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VULNERABILITY IN THE AGRICULTURAL PRODUCTIVITY DUE TO CLIMATE VARIATION IN THE DISTRICT OF WARANGAL, TELANGANA

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Abstract

Agricultural Production in any part of the world is largely impacted by climate change. The range of temperatures and rainfall varying from daily to annual or seasonal impact, impact the moisture holding capacity of the soils, storehouse of minerals essential for the growth of the crops. The climatic impact becomes more crucial in a semiarid or semi humid eco-agricultural region, where the climate variabilities are drastic. Warangal being a District in erstwhile semi humid Telangana Plateau region of South India, an attempt is made in this paper to oversee the climate and agricultural production Correlation. The recently global climate change has to have its impact felt or the agricultural production in this part of country, which is being studied taking into consideration $2^1/_2$ decades Temperature and Rainfall Data. The rapid climate change in last 3-4 decades has resulted in frequent drought, low rainfall, unexpected monsoon and rising temperature. According to Indian Meteorological Department, the average temperature of the country has risen from 3°C to 4°C since last 3 decades. A rise of $1°C/Y_{avg}$ in average temperature of the country has an unanticipated impact on every regional climate of the country and so on the agricultural productivity. Howsoever the inter relationship of agricultural productivity and climate is very complex both in short and long run as it is also dependent on several other factors viz. assured water supply, human labor, soil fertility and fertilizers used, pesticides and insecticides used, quality of the seeds, moisture content of the soil, technique adopted for yielding etc.

Keywords: Agricultural geography, Agronomy, Agrarian economy, Climate change

Introduction

India is primarily an agrarian country and ranks 2nd in farm output across the globe. Almost 70% of its population lives in rural and also 49% of the human labor is engaged in agricultural activity. So the national economy gets highly affected by the agricultural productivity. Indian Agricultural Sector represents 13.7% [India in Business, Ministry of External Affairs (Released by Central Statistics Office-2014)] of its Gross Domestic Product (GDP) of the country. According to World Bank the average yield in India is generally 30% to 50% of the highest average yield in the world and its agriculture shares 16.11% of its

Gross Value Added (GVA) whereas the GDP is 17.1% till now. From a release of PCI on GDP Table analyzed by WB and CIA Fact Book, after independence the share of agricultural GDP in India has fallen from 51.88% to 17.1% till date but in actual 13.7% as announced by Central Statistics Office (2014). It is of course because of the opening and spread of wide range of other income sectors but still it can't be ignored that if the productivity will lessen at this rate then in the coming future the pressure of the demand of food will be more and the resources will be propelled to be over utilised or exploited. A very significant and terrifying threat is the climate change that we have to keep in mind and keep on controlling the impediments. Climate change regulates the crop combination, cropping pattern and has a firm control on cropping intensity within any defined agro-climatic zone and on a particular soil type. Also, it affects several other inputs viz. availability of surface water for irrigation, required soil moisture for the growth of plants, pests and insects including micro-organisms, Temperature, humidity and solar radiation required for plant growth, Controlling the carbon, nitrogen and oxygen contents in the atmosphere etc.

Database and Methodology

Primary data, collected from the field study, was compared with the secondary data, collected from Indian Meteorological Department (IMD), Mandal Revenue Offices (MRO), Directorate of Economics and Statistics and Directorate of Agriculture for a period of 25 years (1988-2012). IBM SPSS and MS Excel were used for correlating several climatic factors. Establishing a correlation between year wise annual rainfall and crop yielded in tons and the variance of year wise percentage deviation of the rainfall. The four mandals were found to be most affected by climate change in agricultural sector. Ordinary Least Square (OLS) model was used to link the GDP and the Prices of the agricultural products to estimate R^2 Values of the major crops selected.

Study Area

Out of the key contributing states to the GDP in terms of Agriculture in India, the state of Telangana is a significant one. It is divided into 4 climatic zones i.e. North Telangana Zone, Central Telangana Zone, High Altitude Zone and Southern Telangana Zone, Warangal District fall under two major zones i.e. Central Telangana and High Altitude zones. Spreading over an area of 12809.78 km^2 within the State, the District is extended from 17.32^{O}N to 18.60^{O}N latitude and 78.82^{O}E - 80.66^{O}E longitude. But all 4 selected mandals i.e. Jangaon, Maripeda, Mulug2 and Raghunathpalle, taken for the purpose of research fall within the Central Telangana Zone only (Fig-1).

Paddy, jowar, maize, pulses, sugarcane, cotton, turmeric, chillyes castor, and sunflower are the primary crops grown in Central Telangana Zone. This paper mainly focuses on the impact of climate change on the production of rice, jowar, maize and chilly in the four selected mandals of the District.

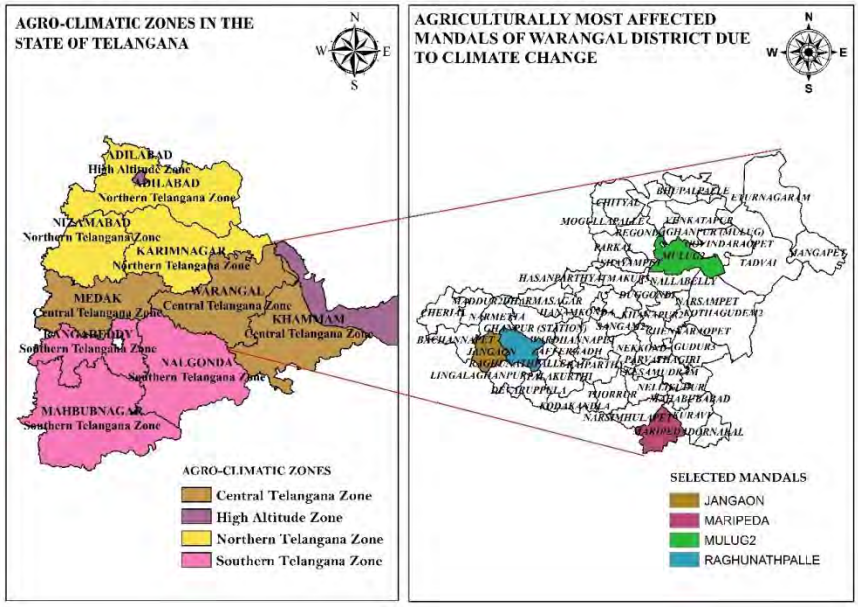


Fig.1. Selected Mandals of Warangal District

Results and Discussion

Climatological Study of the Study Area

Warangal District receives almost 1050mm of normal annual rainfall. Rainfall increases from the South-west to North-east region varying from 749mm to 1285mm during the peak period of the rainy season during the month of August and September. The South-west monsoon contributes the maximum percentage of rainfall that is nearly 80% of the annual total. Generally, the summer season of the District continues from March to end of June. During this season temperature range varies between 30°C and 42°C. Average temperature during this season is about 32°C. The winter continues from End-October to mid-February. During this season temperature range varies between 14°C and 28°C. Average temperature during this season is about 20°C. During Monsoon (from June to end of September) the weather remains hot and humid. Over all the climate of the District is Semi-arid.

The min-max temperature and rainfall in two seasons for the District were correlated for the analysis. A positive correlation was derived in case of maximum temperature and the rainfall in both the seasons whereas it was seen negative (-0.063) in case of min. avg. temperature and NE monsoon. So, the decrease of seasonal rainfall can be seen prominently by the increasing order of temperature. Table 1 below shows the clarity of the correlation between the temperature and the RF in two different monsoon seasons.

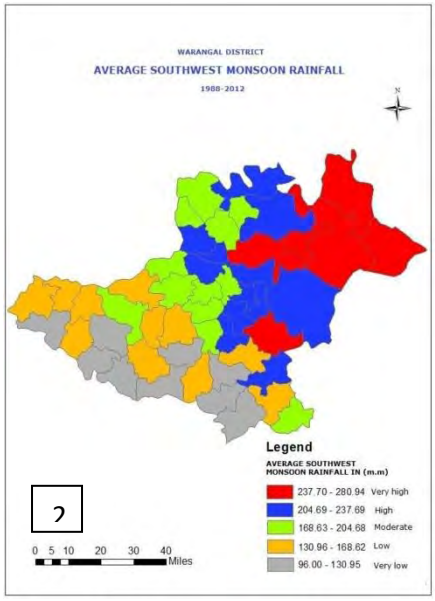
Table 1. Correlation between Temperature and Rainfall during SW and NE Monsoon in Warangal District

Seasons	Avg. Max. Temperature	Avg. Min Temperature
South-West Monsoon	0.168005	0.243598
North-East Monsoon	0.131053	-0.063210

In both the seasons most of the years were found getting below normal rainfall. The percentage deviation from the normal rainfall in the deficit years are listed below in the Table-2.

Table 2. Months with Actual Avg. RF below the normal RF (mm) in Warangal District for the period between 1988-2012

Months	Nos. of years below normal RF	Range of % Dev. From Normal RF for deficit years (Below Normal)	Normal RF
June	16	-82.3 to -5.2	137.2
July	18	-69.5 to -1.3	287.7
August	17	-62.2 to 3.6	238.3
September	12	-84.7 to -0.8	135.8
SWM	**15.75**	**11.7 to -6.1**	**199.75**
October	15	-90.7 to -5.9	86.5
November	18	-99.6 to -6.5	27.1
December	21	00.0 to -46.1	6.4
NEM	**18**	**19.6 to -12.9**	**40**



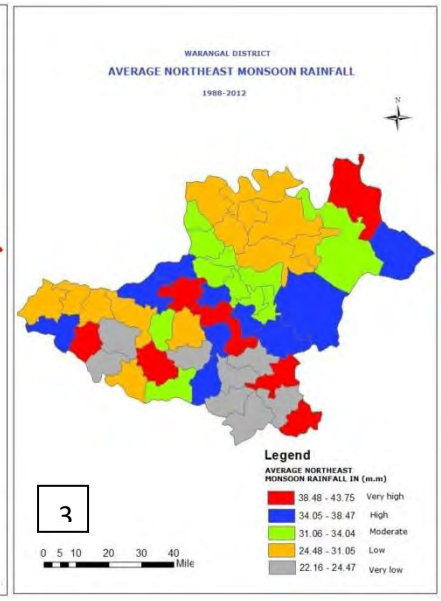


Fig. 2. Average Southwest Monsoon Rainfall
Fig. 3. Average Northeast Monsoon Rainfall

