitate afforestation has reached 34 million ha. Today, the forest coverage rate in China has increased to 16.55 percent, and both the area and reserves of forests have increased. In 12 provinces and autonomous regions, practically all the barren hills and wasteland suitable for afforestation have been covered by greenery.*

Afforestation in North China has helped to harness desertification and soil erosion. The windbreaker belt project in northeast, north and northwest China known as the "No.1 Ecological Project in the World" have entered its fourth construction phase with the trees planted totalling 26 million ha.

In South Africa, afforestation is done by the government for commercial purpose. Since the land under forest got depleted and the indigenous forest are slow in growth, to meet the increasing demand, afforestation has been taken up. Today the commercial forest or the plantation forest cover accounts to 1.5%, whereas the indigenous forest cover accounts to 0.5% (Smith & Scott DF 1992).

Afforestation is the planting of trees for commercial purposes, generally on land supporting non-forest veld types, e.g. grassland or fynbos. This differs from reforestation which is the restocking of existing forests and woodlands which have been depleted. Less than 0.5% of South Africa is covered by indigenous forests. Owing to their slow growth and sensitivity to logging, these forests cannot supply the majority of our country's wood requirements. Additional fast-growing trees are planted to cater for the demand for wood products. Commercial forests, or plantations, cover 1.1% of South Africa (Hoffmann & Jackson, 2000)

The National Capital Power Station near Delhi in India, has implemented the afforestation program for the first time to reclaim the ash mounds which are 55 meters of height. The vegetative land which got submerged under water due to the erection of reservoir in Gujarat across the river Narmada in India is yet another example. The compensatory afforestation has been taken up to compensate the lost forest cover. Many of the projects coming up on Narmada River and its tributaries involve submergence of forest land. In order to compensate the loss of forests, Compensatory Afforestation works are being carried out on revenue and degraded forest lands under various projects.

The successful growth of vegetation cannot be considered as the end of the afforestation program. Many other aspects have to be studied to identify the rate of success and the repercussions. In this direction the Talakad sand dune afforestation program has been studied to bring some interesting facts about the success and the failure of the afforestation program particularly in contrast to environment damage control measure (R. B. Jackson et al., 2000).

Study Area

The Talakadu meander loop is situated in the mid of peninsular plateau along the river bank of Cauvery. It is flanked by Mahadeswara and Billigiriranagna mountains in the SW and SE. The latitude and longitude co- ordinates of the area stretch between 12^0 7' 30" to 76^0 57' 30" to 77^0 10' 00" east. It lies 70 km from Mysore, one of the major cities of Karnataka State and Southern India.

History of Talakadu

Talakad was one of the ancient settlements located on the banks of river Cauvery. Being a capital town of two powerful dynasties of southern India namely, Gangas and Cholas, Talakad possess a monumental treasure safely buried under the sand

sedimentation brought by the river Cauvery (Narasimhachar L. 1950). Perhaps, Talakad represents an ancient settlement buried under the accumulation of large sand deposition, which can be termed as sand dune (Anantharamu and Vaidyanatha 1997). The new talakad settlement is also prone to further expansions of the sand towards the settlements.

The major aspects focused in this paper are, to highlight the usefulness of the afforestation program in checking the sand expansion and the damaged thus controlled in agriculture production. Secondly, this paper also briefly discusses the threat of desertification in the surrounding land in the near future, if not; afforestation program is expanded to the places mentioned herein. Thirdly, the authors have evolved to suggest a new strategy in recommending how to stop the desertification process adopting afforestation as a remote-control tool.

Database and Methodology

The empirical survey followed by repeated field visits is the major backgrounds for the study. GPS survey was done to understand the area, size and the shape of the sand deposit. Villagers of Talakad, Kukkur and Bettahalli and the forest officials in charge of the afforestation program were interrogated to understand the ground situation. Entire analysis was done based on primary data.

Evolution of Sand Deposits and Its Impact

Sedimentation of sand has become one of the significant geomorphic characteristic features in this particular river point (Fig 1.) due to rising height (50 to 70'). Large scale sedimentation has been attributed mainly to the fault plane that has been subjected to Neo tectonic activity (Valdiya 2001). The result of this was the upliftment of the river path, with a sudden loss in its gradation, thereby the sinousity of the river and meanders have developed. Apart from this the construction of a anecut (dam) has reduced the stream velocity resulting in a large scale deposition of sand, transformed into dune. The deposition of sand, which has buried Talakad and Kukkur settlement, is one of the unique features to be noticed along the course of the river Cauvery and also in comparison to any other rivers of Southern India (Radakrishna B.P. et al.,1964).