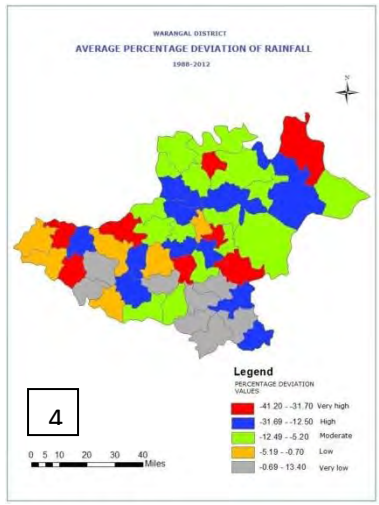


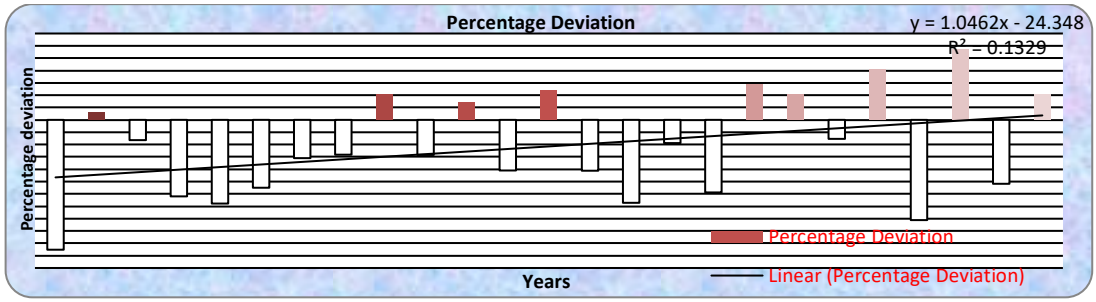
Fig. 4. Average Percentage Deviation of Rainfall

The distribution of SWM RF., over a period of 25 years can be seen in the Fig-2. It is very clearly seen that the higher RF was recorded in the northeastern region of the District covering the mandals Atmakur, Bhupalpalle, Eturunagaram, Govindaraopet, Gudur, Khanapur, Kothagudem, Mahbubabad, Mangapet, Mulug2, Nallaballi, Narsampet, Parkal, Shyampet, Tadvai and Venkatapur. But the RF had been observed to be decreasing gradually or can be said as lower SWM RF was recorded in the southern and south-eastern region of the District. Mandals such as Chityal, Dornakal, Ghanpur, Hanmakonda, Hasanparthy, Mogulapalle and Regonda were observed as having moderate RF. The distribution pattern of the SWM RF was in a decreasing order from the North-west towards south-east part within the District.

The distribution of NEM RF was mapped in the Fig-3. Where, it can be seen that the central and the eastern mandals of the District such as Atmakur, Bachannapet, Dornakal, Hanmakonda, Hasanparthi, Jangaon, Mangapet, Nallaballi, Palakurthy, Sangam and Throur had very high and high RF during NEM. Mandals like Chityal, Ghanpur, Mogulapalle, Parkal, Regonda and Venkatapur in the northwestern region and few mandals such as Cherial and Maddur etc… in the western part of the District were having very low RF during NEM RF over a period of 25 years. Rest of the mandals were recorded as having moderate to low RF during the span of the research.

After studying the RF distribution in two seasons within the District for a period of 25 years, the average percentage deviation was calculated and drawn in the Fig-4. It shows that the percentage deviation was very high and high in the mandals viz. Chemmanaraopet, Dharmasagar, Dornakal, Eturunagaram, Ghanpur, Gudur, Jangaon, Maddur, Mahabubabad, Mulug2, Narmetta,Parkal, Sangam, Shyampet and Tadvai. Whereas in the southern and southeastern part of the District the percentage deviation was recorded to be low and very low. Rest of the mandals were recorded as moderate percentage deviation of Rainfall (RF).

Graph 1. Percentage Deviation of Annual Rainfall from Normal Rainfall for a Period of 25 Years



The percentage Deviation of Annual Average RF from the normal RF for a period of 25 years ranging from 1988 to 2012 has been drawn on the above Graph-1. Very high negative deviation (-62 & -41) were seen in the year of 1988 and 2009 respectively. It indicates the scarce RF in those years. In another eight years were also found to be deviated highly negative from the normal RF ranging from -20 to -34. A continuous negative deviation was seen from the year 1990 to 1995 and 2001 to 2004. This indicated a continuous low rainfall in the consecutive years. Also this level of negative deviation indicates the lower RF in the District. In the years 1989, 1998 and 2012 the deviation was observed a little positive. But in the years 1996, 2000, 2005-06, 2008, 2010 and 2012 the deviation was more positive. Therefore, it can be interpreted as in these years the District got an increased RF than the normal RF. As a whole, the District got low RF for 16 years and a slightly increased RF for 9 years. It can be attributed as the RF was decreasing gradually.

Impact of Climate Change on Cropping

Warangal District is comprised of 51 mandals. Out of them the four selected mandals taken as AOI, fall within the Central Telangana Agro-Climatic Zone. As already discussed that this zone has semi-arid climate, the annual average rainfall ranges between 74.9cm to 128.5cm within the study area. After studying the climate condition of the District in detail, four mandals were selected for the case study. The annual rainfall, Co-efficient of Variance (CoV), percentage deviation and R_2 values for these four selected mandals are presented below in Table 3.

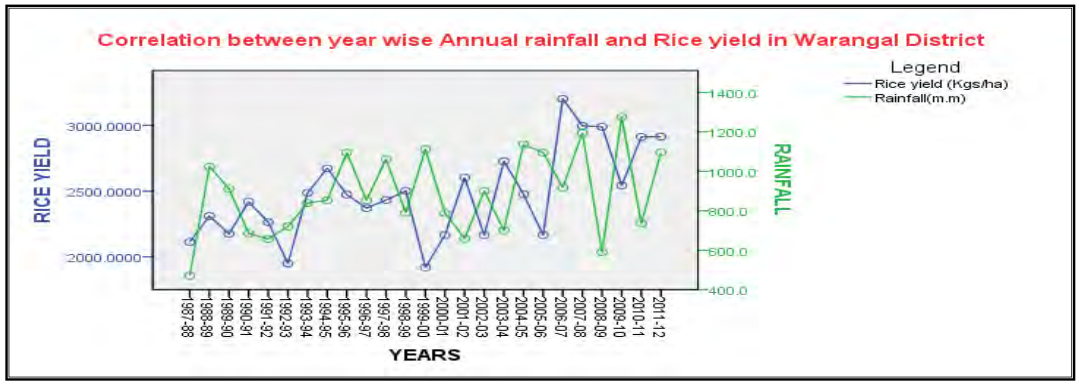
Table 3. Mandals Chosen for Detailed Analysis in Warangal District

Sl. No.	Mandals	Annual Rainfall	Normal Rainfall	CoV	Percentage Deviation	R^2 Values
	Central Telangana Zone					
1	Jangaon	850.0	815.6	24.47	4.2	0.00
2	Maripeda	550.4	824.6	79.16	-33.3	0.42
3	Mulug2	1206.1	1217.9	23.77	-1.0	0.01
4	Raghunathpalle	543.5	828.8	81.46	-34.4	0.54

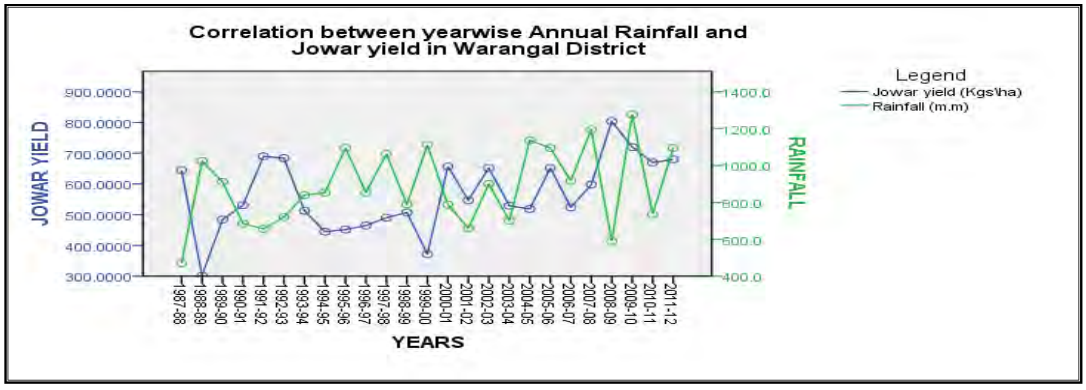
Observing the maximum and minimum on the co-efficient of variance values the two mandals (Maripeda & Raghunathpalle) showing high CoV and the two mandals (Jangaon & Mulug2) showing lowest CoV were selected for the purpose of research in this case study. Low rainfall implies higher CoV (Raghunathpalle - 81.46 & Maripeda - 79.16) where the corresponding rainfall was 543.5mm and 550.4mm, whereas a high rainfall implies the lower CoV (Mulug2 – 23.77 & Jangaon – 24.47) with corresponding rainfall as 1206.1mm and 850.0mm. The R^2 value ranges from 0.00 to 0.54 in case of the study area over a period of 25 years of study.

The major crops grown within the selected mandals are rice, jowar, maize and chilly. Graph-2 to Graph-5 shows the correlation between the year wise annual RF and 4 major crops yielded in the District.

Graph 2. Correlation between Annual Rainfall and Rice Yield in Warangal District

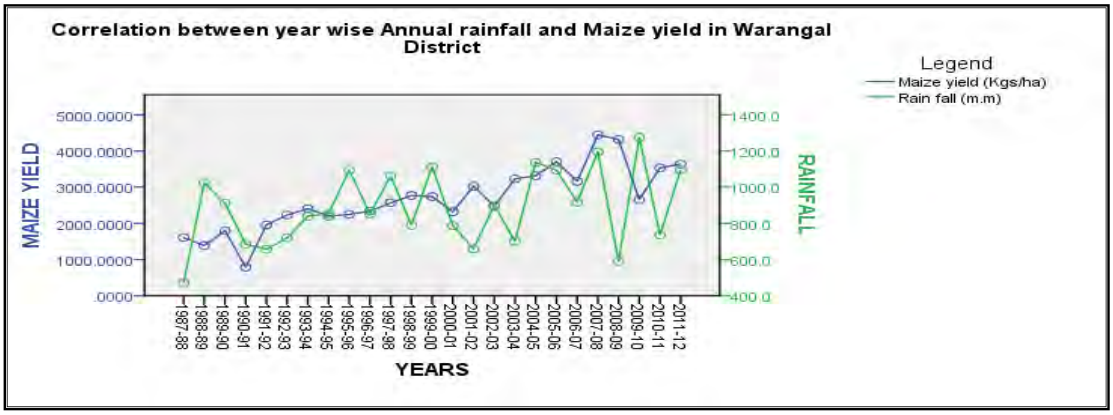


Graph 3. Correlation between Annual Rainfall and Jowar Yield in Warangal District

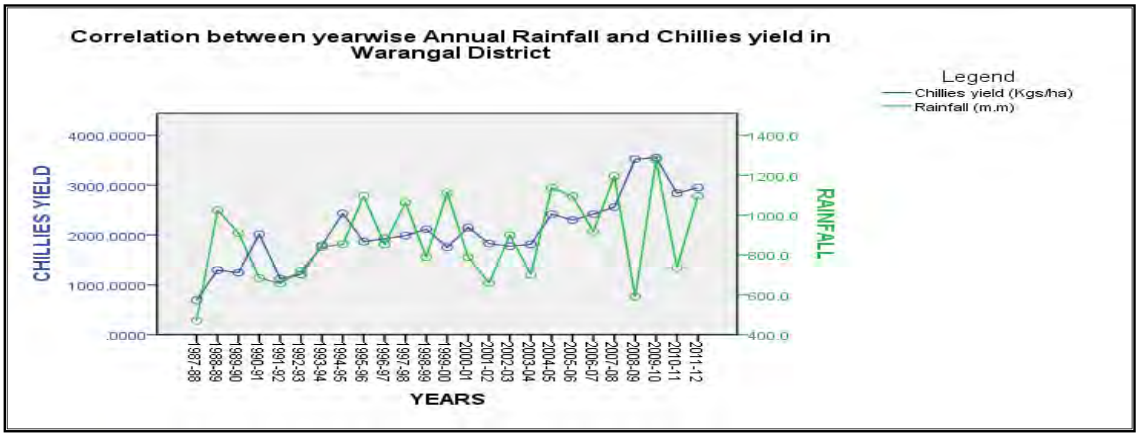


From the Graph-2 it can be seen that from the year 1988-1998 there was a direct relationship between the productions of paddy with the annual RF. But from 1999 to 2012 there was an inverse relationship with the annual RF. Whereas from the Graph-1 one could say that from 1988-99 and 2001-04 there was a scarcity of RF but from 2005 the RF became dynamic.

Graph 4. Correlation between Annual Rainfall and Maize Yield in Warangal District



Graph 5. Correlation between Annual Rainfall and Chilli Yield in Warangal District



Similarly, just opposite to this relationship, in case of jowar it can be seen the Graph-3 that there was a negative relationship between the annual RF and the production from 1088-98 rather it was positive from 1999 onward.

So it is clear that the RF had less effect on paddy yielding during 1988-98 as people were more dependent on groundwater irrigation. As the RF became dynamic during the last 15 years because of inadequate weather change and other factors like supply of fertilisers, pesticides and rise in temperature had affected the productivity mostly and vice-versa for jowar production.

The Graph 4 and Graph 5 shows that the yielding of maize and chilly had a perfect positive relationship with the annual RF. With the increase of annual RF, the production increased and a fall in annual RF decreased the productivity. Only a slight deviation was found from 2008-12 in case of chilly. It can be easily understood that although the agricultural productivity is highly sensitive and vulnerable to the variation of meteorological factors, but all other aspects of stabilizing the productivity cannot be ignored.

After the above analysis of the impact of climate variation on crop yielding, the influence of this variation in production on GDP was correlated with the price. Using Ordinary Least Square Model (OLS) the effects of climate variables on agricultural GDP was evaluated. The R^2 values and its importance were analysed for two data sets (1) Prices, rainfall and agricultural productivity, (2) GDP, prices and productivity using OLS model. The findings are shown in the table below (Table-4).

Table 4. Findings of Fitted Models through Ordinary Least Square Method, Warangal District

Commodities	Prices, Rainfall, Production			GDP, Prices, Rainfall Production	
	Observations	Multiple R	R^2	Multiple R	R^2
Rice	25	0.629	0.395	0.867	0.752
Jowar	25	0.526	0.277	0.904	0.816
Maize	25	0.802	0.643	0.918	0.843
Chilly	25	0.724	0.524	0.873	0.763

The table depicts that the R^2 values without GDP varied from 0.643 to 0.277 for the four crops whereas when the GDP values are considered the R^2 values varied from 0.752 to 0.843. It is concluded that both production and agricultural GDP are affected to a great extent by climate variation in the District.

Conclusions

Weather and climate strongly influence agricultural productivity. To high degree farmers who adapt to the local climate in the form of established infrastructure; local farming practice and experience derived from individual practice climate change can therefore create an impact on agricultural productivity sometimes threatening established aspects of farming system but also providing opportunities for improvements. The study clearly indicates that rainfall in Telangana is highly variable, further the agricultural systems within the state are affected by variability in rainfall because agriculture in the state is largely dependent on rainfall.

This study was conducted in Warangal District of Telangana state, to understand the impact of climate change on agriculture and its effect on productivity was analysed by taking climate data for a period of 25 years. It is found that there was not much deviation in the maximum and minimum temperature in all the selected Mandals of the District during the period. The Co–efficient of Variance (CoV) for the 59 Mandals of the Districts were calculated, the highest and lowest CoV values were taken in selecting the Mandals for a detailed study. The selected Mandals are Maripeda, Raghunathpalle, Jangoan and Mulug2. Further a regression coefficient is computed for the four major crops of the District. The major crops taken are rice, jowar, maize and chillies. At the District level, all the crops have shown above 60% R_2 values, from which we can infer that all the climatic parameters have a positive impact on the crop yield. The study shows that significant changes have occurred in the rainfall patterns and this has also had its impact on the productivity of crops like paddy, chillies, jowar and maize in the study area. The study concludes that the impact

of climate variability on crop productivity and in turn on the GDP is significant in case of maize, chilly and paddy in the Warangal District of Telangana it is also concluded from the study that the negative results need to be addressed on a priority basis and if the current trend continues climate change would have significant adverse effects on crop productivity.

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HYDROGEOMORPHOLOGY, GROUNDWATER LEVEL VARIATIONS, FLUCTUATIONS, RECHARGE AND POTENTIAL OF ANANTAPURAMAM DISTRICT USING REMOTE SENSING DATA

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Abstract

The Anantapuramam District covering an area of about 19,125 km^2 has been studied using IRS-1B geo-coded data on scale 1:50,000 with a view to delineate the landforms and hydrogeomorphic units. Hydrogeomorphologically the fluvial plains possess very good groundwater resources followed by wash plains (good groundwater resources), valley fills (very fair groundwater resources), black soil plains (fair groundwater resources), pediplains (poor groundwater resources) and pediment inselberg complex (very poor groundwater resources).The data pertaining to monthly groundwater level variations has been collected from 100 controlled wells for about 10 years. The groundwater levels are analysed to study the groundwater level variations and groundwater level fluctuations. From the analysis it is found that the shallow groundwater levels exceeded 10 metres below the ground level. Geologically the major part of the Anantapuramam District is comprised of unclassified granitic gneisses. The northeastern part of Anantapuramam District is comprised of Proterozoic formations consisting of shales, limestone, dolomite and quartzite. In the hard rock terrain the groundwater is found in weathered, fissured, fractured and faulted zones. The groundwater recharge is worked out using rainfall recharge method and specific yield method. The average annual recharge of the Anantapuramam District is about 70 mm of the total annual rainfall. The total groundwater resources of the Anantapuramam District are about 133,875,000 m3 which accounts to 12.75% of the total surface water resources (10,518, 750,000 m^3). In the present study an attempt is made to describe the groundwater level variations, fluctuations, recharge and potential of the Anantapuramam District using remote sensing data.

Keywords: Groundwater resources, Weathered, Fissured, Fractured, Faulted

Introduction

Hydrogeomorphlogy deals with the study of groundwater potential in different landforms based on porosity, permeability, transmissivity, and seepage of water from tanks, river beds and return flow from ayacut areas. Hydrogeology deals with the hydrogeological

characteristics of different geological formation present in the sub-surface. The hydrogeological characteristics are porosity, permeability, transmissivity, hydrolic conductivity, specific yield, effective porosity, coefficient of storage and storativity.

The major landforms of the Anantapuramam District are denudational hills in Archean rocks, schistose formation, quartzite formations, residual hills with inselberg complex pediments, pediplains, fluvial plains and sand dune encroachment in patches. As the District is located in rain shadow zone the pediplains are predominant and covers an area of about 60% of the landforms. The valley fills are noticed pediplains of the District. The black soil plains are noticed in north western and northeastern parts of the District. The major part of the District is covered with red sandy soils, which are derived from unclassified granitic gneisses. The fluvial plains are found in the river valleys of Hagari and Pennar. The fluvial plains are bordered by wash plains and creep built plains. The sand dune migration is found along the Hagari river around Kanekal and north of Kanekal in about 22 villages and in small patches along Pennar river.

The valley fills and irrigated pediplains, creep built plains, wash plains and black soil plains are subjected to processes of alkalisation and salinisation. The analysis of the field samples revealed that the pH value is more than 8 in alkaline soils. The saline soil contains an excess of sodium salts. They contain usually fluorides, sulphates, bicarbonates and sometimes nitrates of sodium. The exchangeable sodium percentage is very low. The pH varied 7.5 to 8.5 in saline soils remain in a flocculated condition and it is permeable to water and air.

The process of desertification has been initiated in the Anantapuramam District by way of high intensity of soil erosion, alkalization, salinization of irrigated black soil plains and encroachment of sand dunes in around Kanekal area in about 22 villages and in small patches along Pennar river. There seems to be signs of desertification in the Anantapuramam District. Therefore, the District has to be protected from the desertification process by diverting the water resources from Tungabhadra river and arresting the process of alkalisation, salinisation, erosion and sand dune encroachment.

Study Area

The Anantapuramam District covers an area of about 19125 km^2 and it is geographically located in southwestern part of Andhra Pradesh. It lies in between 13^0-40' to 15^0-15' Northern latitudes and 76^0-50' to 78^0-30' Eastern longitudes. It consists of five major revenue divisions and 63 mandals. It receives an average annual rainfall of about 558 mm. Climatologically it is located in dry sub humid type of climate (Fig.1).

The main objectives of the study are to describe the geology of the Anantapuramam District, to delineate hydrogeomorphic units and to study the hydrogeological conditions.

Fig.1. Anantapuram Mandal

Database and Methodology

- The geology of the region has also been mapped from Remote Sensing data
- The hydrogeomorphic units are mapped using IRS – I B geo-coded data and Survey of India topography sheets on scale 1: 50,000 along with the data pertaining to groundwater level variations, fluctuations recharge and potential.
- The hydrogeological conditions of the Anantapuramam District has been studied with the aid of porosity, permeability, specific conductivity, transmissibility and groundwater yield.

Groundwater Level Variations

During winter period the average groundwater level varies from 5 to 17 metres. The average groundwater level is about 8.56 metres. In summer period the groundwater level ranges from 3 to19 metres. The average groundwater level of the District is 9.0 metres. During southwest monsoon period the groundwater level varies from 4 to 19 metres and the average is 9.12metres. In northeast monsoon period the groundwater level ranges from 3 to 21 metres and the average is 8.60metres. From the analysis of groundwater level variations it is found that during winter period the groundwater levels are low followed by northeastern monsoon period and summer period. In southwest monsoon period the average groundwater levels are above 9 metres. The annual average groundwater level varies 4 to 17 metres and the average annual groundwater level of the District 8.76 metres.

Annual Recharge of the Anantapuram District

The annual recharge worked out according to Seghal's (1970) method is 151.384 mm, Krishna Rao (1970) method is 30.692mm, Radhakrishna (1974) method is 55.307 mm and USGS (1985) method is 82.923mm. The average annual recharge value of the four methods is 80.230 mm. This accounts to 14.69% of the average annual rainfall of the Anantapuramamu District (Table.1).