The south west wind movement from a mountainous gap between Biligirirangan hill and Malaimahadeswara hills has caused havoc on the entire meandering loop. A high velocity wind from southwest direction has elevated the sand deposit to a height of seventy feet and buried two settlements. The buried temple domes and settlement structures have formed as the base for the high-altitude undulating sand cover deposits. The digital elevation model of undulating sand dune topography can be seen in the GPS based DEM can be seen in Fig. 2. The sand dunes are elevated to the height of 50 - 70 feet (Fig. 3) and stretch over a concave length of 10 km and 2 km in width. The deposits have been dated as 500-year-old.

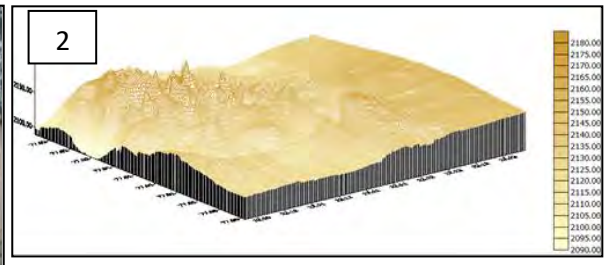

Fig. 1. The heap of sand raised to 50 feet height at Talakad
Fig. 2. The Digital Elevation Model of Sand Morphology in Talakad.
Fig. 3. The satellite image of Talakad Meander Loop and the Sand Bar points.
The Response to Sand Deposits by the Administration.

Understanding the severity of extending sand dunes towards the settlement and the agrarian lands, the government of Karnataka launched a afforestation program in 1972 to check the further mobility of sand. The afforestation program was planned to plant xerophytes species, which can be best adopted to the sand condition. The expanding sand has come to recession through the implementation of this program.

Afforestation and the Success

Afforestation programs are usually implemented in a region where scant vegetation is found. But the afforestation program launched in Talakad is a clear case in different. The

main purpose of the afforestation program in this situation was to prevent the expanding sand material towards the new Talakad Settlement and the adjoining agrarian lands. Therefore, the evaluation of this particular area drew further interest in understanding the overall effect as well as the necessary measures required. The cashew net trees at the lower layer and the eucalyptus high canopy tree prevent the surface level and mid level wind movement. The trees are grown to a height of 15 feet and 60 feet respectively. However, the afforestation program has brought 80 percent result in preventing the rapid expansion of sand. Even at present there are complaints about the sand shower from the tailed roof of the houses are common as per the personal interrogation.

The Returns of Afforestation

The estimated rate of expansion of sand dunes at present is accounted as 2 sq. feet per annum. The afforestation program has prevented an estimated crop production of 7.5 lakh quintals per annum. The quantified agriculture land that is already under buried conditions would have generated income of Rs. 240 million per annum. The falling fertility of the soil with increasing sand content and lower yield are some of the facts which state that, the afforestation program has not brought a cent percent result to the farmers of the region.

Another major effect seen in the region is, the adjoining village next to Talakad called Kukkur village located 3 km from Talakad has become target of wind. Due to the constant onslaught of the wind this village has been half buried in sand and the village has been shifted to the next site 2 km away from the present site. As per the villagers for the past 2 decades the wind activity has intensified shifting sand. This occurred due to the non-implementation of afforestation program. If the afforestation program would have taken well in time as a precautionary measure the present situation could have been prevented. Since the village was situated close to the river bank, the afforestation could not be undertaken. Afforestation can be only done after the complete burial of the village and the plants can be raised on the deposited sand to prevent the further sand movement as it was done for Talakad.

The Desertification Process

The finest sand material has been carried by the wind for about 4- 6 km from the Talakad main sands deposits (Fig. 4). The accumulation of sand layers in Betur village surrounding has enhanced the sand composition in the soil, which has drastically reduced the fertility of the soil. The soil, which was good for agriculture, has now become unfit for crops to grow. Most of the land in this surrounding has become barren and it is in the process of arid condition leading to the desert formation. There is no doubt that, in near future the land will be turned into desert condition. The following are some of the consequences, which were evident, from the field.

The agriculture production has come down drastically from 12.5 lakh quintals to 7.5 quintals per annum.

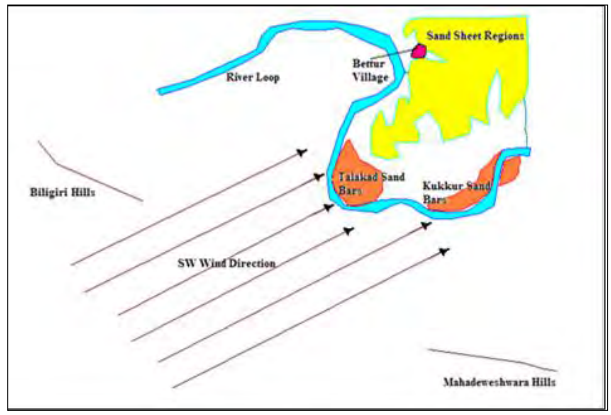

Fig. 4. Talakad River Meander Loop with Sand Bar, Sand Sheet Spread and Wind Direction

- Most of the cultivable land is transforming into shunted growth and thorny bushes, emerging into a xerophytic eco system.

- Few places behind Mallikarjuna hillock near Bettahalli village evidence noticeable layers of sand deposits and in some points, it is developed in sheets.

- Lag deposits are sporadic, representing the infancy of desertification process.

Results and Discussion

The above said desertification process could be controlled if afforestation program is taken up more judiciously as suggested below. Since, there is a strong SW Monsoon winds blowing from SW direction between Biligiri and Male Mahadeshwara Hill ranges it is foreseen that, the wind plays active role in carrying afloat the finest sand material to considerable distance putting a gap at the center. This can be seen in the satellite image (Fig. 1). To prevent the sand movement it is recommended that, the wind velocity should be checked in a step by step process. One of the methods that can be evolved is by adopting afforestation in a space sequential order with plants growing of different height is recommended at an interval of 2 km distance (Fig. 5)

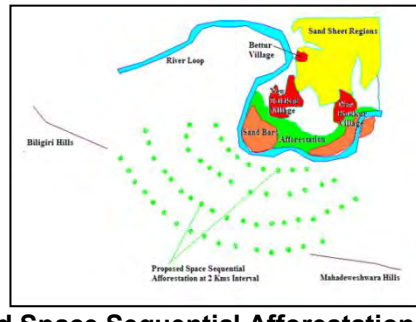

Fig. 5. The Proposed Space Sequential Afforestation Program for Every 2 km as a Wind Breaker to Prevent Desertification Process in Talakad Meander Loop

The plants, which grow to a height of 10 - 15 feet, would be better for afforestation at the site of wind gap. Steady increase in the height of the plants for every 2 km distance towards the point bar deposits, certainly curtail the wind velocity and act as a windbreaker. This stops the heaping sand and floatation of sand by wind up to Bettur Village zone. Thus, the desertification process can be checked. To reclaim the lost land and to bring back the fertility of the soil drip irrigation agriculture system is one of the best recommendations.

Conclusions

Concentrating only at the affected zone do not serve the purpose. Hence it is highly recommended that, afforestation can play a value-added role in disseminating its scope. Through the proposed program afforestation can also be perceived as a 'remote control tool' to check desertification process since the program is proposed to be implemented in a place where the actual problem does not exist.

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TREND ANALYSIS OF DECADAL CHANGE IN MINIMUM TEMPERATURE IN 20th CENTURY: CASE OF DELHI, INDIA

Atul Saini[1] and Subhash Anand[2]

[1] Department of Geography, Delhi School of Economics, University of Delhi, Delhi - 110 007
[2]Swami Sharaddhanand College, University of Delhi, Alipur, Delhi - 110 036
Email: sanandpv@yahoo.co.in, atulsainimail@gmail.com

Abstract

Delhi is the National Capital Territory with State assembly and one of the highly populated regions in India and the world. Changing weather in any region with such a dense population habitation is of very high concern to the policy makers. Temperature is an important parameter to judge the impact on the environment because the change in this parameter is the primary signal of disturbance in the local or regional environment. Using statistical techniques, the minimum temperature of the 20th century in Delhi is analysed at the decadal level. It is found that the minimum temperature in winter months has the highest variation, supported by Mann Kendall's test and Sen's slope values. Moreover, Monsoon season (June - Septembre) along with October month have observed declining minimum temperature at all temporal scales as discussed in the study.