Surface Water Resources and Water Balance of the Anantapuram District

The total surface water resource of the Anantapuram District is 10,442 million m^3

Water Balance of The Anantapuram District

1. Total surface water resources 19125km^2× 546 mm=10,442 million m^3
2. Total surface water resources stored in ponds, lakes, tanks, reservoirs etc. 1042 million m^3 (10%)
3. Total surface water resources recharged to groundwater 1,533 million m^3 (14.69%)
4. Total surface water resources lost in the form of surface run-off 2,088 million m^3 (20%)
5. Total water resources lost in the form of evaporation and evapotranspiration 5,779 million m^3 (53.72%)

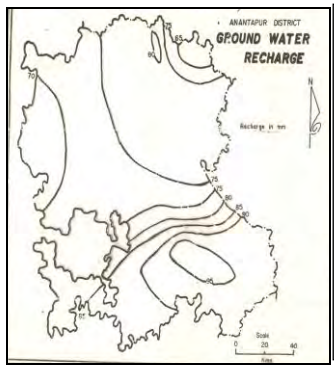
From the study of water balance it is found that out of 10,442 million m^3 of water availability about 10% is stored in ponds, lakes, tanks and reservoirs, 14.69% is recharged to groundwater, 20% is lost in the form of surface run-off and 55.31% is lost in the form of evaporation and evapotranspiration.

Table 1. Groundwater Recharge of Anantapuram District (in mm)

Sl.No	Station	Seghal Method	Krishna Rao Method	Radhakrishna Method	US Geological Method	Average
1	Anantapuram	145	28	54	81	77
2	Gooty	160	34	57	85	84
3	Bukkapatnam	181	43	61	92	95
4	Yadiki	114	18	49	73	64
5	Dharmavaram	140	25	53	79	74
6	Rayadurgam	122	20	50	75	67
7	Kadiri	183	43	62	92	95
8	Kalyanadurgam	132	23	52	77	71
9	Hindupur	168	37	58	88	88
10	Madakasira	163	35	57	86	85
11	Penukonda	173	39	59	89	90
12	Uravakonda	137	25	52	79	74
13	Tadipatri	150	29	55	82	79

Groundwater Potential

In Anantapuramamu District the maximum groundwater potential of 56 million m^3 is found in Beluguppa mandal and the minimum groundwater potential of 17 million m^3 is noticed in Agali mandal. The total groundwater potential of Anantapuramamu District is 1,553 million m^3 (Figure.3).



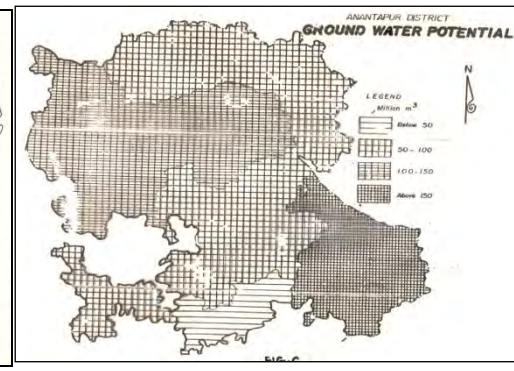


Fig. 2. Groundwater Recharge **Fig. 3. Groundwater Potential**

Hydrogeomorphology

Hydrogeomorphologically the fluvial plains possess very high groundwater resources because of high porosity, permeability, transmissibility and storativity. The good water resources found in ayacut areas are very good due to return flow from irrigated water the groundwater resources are good in valley fills and wash plains. The fair water resources are found in creepbuilt plains, piedmont plains, bajadas, and black soil plains. The poor water resources are found in pediments and pediplains. The run- off zones are hilly terrain, cuesta hills and pediment inselberg complex.

Hydrogeomorphologically the groundwater level variations range in depth from 3 to 5 metres in fluvial plains. The groundwater recharge is high and the specific yield is above 10%. The groundwater yield is very high. The groundwater in ayacut areas are very good due to high recharge. The groundwater level variations range from 6 to 10 metres. The specific yield varies from 5% to 8% and groundwater yield is high. The groundwater in wash plains and valley fills is also due to high recharge. The specific yield ranges from 6% to 9%. The groundwater in creep built plains, piedmont plains, bajadas and black soil plains are fair due to moderate recharge. The specific yield varies from 3% to 6%. The groundwater level variations range from 8 to 12 metres. The groundwater yield is moderate. The groundwater in pediments, pediment inselberg complex and pediplains is poor due to very low specific yield of less than 5%. The groundwater recharge is poor due to exposure of bed rock and poor soil formation. The groundwater is found in weathered, fissured, fractured and faulted zones of the pediplains because they are formed in hard rock terrain consisting of unclassified granites (Table 2).

Hydrogeology

Hydrogeologically the Anantapuram District is divided into six major hydrogeological formations. They are recent to sub recent alluvial formations Late Proterozoic hydrogeological formation consisting of Kurnool group and Middle Proterozoic formation consisting Kadapa super group. The Archean rocks consisting of un-classified granitic

genies. The Recent and Sub-recent alluvial is found in the river valley in semi-confined aquifer state. The permeability varies from 5 to 50 metre/day. The transmissibility ranges from 1200 to 1750 m^3/m/d. The groundwater yield ranges from 25,000 to 1, 00,000 lph/d. The Kurnool group consisting of Late Proterozic formations consists of quartzites, shales, limestone and conglomerate. The groundwater is found in weathered, jointed, faulted, fractured, caverns and bending plains. The permeability varies from 0.05 to 15 m/d. The transmissibility ranges from 50 to 270 m^3 /m/d. The groundwater yield varies from 3,000 to 8,000 lph/d. (Table 3)

Table 2. Hydro-Geomorphology in Anantapuram District

Sl.no	Landforms	Annual groundwater level variations in m	Annual groundwater level fluctuation in m	Specific yield and recharge	Hydro-geomorphic unit
1	Fluvial plains and deltaic plains	3-5	0.5-1.0	10% very high (72.40)	Excellent
2	Irrigated area other than fluvial, deltaic and coastal plains	4-6	0.75-1.50	85% good (52.92)	Good
3	Wash plains, creep built plains, valley fills pedimont plains and bajadas	4.5-6.5	1.0-1.50	5% fair (36.20)	Fair
4	Shallow weathered, moderately weathered and deeply weathered pediplains	5-8	1.5-2.0	3% poor (21.72)	poor
5	Slope zone of hilly terrain	-	-	-	Run-off zone

The Archean rocks consist of young intrusive rocks like basic dykes, pegmatite's, quartz and fine granites. The groundwater is found in weathered, jointed, fractured, fissured and faulted zones. The permeability ranges from 0.1 to 5 m/d. The transmissibility varies from 35 to 280 m^3 /m/d. The groundwater yield ranges from 4,500 to 10,000 lph. The Dharwar super group consists of chlorites, hornblends, schists and granulites. The groundwater is found in weathered, jointed, fractured, fissured and faulted zones. The permeability ranges from 0.1 to 10 m/d. The transmissibility varies from 65 to 410 m^3 /m/d. The groundwater yield ranges from 4,500 to 20,000 lph. In the peninsular gneisses complex the groundwater is found in weathered, jointed, fractured, fissured and faulted zones. The permeability ranges from 0.5 to 20 m/d. The transmissibility varies from 75 to 335 m^3 /m/d. The groundwater yield ranges from 6,000 to 30,000 lph. The old metamorphic rocks consists in the groundwater is found in weathered, jointed, fractures, fissured and faulted zones.

The permeability ranges from 0.1-10 m/d. The transmissibility varies from 55 to 300 m^3 /m/d. The groundwater yield ranges from 5,000 to 12,000 lph.

Table 3. Hydrogeology of Anantapuram District

Geological formation	Groundwater conditions	Transmissibility in m^3/d/m	Permeability m/day	Yield in 1ph
Recent and sub-recent	Groundwater is found in semi-confined and confined aquifers in the fluvial and deltaic plains	1200-1750	5-50	25,000-1,00,000
Proterozoic formations Kurnool Group, quartzite's (600-1100 million years ago) shales, limestone and conglomerate	Groundwater is found in weathered, jointed, caverns, bedding planes and fractures	50-270	0.05-15	3,000-8,000
Archeans young intrusive rocks (quartzites, basic dykes, dolerites, pegmatite quartz and fine granites)	Groundwater is found in weathered, jointed, fractures, faulted and fissured zones.	35-280	0.1-5	4,500-10,000
Dharwar Super Group (chlorites, hornblende, schists and granites)	Groundwater is found in weathered, jointed, fractures, faulted and fissured zones.	65-410	0.1-10	4,500-20,000
Peninsular gneisses complex	Groundwater is found in weathered, jointed, fractures, faulted and fissured zones.	75-335	0.5-20	6,000-30,000
Old metamorphic rocks	Groundwater is found in weathered, jointed, fractures, fissured and faulted zones.	35-300	0.1-10	5,000-12,000

Conclusions

Hydrogeomorphologically the fluvial plains possess good groundwater potential. In the pediplains and pediment inselberg complex the groundwater potential is poor. The Anantapuram District possess major part of the area Archean, granitic gneisses. The groundwater in these rocks is found in fissured, weathered, faulted and fractured zones. The average annual groundwater fluctuation over a period of 10 years revealed that the shallow groundwater level varies from 7 to 10 metres depth. The annual groundwater recharge is about 70 mm. Hydrogeologically the recent and sub-recent deposits in the fluvial plains the groundwater yield is high. The groundwater yield is low in Dharwar Super Group, granitic gneisses complex and old metamorphic rocks.

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BIOGAS PROSPERITY IN KOLHAPUR DISTRICT OF MAHARASHTRA

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Abstract

The present work attempts to make a specific study of spatial distribution of biogas in 12 talukas of Kolhapur District of Maharashtra, as the District is best in India in installation and use of biogas. The problems and prospects of biogas energy progress in this District are also discussed. It is observed through the study that one of the major factors of biogas development is how well the people are made aware about the benefits of schemes, biogas plants. Kolhapur District authority has done excellent, so they are the best in India in biogas implementation and received lot of accolades.

Keywords: Biogas, Distribution, Kolhapur, Bovine, Importance of biogas energy

Introduction

The need for energy is rapidly increasing due to explosive growth of world population and the per capita energy consumption for better quality of life. Today one of the major problems in developing countries is shortage of energy resources. Few other major problems are deforestation and the oscillating price of oil and gas along with paucity of fine technology for taping non-conventional energy resources. Moreover, a world which is on the rapid path of development has led to an increasing waste generating world. It has also posed a challenge with respect to not only treating and disposing the waste properly but also to see this as an opportunity to derive useful products from it. Today, people live in a world where solid waste is no more a waste, but a store house of precious non- conventional energy and other potential resources. This can be harvested for generation of energy without damaging the environment. One of the options is Biogas generation. Biogas energy is an essential requirement for improving the physical quality of life, and also for the socio-economic development of the rural people of the country. Biogas (methane generated from human and animal waste) is called as *Deep Green Gas* for its benefits in rural human ecology. It provides clean burning fuel for stoves and lamps instead of using wood or dung, which lose their soil building and fertilizing value when burned. Biogas yield more potent fertilizer than the original constituent waste like the dung. India has high potential of Biogas energy production but it is underutilised due to mostly lack of motivation and government support. But one

exception could be seen in Kolhapur District of Maharashtra where Biogas development section is very much enthusiastic about developing Biogas in the District and visibly they own this drive. That is the reason last three years they are ranking as first in the county in promoting Biogas energy.