Keywords: *Decadal, Temperature, Variation, Trend, Mann Kendall, Sen's slope*

Introduction

Delhi is located in Northern India and has continental geographical location (Figure 1). Based on Koppen's classification, it falls in Humid Subtropical (Cwa) and Semi-Arid (Bsh) climatic zones. Along with its geographical location and climatic zone, it is a city with more than 10 million population. Change in the core environmental conditions always makes a huge size of population vulnerable to the adversarial impact of the imbalance created.

Here in the present paper, it is studied the trend of minimum temperature in Delhi, which is the variant of temperature that is prone to climate change in almost all the climatic zones across the globe. The temperature in particular is perceived as always increasing by people but technically it is always more scientific to look into the variants of temperature i.e. mean temperature, minimum temperature and maximum temperature. In many previous studies, the minimum temperature is found to be very sensitive to the changing climate phenomena (Majra and Gur, 2009; Dash et al., 2007). Hence, minimum temperature is studied to find out the change in the trend at different temporal scale. Temporal scales selected for the study are monthly decadal, annual decadal and seasonal decadal.

Many climatic parameters are found on changing with the passage of time and in India minimum temperature kept on changing its pace at different points in the 20th century (Dash et al., 2007). Other than the studies at India level, comparative studies on urban areas reveal some interesting trend in temperature and rainfall (Rana et al., 2011 and Rao et al., 2004). One very interesting study reveals the decadal trend of climate parameters over India and used different variants of temperature along with rainfall and pressure level (Srivastava et al., 1992). In their study, Srivastava et al., 1992 found the decreasing temperature trend in the region lying north of tropic of cancer and the opposite trend in the southern region of tropic of cancer. In the surrounding arid and semi-arid regions of Delhi, studies reveal the declining trend of mean temperature and this trend is based on the period of 1901 to 1982 (Pant and Hingane, 1988). Apart from focussing on the trend, a study conducted by Pant and Hingane in 1988 attempted to find out the link between swiftly changing landuse / land cover and climatic parameters.

Heavy industrialisation and associated activities are always held responsible for air pollution in almost all the urban areas of the world. In a study, comparing the temperature in the industrial and non-industrial cities of India reveals that Delhi is the only city with the cooling trend of mean annual temperature among Chennai, Mumbai, Pune and Bangalore (Kumar and Hingane, 1988). Aerosols and greenhouse gases are always found responsible for the decreasing or increasing temperature respectively. Considering the very important stimulus at the micro and macro level atmospheric circulation, aerosols and greenhouse gases have been given due importance by the research community. Though it must be admitted that their role is only for a short period of time in the urban areas and with the change in seasons, their proliferation changes. Therefore, stability in the prevalence of aerosols and greenhouse gases at any spatial scale is the only point of concern, when talking about the change of climate due to these factors. With respect to the urban areas of India, Delhi has its own importance with its horizontal expansion at a very rapid pace. Therefore, some studies also found the urban heat island effect responsible for the changing trend of temperature in urban areas like Delhi (Mohan et al., 2011). The period spanning after 1950 has seen a lot of studies discussing the trend of temperature using station data of different station located in Delhi but a few discussed the decadal trend of minimum temperature in the 20th century. Here it is found that some important concepts mission in most of the similar studies discussed is the focus on the decadal trend of minimum temperature at monthly, seasonal and annual scale.

Database and Methodology

For the completion of the present study, the monthly minimum temperature data of Delhi from 1901 to 2000 has been utilised. The data is obtained from the India Meteorological Department (IMD) which is the averaged value of Delhi in spite of data related to different stations in Delhi. Based on the obtained data, the monthly, seasonal and annual trend is calculated for the fulfilment of the present work on the trend of minimum

temperature in Delhi. We examined the minimum temperature at decadal trend at monthly, seasonal and annual level for the study. The decadal trend at a monthly level simply means the average value calculated for each month for different decade e.g. one value for January month for the period 1901-1910. In the similar manner, the seasonal and annual decadal patterns are considered.

Fig. 1. Delhi - Study Area

The statistical techniques are also employed to find out the trend of minimum temperature in Delhi. Mann Kendall's test, Sen's slope and co-efficient of variability are calculated to examine the trend. Mann Kendall's test is a non-parametric trend test and is used to find out the monotonic positive or negative trend in the data series. Sen's slope is used to calculate the slope in the data if there any trend exists and its advantage is that it remains silent to the outliers. It is simply explained as the method to calculate the magnitude of the trend. Mann Kendall's test simply reveals about the increasing and decreasing trend but Sen's slope tells about the magnitude of increase or decrease. How much temperature has increased each year, decade, season or required time scale?

Moreover, Coefficient of variability is adopted to look into the dispersion in the data set at different time scales as discussed above. It is the ratio of the standard deviation to the mean.

$$CV = \frac{\sigma}{\mu}$$

where, CV is the Coefficient of Variation, σ represents standard deviation and μ is for the calculated mean.

Results and Discussion

The minimum temperature in Delhi kept on fluctuating and the average annual minimum temperature calculated for the period of 1901-2000 is 18.37°C. Linear trend as shown in Figure 2 which reveals that there exists a lot of variability in the average annual temperature. Based on the trend, it is classified into different phases i.e. 1901-1920 (high deviation), 1920-1955 (declining deviation), 1956-1988 (increasing deviation) and 1989 onwards (abrupt deviation). Here, the year 1955 is found to be the change point in the whole century. It is due to the initial gradual increase in deviation and its rapid pace after 1988.

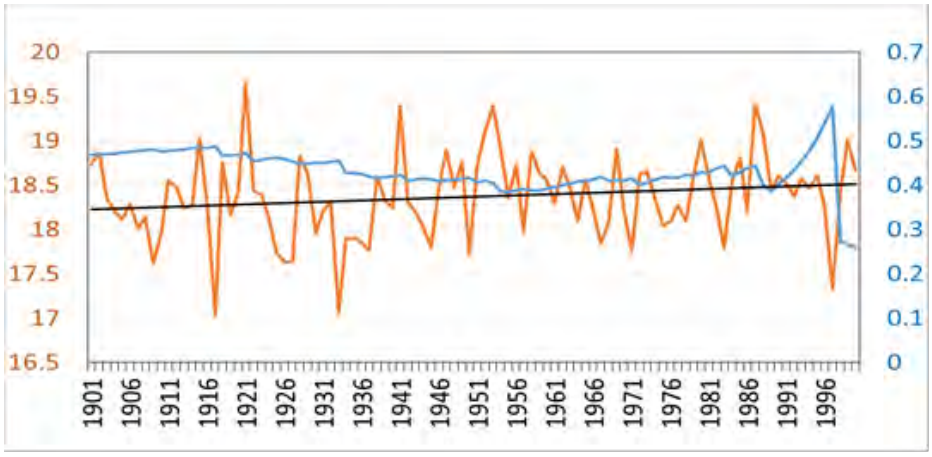

Fig. 2. Annual Average Trend of the Minimum Temperature in Delhi

(Y-axis in the graph represents the temperature value in degree celsius and X-axis is for the year. The orange color trend line is representing the series of the minimum temperature from 1901-2000. Figure is made by the author based on the data obtained from India Meteorological Department. The blue solid line is the calculated annual standard deviation)

Inter-annual variability is also one of the reason in many years having high average annual variability but it is not the part of the current study. In many previous research studies, it is found that prevailing temperature deviation from the mean is dependent on the sea surface temperature in the Indo-Pacific region which plays a very significant role in deciding the minimum and maximum temperature in India.

Mann Kendall's Test

The test has shown the increasing trend of minimum temperature significant at 95 percent interval in all the months except June, July, August, September and October. This is a very important point to be noted here that in the months when the majority of the annual rainfall takes place, the minimum temperature is exceptionally following the declining trend (Figure 3 and Figure 4).