Study Area

Location

Geographically, the study region, Kolhapur District is a western District of Maharashtra. The Maharashtra state covers 3, 07,713 sq. km of geographical area and situated between the N latitude 15° 40' and 22° 00' and E longitude 72° 30' and 80° 30'. Administratively, the state is divided into 35 Districts and 353 talukas. The Kolhapur District lies between 15°N and 17° N latitude and 73°E and 74° E longitude. It has an area of 7,746 sq. km and a population of 38,74,015 as per 2011 census. The District consists of 4 sub divisions and 12 talukas namely Karveer, Kagal, Panhala, Shahuwadi, Hatkalangale, Shirole, Radhanagri, Bhudargad, Gadhinglaj, Gaganbawda, Aajra and Chandgad. Population density of the District is 500.

Physiography

Kolhapur District is a part of the Deccan table land with an average height of 550 m above mean sea level, with Sahyadrian scarp forming the most prominent feature along the western border. Two distinct trends in the hill ranges are seen in the District. One runs roughly north-south, along the main range of the Western Ghats and the other one comprises the narrow broken crested ridges and flat topped masses stretching eastwards and merging gradually into the plains in the east.

Drainage and Soil

The drainage pattern of the plateau Kolhapur differs in several respects from that of the Konkan streams. It is, first of all, well developed, and geared to the base level of the Krishna which has mastered all the river courses of the District. Almost the whole of the western half of the Kolhapur District is covered by the basaltic Sahyadri ranges. The land gradually slopes towards the east into the Deccan plateau which is gently undulating with ridges and valleys. Due to these topographical features, the soils in the District vary from tract to tract, so much so that even in a single village, between different fields a variety of soils from rich- loam to poor thin murmad is met.

Climate

In Kolhapur District there is a rapid rise in temperature in March, reaching the maximum in April. April is the hottest month of the year, with mean maximum temperature of 37.1°C. December and January are the coldest months of the year. Some part of the District even witnesses the lowest temperature on individual day up to 7.2°C.

Temperature starts shooting up again from February month. The average annual rainfall in the Kolhapur District varies widely from about 510 mm in Kurundwad-Shirol area in the north-east to over 6100 mm in Gaganbavada area near Sahyadri in the west. About three-fourths of the District receives more than 1020 mm rainfall annually.

Forest

In Kolhapur District the forest area has a southward extension of the forest types of Pune and Satara Districts. Three main forests types can be distinctly located, viz., (1) the sub-tropical evergreen, (2) the moist deciduous and the semi-evergreen, and (3) the dry deciduous forests.

Population

As per the census 2011 the population, total population of Kolhapur is 38,74,015 with male 19,83,274 and female 18,90,741. In this District population density was 389 persons/ sq. km in 1991 which increased to 457 persons/ sq km in 2001, i.e. increase of 68 persons/ sq km. In 2011 population density of this District increased to 504, which is an increase of 47. As per 2003 bovine census, Kolhapur District has 1,275,390 bovine population.

The Biogas Plant

Biogas plants are run by using animal dung together with a few other organic matters namely kitchen waste, agricultural waste and night soil.

Biogas plant essentially consists of the following components:

1. A digester (or fermentation tank) to digest the feed (biodegradable) material.
2. A gas holder (storage tank) to store the gas generated.
3. Conveyance system to convey gas from the plant to the place of its utility.
4. Application like stove, lamps and other uses to burn the gas.

Biogas plant is a device for conversion of fermentable organic matter, in particular cattle dung, into combustible gas and fully matured organic manure. This is achieved by subjecting the material to anaerobic fermentation. In Biogas plant the whole system is based on continuous operation i.e. the matter to be fermented is fed in semi fluid form at one end and the fermented spent slurry (slurry left after fermentation) is extracted at the other end periodically, without disturbing the whole system.

The most important types of Biogas plant digesters are as follows:

- Fixed-dome plants (Example: Deenbandhu, Janta model)
- Floating dome plants (Example: KVIC model, Pragati model)
- Balloon plants
- Horizontal plants

- Earth-pit- plants
- Ferro cement plants

Among these, fixed-dome plants and the floating-drum plants are the most familiar types in India.

Biogas Development in Kolhapur District

The study of distribution of biogas energy shows a complex structure as there are various reasons associated with it. For a successful planning warrants a detailed study of existing situation to make well defined forward path. Thus, an analysis of the Biogas development and distribution in the most successful District of India at micro level contributes its own share in understanding the complex problem. The present investigation is one such attempt towards the understanding the prosperity of Biogas installation in Kolhapur District of Maharashtra and potential and issues of Biogas plant installations in rural and urban areas of this District.

Before 1982, there was no positive drive from the Government of India to motivate people to install Biogas plant and use renewable energy. Table 1 gives the statistics of Biogas plant installation year wise in the study area in Kolhapur District to understand year wise installation. In the year 1982-1983 it shows a very poor response to installation of Biogas plants in Kolhapur merely 0.15 % (of total Biogas plants installed in respective Districts till 2009-2010). It is evident from the Table 1 that initially the momentum of campaign for Biogas installation did not pick up at all and had a very slow beginning in the adoption of Biogas. In the very next year the District exhibited slightly better response with 0.67%. During the year 1983-1984 to 1988-1989 there was a rising trend in the installation of the Biogas plants from 0.67% to 7.34% in the year 1982-1983 to 1988-1989. The main reason for initial notable increase was very lucrative government schemes which attracted rural people very much resulting into the establishment of lot of Biogas plants. But during the period from 1989-1990 to 1994-1995, Kolhapur demonstrated general downward trend in installation of Biogas plants. Kolhapur District Biogas installation went down from 5.3% (which was less than previous year) in 1989-1990 to as low as 2.37% in 1994-95. It had reduced to all time low 1.50% in the year 1996-1997. Upon the interview of Biogas installation District coordinators and owners it is learnt that the main reason for this down fall was that by this time many of the Biogas digesters started malfunctioning and many of the people who installed it with full enthusiasm, abandon their plant because of very less to nil technical help to solve the problem of the plants from the government authority. People installed Biogas because of the monitory help from government in the form of subsidy but in many cases it was even wrongly designed without giving much thought on the available raw materials and required size. Thus, there was a negative feeling started growing in the District. The campaign for Biogas installation which was very encouraging initially started dying down. Another major reason for this downward trend was by this time use of LPG started increasing, which in turn made people less motivated for installing biogas.

Kolhapur District started showing improvement from 1997-1998 and in 1999-2000 it had 3.0% Biogas installation. However, it was not going up as it had few years back. It slipped to 1.86% only in 2003-2004. Kolhapur District made very encouraging recovery and achieved 6.05% in 2006-2007. In the nineth five year plan, government did an expanded, ambitious and aggressive Biogas and Biomass expansion plan. That also failed to encourage people of rural Maharashtra for Biogas installation. One major factor contribute to the success of Biogas implementation is making people aware through campaign from government authority/NGOs and timely support to the rural people in case of problem. Kolhapur District Biogas installation section of its Zilla Parishad office made a very strategic plan of campaign and follow up. Due to this only this District could manage to recover. In the last part of 2007-08 to 2008-09 Kolhapur has demonstrated tremendous improvement by increasing from 8.11% to 9.79%. In this period alone this District has installed 17.9% Biogas plants of total Biogas plants till 2009-2010. Kolhapur District could continue its successful journey as different NGOs also came forward to lend their helping hand in Biogas implementation along with Zilla Parishad office. Upon the interview with co-ordinator of Biogas projects and holder in Kolhapur District it is learnt that the effectiveness of campaign in the District is very pronounced and fruitful because of direct communication and contact.

Spatial Distribution of Biogas Plants in the Different Talukas of Kolhapur District.

Spatial density of Biogas plants favours the regional pattern, socio economic and cultural variations in the study area. Since, population participation, perception, motivation and adoption of Biogas energy in the rural parts of Kolhapur District largely associated with socio economic and cultural background of the people.

In an average, Kolhapur District has 11.21 Biogas plants per sq. km of geographical area. The Table 2 exhibits the density pattern of Biogas plants. The talukas of Kolhapur District reflects a wide variation in the development of Biogas plant. At the top it is the Karveer taluka which is located at the centre of Kolhapur District. It has 21.6 Biogas plants per sq km area. Followed by Gadhingalaj with 18.39 Biogas plants per sq km area followed by Panhala (14.43), Bhudargad (14.41), Ajara (14.04), Kagal (14.09) and Radhanagri (11.71) all of them are from central part of the District. Next in the series, Hatkangale (7.62), Shirol (6.23) which are located at the eastern side of the District and Chandgad (6.32) which is the southern most taluka. Two talukas which have lowest Biogas density installation are Sahuwadi (4.83) and Gaganbavada (4.12), are at the north-west side of the District at the border and has least population density 178 and 127 per sq km respectively, appears to be least developed area. Whereas Karveer has highest population density of 1,546 per sq km. This is the only urban area (includes Kolhapur city) in total study area where Biogas density is very impressive.

Table 1. Installation of Biogas Plants (in Percentage) in Kolhapur District

Year	Biogas Plant installed
1982-1983	0.15
1983-1984	0.67
1984-1985	2.48
1985-1986	4.70
1986-1987	3.64
1987-1988	4.83
1988-1989	7.34
1989-1990	5.34
1990-1991	4.94
1991-1992	3.81
1992-1993	4.85
1993-1994	2.62
1994-1995	2.37
1995-1996	1.51
1996-1997	1.50
1997-1998	2.52
1998-1999	2.67
1999-2000	3.00
2000-2001	2.33
2001-2002	2.64
2002-2003	2.53
2003-2004	1.86
2004-2005	1.90
2005-2006	3.04
2006-2007	6.05
2007-2008	8.11
2008-2009	9.79
2009-2010	2.83

(Source: ZP and Socio Economic Survey of Kolhapur District)

Definitely number of households is a major contributory factor in Biogas plant installation and prospect of renewable energy. The analysis of Biogas plant per 100 households is attempted in order to explain the ratio of households and Biogas plants in the different talukas of Kolhapur District, which is depicted in Table 3. On an average there are 9.64 Biogas plants per 100 households in the District. Distinct range of variation of Biogas density with respect to household population of this taluka can be observed. In descending order, at the top is Bhudargad (25.94), this taluka has hardly 4% of total household of the District, Aajara (25.67), Radhanagri (24.5) with 3% and 5% household of the total District respectively. All the three talukas are underdeveloped as household density is 54.7, 55.6 and only 47.8 respectively. Next 5 talukas, Gadhingalaj (16.47), Chandgad (15.63), Panhala), Kagal(13.02), Gaganbavada (13.0), whereas they have 6%, 4%, 6%, 7% and only 1% household respectively. Gaganbavada has minimum household density per sq km (31.7). In this District urban taluka Karveer with 26% household of the District and Biogas density of 6.32, Shirol with 7% household and

density of 5.34, Shahuwadi 4.35 with 13 % household and Hatkangale (2.71), in this taluka household is substantially high- 19 % and density is also 280.7 per sq. km which is second highest after Karveer. So it is getting established that in Kolhapur District Biogas development is more in less household areas. So it also can be inferred that high house hold population which indicates more developed area in most of the cases has less Biogas density, even if the potential is high. Normally more the households less the Biogas density because concentrated households are observed in urban areas and thus restrict the growth of Biogas development or other non-conventional energy sources.