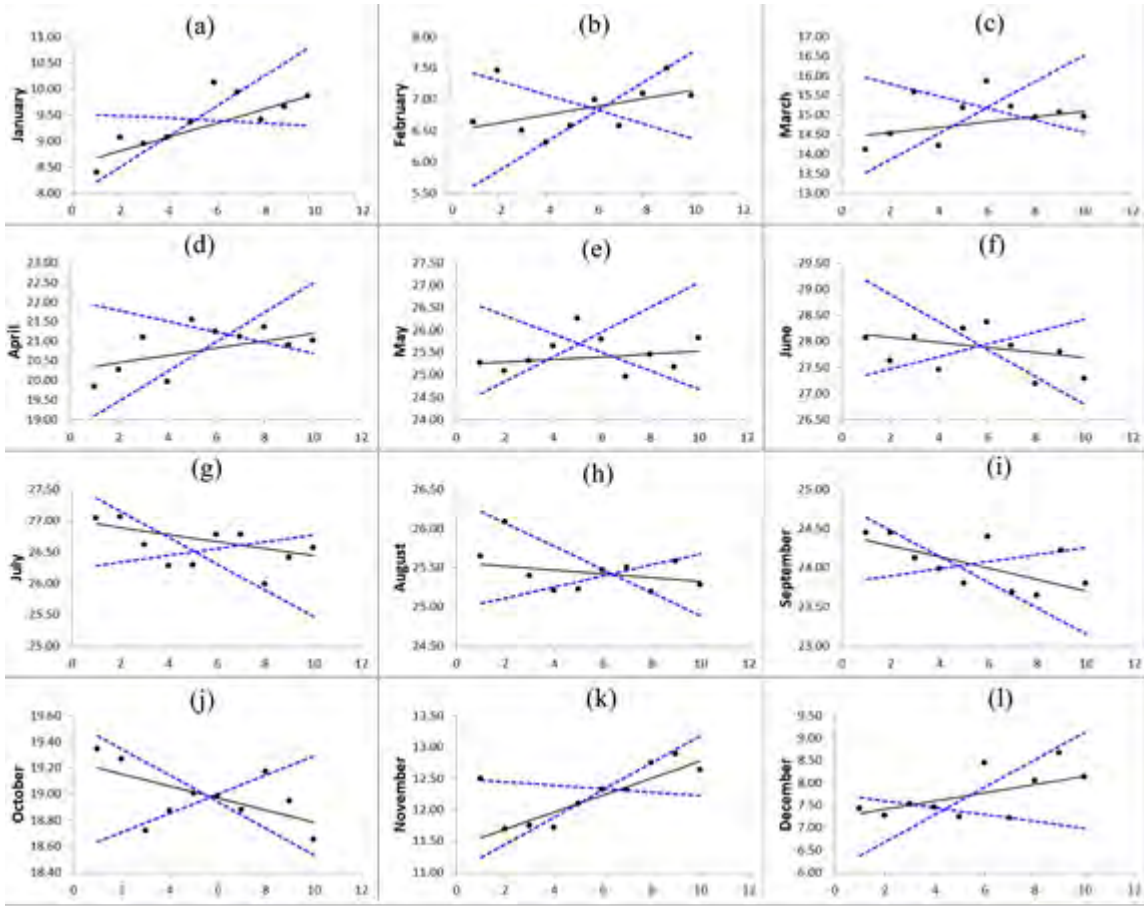

Fig. 3. Monthly Teperature Variations

(*Decadal monthly values where* ***s****cattered dots are the value of Mann Kendall's test and black solid line represent the Sen's slope. Blue dash lines are the 95% maximum and 95% minimum interval of the Mann Kendall's test. The X-axis has the number of a decade starting from 1901-1910 as 1 to 1991-2000 as 10. Figure is made by the author based on the statistical calculation done by author based on the data obtained from India Meteorological Department)*

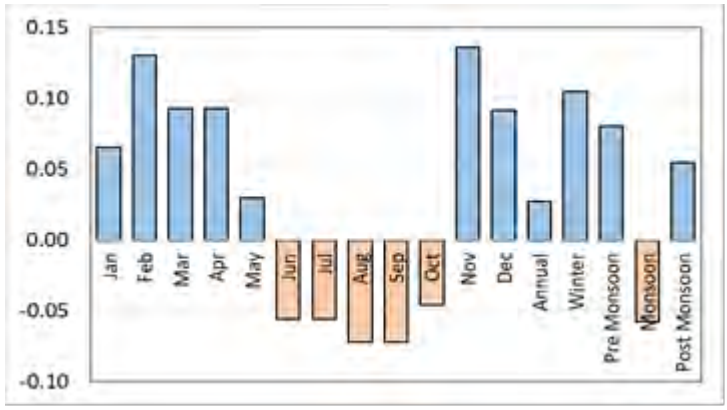

Fig. 4. Sen's Slope Value at Different Time Scales

(The blue bar is for the positive value of slope and red bar are for negative slope value. Figure is made by the author based on the statistical calculation done by author based on the data obtained from India Meteorological Department)

Abruptly high increase in the minimum temperature after the post-monsoon period is one another peculiar thing found in the trend. Among all the seasons, winter is the season with highest Sen's slope value indicating towards the high warming in Delhi during this season. Within the Monsoon season, August and September month have shown the highest decline in the minimum monthly temperature (Figure 3, 4 and 5).