Table 2. Biogas Density (No.of Biogas Plants/ sq km) Kolhapur

Talukas	Total Biogas Plants	Area in sq km Area	Biogas Plants / sq km
Karveer	14,497	671.13	21.60
Gadhingalaj	8,846	481.15	18.39
Panhala	8,208	568.8	14.43
Bhudargad	9,289	644.46	14.41
Kagal	7,714	547.54	14.09
Aajara	7,708	548.88	14.04
Radha Nagari	10,448	892.32	11.71
Hatkangale	4,642	609.4	7.62
Chandgad	6,099	965.42	6.32
Shirol	3,165	507.9	6.23
Shahuwadi	5,041	1,043.5	4.83
Gaganbavada	1,163	282.28	4.12
Total	86,820	7746	11.21

(Source: ZP and Socio Economic Survey of Kolhapur District)

Hypothetically, biogas, many a time called as Gobar Gas is very much dependent on the bovine population of any taluka. Average density of the Biogas plant in the Kolhapur District is 6.8 per 100 bovine population. Table 4 shows, out of 12 talukas of Kolhapur Aajara, an eastern taluka has highest (15.7) density of Biogas plants for every 100 bovine population, although the taluka has only 4% bovine population of the total District and least bovine density of 89 per sq km. So this taluka has used its potential at its best. Next in descending order is Bhudargad (14.7), an western taluka with 5% bovine population. Next is Radhanagari (10.6) with 8% bovine population of the District and bovine density of 110 per sq km respectively. Karveer constitutes 16% of bovine population of the District with highest density of bovine population of 298. But its Biogas plant installation is comparatively low, it is 7.2 per 100 bovine population. This taluka is followed by Chandgad (7.0), Panhala (6.8), Gadhingalaj (6.7), Kagal (6.7) with Bovine population of 7%, 10%, 10% and 9% respectively. Next is Gaganbavada (5.3) and Shahuwadi (4.8). In these talukas percentage of bovine population of the total District is only 2% and 8% respectively. Last two eastern side talukas have „Low" Biogas density with respect to 100 bovine population. They are

Hatkangale (2.8) and Shirol (2.7) with quite high 13% and 9% bovine population of the total District.

Table 3. Biogas Density (No. of Biogas Plants/ 100 Household), Kolhapur

Taluks	Total Biogas Plants	No of Household	Biogas Plant / 100 Household	% Household
Bhudargad	9289	3580	25.9	4
Aajara	7708	3003	25.6	3
Radha Nagari	1044	4264	24.5	5
Gadhingalaj	8846	5372	16.4	6
Chandgad	6099	3901	15.6	4
Panhala	8208	5585	14.6	6
Kagal	7714	5924	13.0	7
Gaganbavad	1163	8944	13.0	1
Karveer	1449	229495	6.32	2
Shirol	3165	5925	5.34	7
Shahuwadi	5041	115806	4.35	1
Hatkangale	4642	171077	2.71	1
Total	8682	900903	9.64	

(Source: ZP and Socio Economic Survey of Kolhapur District, Projected Figure of 2011 Household)

Table 4. Biogas Density (No. of Biogas Plants / 100 Bovine Population), Kolhapur

Talukas	Total Biogas Plants	Bovine Population	Biogas plant/ 100 Bovine Population	% Bovine Population
Aajara	7,708	49,1	1	4
Bhudargad	9,289	62,9	1	5
Radha Nagari	10,448	98,1	1	8
Karveer	14,497	2,00,188	7	16
Chandgad	6,099	86,9	7	7
Panhala	8,208	1,21,219	6	10
Gadhingalaj	8,846	1,31,108	6	10
Kagal	7,714	1,15534	6	9
Gaganbavada	1,163	21,9	5	2
Shahuwadi	5,041	1,04,293	4	8
Hatkangale	4,642	1,65,654	2	13
Shirol	3,165	1,18,227	2	9
Total	86,820	12,75,390	6	-

(Source: ZP and Socio Economic Survey of Kolhapur District)

Biogas density in terms of per 100 human population is tabulated for the talukas of Kolhapur District can be seen in Table 5. In descending order they are Ajara (6.4) with only 3% population, Bhudargad (6.2) with 4% population of the total District population, Radha Nagari (5.2) has 5% population, Next 6 talukas are-Gadhingalaj (3.9) with 6% population,

Chandgad (3.3) with 5% human population, Gaganbavada (3.3) with only 1% population, Panhala (3.2) with 7% population, Kagal (2.8) with 7% population and Shahuwadi (2.7) has 5% human population of the total District. All these talukas are located from north to south though out the District. Rest of the 3 talukas are Karveer (1.4) with mighty 27% human population and Shirol (0.8) with 10% human population Hatkangale (0.6) where as 21% is its share of population of the District have low density of biogas plants, these are located from central to eastern side, all three are adjacent talukas. These three talukas all together hold more than 50% population. So highly populated areas which are normally urban areas do not have high Biogas installation.

Table 5. Biogas Density (Number of Biogas Plants /100 Human Population), Kolhapur

Talukas	Total Biogas Plants	Human Population	Biogas Plants/100 Human Population	% Population
Aajara	7,70	1,20,124	6.4	3
Bhudargad	9,28	1,50,381	6.2	4
Radha Nagari	10,44	1,99,557	5.2	5
Gadhingalaj	8,84	2,25,633	3.9	6
Chandgad	6,09	1,87,278	3.3	5
Gaganbavada	1,16	35,777	3.3	1
Panhala	8,20	2,59,182	3.2	7
Kagal	7,71	2,74,880	2.8	7
Shahuwadi	5,04	1,85,290	2.7	5
Karveer	14,49	10,37,318	1.4	27
Shirol	3,16	3,91,112	0.8	10
Hatkangale	4,64	8,07,483	0.6	21
Total	86,82	38,74,015		

(Source: ZP and Provisional data of Census 2011)

So we can conclude from above analysis that:

1. Very High Biogas density with respect to Bovine population, households or human population in any of the Taluka does not mean that taluka has very high % of Bovine population or % of households or % of human population; in fact it is true in other way. Whenever Human population or household figures are high the Biogas density is low. For example: Karveer and Hatkangale talukas. In respect to area, this urban talukas have good Biogas installation but in respect to number of households, Bovine numbers or Human Population, Biogas installation is poor. So it can be concluded that in urban area Biogas development is not high because of easy availability of conventional energy, space constraint. In fact in rural areas of the District like Ajara, Bhudargad and Radha Nagri Biogas installation is more.

2. This fact revealed from the field survey interviews that Kolhapur District Zilla Parishad Biogas development section has done excellent job in creating awareness for installing biogas plant, hence the best in biogas implementation in all over India and got lots of rewards and recognitions.

Problems and Prospects of Biogas Production in Kolhapur District

Problems

Types of biogas plants in the study area are mostly KVIC model (floating dome) and Deenabandu model (fixed dome). From the field survey it is established success rate of Deenabandu is much higher. Problems associated with the implementation of biogas technology and the potential prospect for the development of biogas plants in the study area has been discussed as under:

Motivational Problems

In fact the first genuine question is “Is there sufficient motivation for small farmer to install a biogas plant?” Whether the person is interested to own the biogas plant? The amount of biogas used to cook the food is less than that of dung cakes. The main importance of biogas plant is as the source of fertilizer. The amount of fertilizer obtained from a 2 m3 per day in a year is equivalent to 109 kg of urea, 275 kg of super phosphate and 50 kg of potash. This can meet the fertiliser requirements for one acre of land for 2 crops in a year. The awareness of these benefits is not high among the farmers in rural area.

Technical Problems

It has been observed that the initial biogas plants installed (in 1980-90) as many as 70% of them are inoperative now. In the enthusiasm to promote biogas technology, many 'marginal' farmers were hastily provided with plants, as full subsidies were given, and NGO's and other organisations had targets to meet. However, many are inoperative, due to a variety of reasons, but critically, due to an inability to fulfil the requirements necessary for operating the plant or there is a design fault right from the beginning. Many a time without considering the number of cattle or raw feed available the size of the biogas plant was decided, naturally these plants had to take permanent shutdown later due to shortage of required feed stock.

Environmental Problems

Another problem faced is sudden drop in temperature during winter that reduces the quantity of production of gas. This sometimes imposes a serious limitation on the usefulness of biogas plants.

Financial Problems / Economic Problems

Implementation and development of biogas technology in the rural community is associated greatly with financial problems. Loans and subsidies were offered for construction of biogas plants till 1994. Since then the government has stopped offering loan facilities for different reasons.

Operational Problems

Regular operation of biogas plant involves collection of required amount of cow dung, followed by preparation of the inlet slurry, removal and drying of the split out manure, removal of condensed water in the gas pipe line etc. Improper feeding may be one of the main reasons of its failure. If the quantity of dung fed is low, the gas production will be less and if the input quantity is more, the digester tends to become acidic, again reduce or even stop gas production. The problem of under- feeding is actually found in the case of the 2 m3 plant in study area. Another very common problem is ratio of waste and water (1:1), i.e for 50 kg waste, 50 kg water needs to be put to get optimum rate, if supply of water is not sufficient in a District like Kolhapur, it may even lead to sludge drain choking. It is also noticed that the biogas users do not put off regulator gas switch properly. As a consequence the gas in the pipe liquefier results in wastage and remained scum within the pipeline causes blockage.

Organisational Problem

The planning, construction, and operation of biogas plants in an effective way calls for a well organised network providing:

- Trained Masons
- Supervising technicians
- Easy access to loans
- Availability of materials for construction etc.

Under the existing set up, with all its bureaucratic loopholes, it is difficult to envisage the formation and proper functioning of such a network. Sometimes, government authorities do provide some services but these are not many in number.

Prospects

Fuel Saving From Biogas

Among the various benefits from biogas technology, the users perceived wood saving as the important benefit. It was assessed during field survey in Kolhapur District, about 45% of the biogas plant owners were more concern about saving of wood. Most households informed that they are using about 20% to 35% less fuel wood after switching over to biogas. It is interesting to note that most users of biogas plants are also using other traditional fuels like wood, agricultural residue, LPG. Approximately 30% saving in kerosene has been observed in the case of Biogas user households.

Health Benefit

Besides in addition to the time saving and convenience aspect biogas leads to a better quality of life. As it is a clean fuel, the incidences of eye diseases, asthma, skin diseases among women are going to reduce. Cattle dung which is used directly as fuel or fertilizer has very strong pungent smell and attracts lot of flies and make the living place unhygienic, which can be solved by using Biogas digester. Even today, some of the villages have no lavatory facilities and the inhabitants use surrounding area to attend the nature call, which creates unhealthy condition. With the construction of toilets (as a part of Swatch Bharat initiative of government), sanitary condition can be improved; these public toilets can be used to produce methane by establishing community biogas plants. Thus, it helps to check the environmental degradation also.