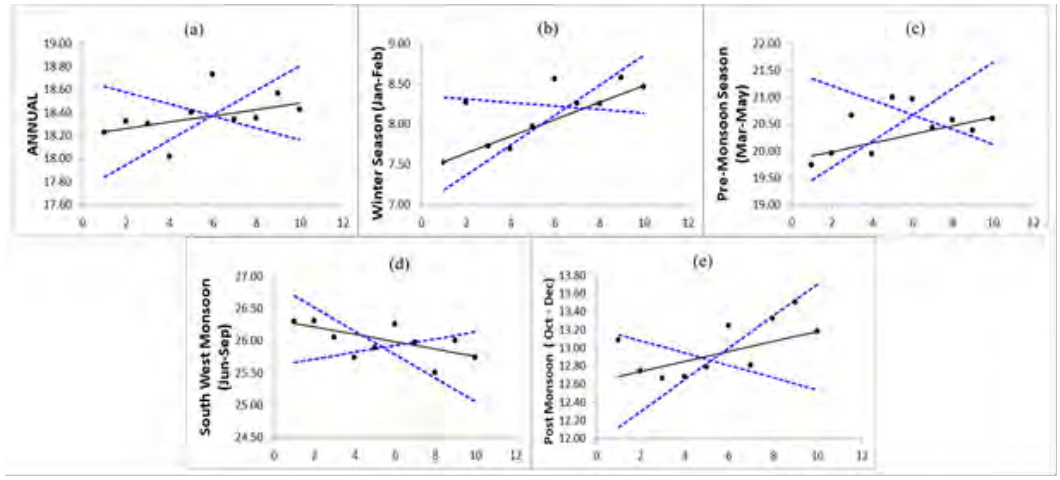

Fig. 5. Decadal Annual and Seasonal Temperature

(The value of Mann Kendall's test and black solid line represent the Sen's slope. Blue dash lines are the 95% maximum and 95% minimum interval of the Mann Kendall's

test. The X-axis has the number of a decade starting from 1901-1910 as 1 to 1991-2000 as 10. Figure is made by the author based on the statistical calculation done by author based on the data obtained from India Meteorological Department)

In the majority of months, sixth and fifth decade i.e. 1951-1960 and 1941-1950 respectively has proved to be the decade confirm change into the new positive or negative growth. All the seasons also followed the same trend of change point in a sixth or fifth decade except the notable change point coming in the seventh decade (1961-1970) for the winter month (Figure 5). But moving towards the decadal annual trend of the minimum temperature clear the picture as showing the increasing minimum temperature trend. Annual trend generalises the picture of the trend and therefore for focussing and extracting the trend of minimum temperature smaller scale of time is considered.

Coefficient of Variation

Calculated coefficient of variation at decadal monthly scale shows the high variation in the months of December, January and February. Decadal monthly here mean is calculated by taking into consideration the monthly values at decade level. Hence, 10 values for each month of all the ten decades. Among the three months (December-February), the highest variation exists in January (Table 1).

Table 1. Monthly Variation Temperature Calculated, 1901-2000

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean	6.87	9.39	14.97	20.86	25.48	27.78	26.59	25.48	24.04	18.99	12.29	7.76
SD	1.02	1.23	1.327	1.48	1.47	1.22	1.16	0.85	0.88	0.88	0.97	0.96
CV	14.89	13.09	8.86	7.09	5.75	4.39	4.36	3.32	3.67	4.64	7.86	12.39

On the basis of the previous discussion based on Mann Kendall's test value, it can be said that winter season is highly vulnerable with respect to the minimum temperature as all the strong signals of change are very clear in this season. Highest inter decadal seasonal variation also shows the highest variation in winter season with 4.656 coefficient of variation, which is almost double the value of other seasons of the year (Table 2).