Economic Prospect

The use of biogas plant can help the user to save money in different ways. The first case is that of households, the use of biogas plant has either eliminated or reduced the quantity of fuel purchase. Cash savings also occur when commercial fertilizer is replaced by biogas slurry. As in the third case the use of biogas slurry brings about an increase in the yield of crops and a higher income for the farmer. From biogas plant provision of street lighting, home lighting, pumping of water for irrigation, washing, running of small cottage industries like grinding, paddy husking, oil extraction can be done. Construction of biogas plant provides regular means of livelihood to a large number of entrepreneurs and turnkey operators, and has provided employment to masons and daily wage earners. Many masons have been trained in the courses organised by different govt. bodies and NGOs who has sound skill. Some of them are operating now as master mason and independent turnkey operators.

Conclusions

In present world scenario, there is acute shortage of conventional energy. The bottleneck of biogas energy development in rural areas of the study area is proper utilisation of bovine population and its dung. Government and NGO agencies campaign to increase biogas plant is not getting the required steam to push. From the field study it was found that as conventional energy (electricity) is provided free or at very low cost to the farmer, they are reluctant to go for biogas energy. They do not understand the requirement of very important shift from conventional to non- conventional energy.

The survey has revealed that many biogas plants are not functioning in several parts of the study area, especially KVIC model. To revive this non-functional model remedial steps suggestions are as follows: Data is available with Zilla Parishad office who are the people got the loan for installing biogas plant. Using that list a survey can be undertaken to find out the present status of the digester and accordingly maintenance help can be extended. It is established truth that forest resources are vanishing at a faster rate. It was found from the field survey that till date many of the people in the study area using

forest wood which is easily available as fuel. So to stop deforestation it is very important to motivate people to install biogas digester. Immediately after The DNES establishment in 1982 there was not much of response but next year the rise of biogas installation could be seen the District. Installation of biogas plant in Kolhapur District was slow. But surprisingly from next year only biogas installation rate started dropping. The biogas energy movement lost the enthusiasm. It was clearly visible that there was deficiency in government policy which was not encouraging rapid growth of biomass. There was very little thought process was given for technical improvement of biogas digester so many of the digesters started becoming non-functional. Along with that the government aid in form of loan and other subsidy was not increased over the time whereas installation and maintenance cost increased. The biogas installation development reduced to minimum by 2003- 2004 year in the study area. So it can be concluded as an observation that in urban area Biogas development is limited, mostly because of easy availability of conventional energy, space constraint, does not encourage people to upgrade from conventional energy to Biogas energy.

The main raw material requirement for Biogas production is met from bovine population. The animal wealth is very significantly utilised in Kolhapur District than any other Districts for Biogas production. In Kolhapur whenever there is any new scheme is declared by government regarding Biogas energy development Zilla Parishad office Biogas section members start campaigning through direct users, farmers verbally. This is the major reason for their success as effectiveness of campaign is very high because of direct communication upon interview of coordinator of Biogas installation project in Kolhapur District.

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RESIDENTIAL MOBILITY IN SLUMS OF KOZHIKODE CITY, KERALA

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Abstract

Slums and squatter settlements are associated in the zone of deterioration encircling the central business district or at the fringe of the city and are the home of the poor and the stranger. The function of these settlement is to house these strangers, until they are absorbed into the city life. This assimilation should be possible when a poor person has attained sufficient skill to achieve a higher wage level and when a stranger has accepted the culture and behavior pattern of the urban dwellers and thus enjoyable. The term slums and squatter settlement are interchangeable, even though they are different in term of nature. A survey report on slum improvement and up gradation project of Trivandrum, Cochin and Calicut by the National Institute of Urban Affairs, New Delhi, records that the slum house holds in Kerala are owing land occupied by them, this is because of the ownership right of land, enacted by the state legislation of Kerala, viz., the land reforms act 1963 as amended in 1969 in which he gets a protection against eviction and thus pattas has been awarded to slum household located on government land.

Keywords: Slums, Settlements, Deterioration, Urban affairs, Household

Introduction

Urbanisation in India has brought rapid changes in the process of settlement. The wide scope of economic activity in urban areas have generated the scope of employment in the formal and informal sectors when compared to the rural scene. The process has resulted in a large-scale increase of urban population especially in the lower income group. Thus leading to the formation of slum areas in the urban centers (Reddy, 1988). But all the same, the poverty remains in the most staggering form (Thakur, 1988).

The rapid urbanisation in recent times have given rise to many problems to cities, one among those in the formation of slums, one of the fact is that there is no balance in the distribution of economic activities and the higher concentration of activities, particularly industries, in large cities, have created a gravitational force towards them. The rural hinterlands, also due to extremely lower level of economic activity diversification have sent a large number of rural migrants to the cities. As these intruders require low level unskilled jobs, a rapid increase in the population has resulted in serious short falls in housing, public utility and community facilities. These migrants mostly rural people usually tend to absorb

with the core itself or in the fringe areas, which are almost devoid of all kinds of service and amenities of urban living such as water supply, sanitation drainage, sewerage and lighting thus giving rise to slum.

The migrants who come to the urban areas are detached from families and uprooted from the social morning, these migrants after coming to new areas are faced with the economic hardships, as a result they fall to assimilate into urban social structure. These rural migrants who come to the city has always served as a pool of labour who could be forced to accept the iron wage (Mitra, 1981)

No Indian city is free from slum, and this phenomena is regarded as a major problem of urbanization, more over the problem of slum appears to be more acute in metropolitan cities, slums are known by different terms in different regions, katras, gallis and Juggi Jopdi in Delhi, Chawls in Bombay, Ahatas in Kanpur, Bustees in Calcutta, Cheries in Madraa, Keris in Banglore and Petas in Andhara Pradesh.

The conditions under which slums emerge are varied, broadly the situation can be identified as follows: A slum develops as a result of shuttering of poor migrants, as they are new to the city and unable to pay rent or any urban facilities, they squat on public land near to the place of work, secondly the deterioration of a group of building in the old part of the city, this area gets congested and overcrowded and, thirdly as the city expands it sucks in the colony of fisherman herdman and the like, and the villages situated on the periphery.

The Jewish ghettos was a unique type of medieval urban slum. It therefore require special mention in the study of slum. Its uniqueness as a complex set of social, religious, political, and economic factors created a unified homogeneous group which lived for centuries isolated from the rest of the society in slum like condition (Clinad, 1970).

The development of slums in the United States is closely related to immigration. In the cities of New York and Boston, the recently arrived foreign groups were forced to live in the worst neighbourhoods. Slums in the growing cities are composed of the houses originally built for one family, these were sub-divided to accommodate more families as immigrants seeking housing increased. Lack of housing and high rent throughout the nineteenth century made the immigrate families to find accommodation in small and congested damp cellars with poor water supply, inadequate toilet and washing facilities (Clinad, 1970; Forma 1971).

In Britain cities have experienced a rapid growth of population owing to Industrial revolution. It has brought greater opportunities for employment and to earn livelihood in urban areas than in the country. As a result workers poured into the cities as factories grew with industrial revolution in a manner as seen in many cities of developing countries where the entire family lives in a single room close to their workplace.

In Asian cities the development of slums is attributed to the urbanization process. These slums are important component of city growth and two third of the population of the city are residents of slum. These cities were not prepared to receive the un precedent immigrants of people from the rural areas in search of job, these village folks who were mostly illiterates and poor with their village culture and ethos could not find any working employment or a proper dwelling (Madadev, 1975)

In India urbanization and political instability allowed the city population to occupy illegal land at their will. In Delhi the partition of India brought thousands of homeless from Pakistan and to old Delhi to the extremely congested city dotted with slums (Desai and Pillai, 1970). In Bombay private enterprises constructed houses with a profit motive, which gave birth to buildings known as Chawls. The Chawls consist of a number of tenements, usually of a small room for each family and is served by water, closet, washing place and water tap common to all tenements such Chawls are mostly 3-4 storied.

Residential Mobility

Since 1885, when Ravenstein first formulated his migration laws, a substantial literature has appeared concerned with the spatial mobility of population. The term mobility is perhaps the most general concept in migration studies. It includes all kind of territorial movements, both temporary and permanent, over various distances (Zelinsky, 1971). Migration is much more restricted and relates to a permanent change of residence. Usually, a migrant is defined as a person who moves from one administrative unit another; on the other hand, a migrant is considered to be a person who moves with the intention to establish a new residence in a different country or a region. Some may distinguish between those who move between political units (migrants), and those move within them (movers). Thus, at any given time, the total population of a region can be divided into migrant and non- migrant and movers and non- movers population. This in turn establishes the mobility status of the population.

Simmons (1968) in his study of an important, but relatively neglected aspect of migration, namely, change in residence that takes place within a city, investigates under three headings .First, who moves? Secondly why do they move? and finally, where do they move? He further explains that the spatial distribution of demographic characteristics is a major factor in differentiating mobility rates throughout the city and the mobility rates are slightly higher in the low income sectors of the city.

Housing needs generated by life cycle changes cause the majority of movers and produce high rate of out-migration in all parts of the city. The life cycle change accounts for at least five out the eight or nine moves that might be expected in a life time as an individual grows up, leave home, marries, and has children and ages.

Residential mobility refers to moves within an urban area which is differentiated from migration as movers between urban areas although the two phenomena have a

number of similar consequence. Pickvance (1974) has distinguished several types of determinants of the level of residential mobility as household characteristics like life cycle and housing tenure, housing value, reference of owner occupation, neighbourhood characteristics such as proximity to amenities and social status, housing characteristic such as age, size, occupation and tenure type.

Clark (1971) has explained that residential mobility is generally used to short distance moves while migration is for greater distance. Short distance moves do not break the web of contacts- employment, cultural and social links- and is of the opinion that less attention has been paid to such residential mobility studies. While studding the intra-urban residential mobility in Christchurch urban area of New Zealand, he focuses on lifecycle factors as the most important variable influencing residential change. The two important reason for residential change have been resulting from eviction from and conversion of the rented property. These forced move may also be taken as an important facet of intra-urban mobility, and in few cases the move do not shorten work trips as it is not an important factor of residential change.

Boyce (1970) is of the opinion that employment opportunity is the key factor for intercity residential mobility and this movement is much more in people who live in low value housing area and the movement is from suburbs. Turner (1969) while studding the slums of Lima, which has been one of the rapidly growing city in a transitional economy, has found that in the suburbs the vast majority of squatter homebuilders are ex-city slum dwellers. Contrary to the common belief the poor rural migrants are unable to find a job in the city proper. These slum builders are consolidating their status by doing so further improving it themselves.

Clark and Onaka (1983) have developed a topology of reasons for residential mobility. These moves are either forced or voluntary. The forced move are due to eviction by public or private action and destruction of the housing unit. The voluntary movement is of either adjustment or by inducement. Adjustments are of housing unit, neighbourhood and accessibility. I housing, space and change in tenure from rental to owned units are the dominant factor in the decision to move. The neighbourhood characteristics is mainly determined by the socio-economic status of the area. Accessibility in terms of work place and to relatives and friends is expressed by the moving households.