Table 2. Seasonal Variation in Temperature calculated for the period 1901-2000

Season	Winter	Pre-monsoon	Southwest Monsoon	Post-monsoon
Mean	8.13	20.42	25.98	13.00
SD	0.38	0.43	0.27	0.30
CV	4.66	2.11	1.03	2.33

The inter-decadal monthly variation shows the comparatively high variation in December, January, and February. Among all these three months, December month has the highest level of variation (Table 3).

Table 3. Inter-decadal Monthly Variation in Temperature, 1901-2000

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean	6.873	9.382	14.960	20.834	25.475	27.803	26.579	25.458	24.054	18.983	12.266	7.741
SD	0.411	0.525	0.556	0.597	0.403	0.404	0.345	0.272	0.315	0.224	0.441	0.535
CV	5.976	5.598	3.715	2.865	1.581	1.452	1.298	1.068	1.310	1.182	3.594	6.907

Other than the highest variation trend, the time with high symmetry is also very important as a representative of the stability. At the monthly level, comparatively low-level symmetry is found in the month of August and September (3.32 and 3.67 respectively). The seasonal low-level variation is in monsoon season and it is about one fourth the variation in the winter season. Moreover, a similar trend of variation is found in the interdecadal monthly variation with the least variation in August month. Thus, as far as the variation is concerned, monsoon season and the months falling within it along with the inter-decadal monthly variation, variation is comparatively very less.

Conclusions

In the present study, it is found that the minimum temperature has started declining since the seventh decade (1961-1970). However, at a smaller scale of months, it is found to be in an increasing trend of mean monthly temperature in the period except for monsoon (June to September). The sixth and fifth decade has been identified as the decade with starting of confirming the change. The monsoon season, in particular, has observed the declining minimum temperature along with the lower value of the co-efficient of variation, which signifies the stability in the trend. Many previous research studies have also revealed that the minimum temperature is on continuous trend either positive or decreasing. The simple annual trend has shown 1901-1920 (high deviation), 1920-1955 (declining deviation), 1956-1988 (increasing deviation) and 1989 onwards (abrupt deviation). Here in the present study, it is suggested to prohibit the adoption of other variants of temperature and choosing Delhi as the region of study. Gradual but continuous increase in the minimum temperature in seasons other than June - October is a loud voice of danger. Similar studies in future for Delhi and other cities in India will provide a clear picture of how and why it happens. A lot of new in-depth research is required to find out the atmospheric circulation prevailing during the time or impact of some seasonal anthropogenic activity in the region.

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY

Department of Geography, University of Madras, Chennai - 600 005

Conduct of 4th Talent Test - 2014 for Geography Students on 20th January, 2014

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The Indian Geographical Society is organising the state wide **Fourth Talent Test - 2014** for final year UG and PG students of the Geography Departments in Tamil Nadu on **20th January, 2014**. The Executive Committee of the Society has identified the following coordinators to organise this event successfully with the support of Principals of the respective colleges and Heads of Geography Departments.

Regional Coordinators

1**. Dr. G. Bhaskaran (Chennai Region)**
Assistant Professor, Department of Geography, University of Madras,
Chennai - 600 005, ***Mobile****: 94444 14688,* ***E-mail****: grbhaskaran@gmail.com*

2. **Dr. K. Balasubramani (Rest of Tamil Nadu)**
Assistant Professor, Department of Geography, Bharathidasan University,
Tiruchirappalli - 620 024, ***Mobile****:99440 60319,* ***E-mail*****:** *geobalas@gmail.com*

Details of Awards and Prizes

Prize	Award and Prize Amount	
	UG The IGS Founder Prof. N. Subrahmanyam Award	PG Prof. A. Ramesh Award
I	Rs. 5,000/-	Rs. 7,000/-
II	Rs. 3,000/-	Rs. 5,000/-
III	Rs. 2,000/-	Rs. 3,000/-

Prizes will be awarded to the winners of Talent Tests during ***89th IGS Annual Conference*** to be held at Bharathidasan University, Tiruchirappalli on Saturday, the 25th January, 2014 at 3:00 p.m. All other participants will be given Certificate of Participation. Please visit IGS website for registration forms and further information: http://www.igschennai.org/

Dates to Remember

Last Date for the Enrolment: 10-01-2014 (Friday)

Date of the Talent Test: 20-01-2014 (Monday)

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I, K. Kumaraswamy, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Dr. K. Kumaraswamy
Editor, The Indian Geographical Journal