Conceptual Frame

Housing mobility is an important aspect that needs to be looked into, because high mobility seems to be an undesirable phenomenon indicating major problems in the slum housing. Residential mobility may possibly be attributed to three reasons, Firstly some slum dwellers may change their accommodation because of change in employment location, secondly as they are unable to pay the increased rent and thirdly, the evection by the government. John Turner (1968) has developed a model of typical migrants to the urban

context using Lima as a case study, comparing priorities of location, Levels of development of the shelter and terms by tracing the priorities as they shift over time. Benninger Christopher (1970) has developed a model, which represents South East Asia and designates from possible situation in which the poor urban dweller may live, these situations as: Reception, Intermediate consolidation, and prolonged reception. This study will discuss, the residential mobility patter in terms of tenure, location choice and shelter.

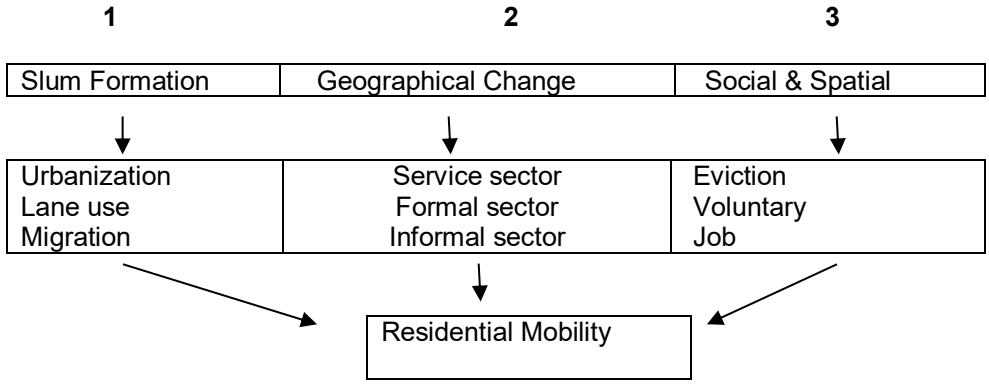

Fig. 1. Analytical Framework for Slums Residential Mobility –Kozhikode

The objectives of the study are to identify the direction of mobility and to identify the reason for residential mobility.

Research Design

The study takes into account three slum settlements of Kozhikode city, different location from the centre to periphery is been taken they are: a) Kalluthankadav (city centre) b) Kovilthazam (periphery) and c) Puthivakadav (beach). To avoid the same characteristic feature 25 sample households from each of these slums were randomly selected and interviewed to fill up the questionnaire. Data relating to the secondary information is been collected from the town planning department and corporation office.

Study Area

Kozhikode or Calicut is the headquarters of the District of the same name and is situated on the west coast at latitude 11^0 05' and longitude 75^0 47'E. The origin of the name Kozhikode emerges from the Keralaopathi a document of the state of Kerala, which was compiled during the British administration. In Kerala, Kozhikode was called the Cock Fort or the land where cock crows. It is believed to have been called so because of the place was so small that the crow of a cock could be heard all over it.

Kozhikode is situated on the Malabar Coast, and the Arabian Sea washes its western boundary. On the northeast flows the river Punnurpuzha, a tributary of Korapuzha, which forms the boundary .The Kallai river passes across the city dividing a portion of it in

the south from the northern sector. The Canolly Canal, an artificial navigable channel, connects the Kallai river with Korapuzha, 9.5 km to the north. The industrial pockets of the city are mostly concentrated on the banks of the Kallai river. The railway as well as the west coast road pass across the entire length of the city.

In Kozhikode city, the central area is more towards the coast and the area is of high density of population, that is more than 10,000 persons per sq.km, which lie around the Railway Station in the north and extending westwards up to the coast and the southern boundary of this area is the Kallai river, the eastern boundary is the Kozhikode trunk road and the northern boundary is the big bazaar. South of river Kallai, the population density is the second highest, that is 8,000-9,999 person per sq.km.

The landuse details are on developed, underdeveloped and developable areas. It is observed that the residential areas and agriculture uses are the dominating land use and they put together occupy about 86.5. per cent. Apart from agriculture, the area underdeveloped category, other vacant land is seen only in Kozhikode city which forms 0.84 per cent of the total area, this land is mainly marshy, and under water bodies occupy 1.86 per cent. The undeveloped areas comprise mainly of river, canal, tank and pond. The area under commercial is 0.94 per cent and area under industries is 1.39 per cent.

One of the important fact about slum life in Kerala is that for a long it has not been focused upon, like in the recent years. There are four sources of data on the proportion of urban slums in the state of Kerala: The National Sample Survey data on survey of slums, the estimates of Town and Country Planning office of slum population, the estimates of Planning Commission Task force on Housing and Urban Development and survey of slums conducted by Town Planning Department. The data presented here have been extracted from these sources.

In Kozhikode the settlement habitats coming under the preview of the definition of slum area is 75 in number, in which there are 10 special slums, the special slums are those of which the slum dwellers do not have any legal rights, the slum dwellers in special slums can be evicted at any time. These settlements are such that improvement cannot be made on them and they require resettlement. The slums, as against special slums, occupy private and/ or government land over which the slum dwellers have legal rights, which is empowered by the state legislature of Kerala: the land reform act 1963, amended in 1969. The act designates person as a *Kudikidappukaran* if he does not have any homestead or any land more than three cents in any city or municipalities and has continued to occupy any land and the dwelling house on it from 16th August 1968 to 1st January 1970.

Table 1. Slums And Special Slums in Kozhikode

Slum Type	Numbers	Households	Population
Slums	65	11,599	80,573
Special Slums	10	613	3,763

(Source: Dept. of Town Planning, Kerala; National Institute of Urban Affairs, New Delhi)

Kozhikode has the second largest number of slums in (75) in the state, with 12,212 households and 84,336 populations and is the topmost corporation in the state to hold the largest population and the largest number of households, as well.

Findings

1. In Kozhikode city 62 percent of the slum households live in single nuclear family, whereas 38 percent as joint family
2. For 77 percent of the slum household the current slum is the first slum
3. A large majority of the slum dwellers are of migrant origin, with 91 percent owing from place close to .5 km, 2.7 percent from a distance of 35 km and 2.7 percent up to 170 km.
4. In terms of family income 42 percent receive Rs 1,001- 1,500, 20 per cent Rs.3,000 or more, 12.7 per cent 1,501 -2,000, and the rest between Rs.2,001- 3,000.
5. In terms of mobility 50.8 per cent of the households have changed their residence from non-slum to slum, as they move from rental accommodation town house.
6. The mobility of 49.2 per cent is due to deterioration of social and economic condition
7. Mobility is also due to better amenities, like water supply, and sanitation and availability of land and better economic opportunities.

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AN ASSESSMENT OF LANDUSE / LAND COVER CHANGES IN THIRUVANANTHAPURAM DISTRICT, KERALA

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Abstract

Land is the basic input for all activities and hence occupies an imperative position among the resources. This makes landuse a decisive aspect capable of causing global changes and is very much related with both natural and human forces. The present study of landuse changes in Thiruvananthapuram District has been attempted using data spanning over forty five years from 1966-67 to 2011. The study revealed that substantial changes have occurred in landuse and land cover of the District in each period. The changes are more evident in the categories of built- up land, paddy fields, forest areas and scrub forest. The major drivers for this sort of landuse /land cover changes identified are mainly increase in population, growing urbanisation and technological developments.

Keywords: Landuse / Land Cover change, Landuse matrix, Landuse dynamic degree model

Introduction

Human actions arising from multiple social objectives are the immediate source of landuse change and are the source of most contemporary changes to the natural forces. The landuse pattern in an area depends upon both physical and environmental factors as well as pressure of population on land and so the dynamics of land use is a complex phenomenon, which is affected by several socio economic, agro-climatic and ecological variables. The extent of landuse change is also influenced by technological changes over a period of time (Gaire, 2011). Knowledge of these changes and the social forces that drive them is crucial to understanding, modelling and predicting local, regional as well as global environmental change and also for managing and responding to such change (Fazal Shahab, 2000). In this context, the present study tries to analyse the changing characteristics in the landuse /land cover scenario of Thiruvananthapuram District.

Study Area

Thiruvananthapuram, the southern most District of Kerala State lies between north latitudes 8° 17' 27" and 8° 51' 41" and east longitudes 76° 40' 25" and 77° 17' 06" (Fig.1). The District ranks eleventh in area among the Districts of Kerala with an area of 2,192 km^2. The District is bounded by Kottarakkara, Kollam and Pathanapuram Taluks of Kollam

District on the north, Ambasamudram Taluk of Thirunelveli District on the east and Vilavancode Taluk of Kanyakumari District of Tamil Nadu on the south and southeast and Lakshadweep Sea on the west (District Census Handbook, Thiruvananthapuram, 2001).

Database and Methodology

The study made use of two sets of data which include historical documents (published maps and texts) and remote sensing data. Landuse / Land cover of 1966-67 was extracted from topographic maps of 1966-67 (1:50000), 1991 landuse data was mainly obtained from Landsat TM images of 1991 and data of 2001 and 2011 were extracted from Indian Remote Sensing (IRS) LISS III images. Visual interpretation techniques were incorporated for the work. For the preparation of recent landuse /cover maps field verifications were made as well as Google earth images were also utilized. This provided a platform for the detailed analysis of landuse changes. Arc GIS 9.3 software was used for editing, labelling, projecting and for the preparation of landuse matrices.

Data Processing

The processing of the compiled data was in the following sequence: the scanned topographic maps of 1966-67, which was used as the base map, was geo-referenced and all the other maps and images were registered using this map. Subsequently, visual interpretation and digitization of the maps and images were done and a series of landuse maps belonging to four different time periods viz., 1966-67, 1991, 2001, 2011 were prepared. The landuse /cover of the study area was classified into ten types namely, settlement with mixed trees, airport, built-up land, paddy field, forest, grassland, sandy area, scrub land, wasteland and water bodies. The reprojected vector maps were used for the preparation of landuse change matrices.

Landuse Dynamic Degree Model

The landuse dynamic degree model which was helpful in knowing the time rate of change of one type of land use to other type has been used for understanding the dynamics of landuse in the District. This method used the rate of change of one type of landuse to another relative to the landuse situation at the beginning of the monitoring period (W.W.Zhang et.al. 2011). It can be mathematically expressed as (Li and He, 2002):

$$S_i = \left[\frac{\left(\frac{A_i - \cup A_i}{A_i} \right)}{(t_2 - t_1)} \right] \times 100$$

where S_i is the rate of the i^{th} type of landuse change during the monitoring period T_1 and T_2; A_i is the area of the i^{th} type of landuse at the beginning, and $\cup A_i$ is the area of the i^{th} type of landuse that remains unchanged during this monitoring.

Results and Discussion

Landuse Change

As per the study, similar to the changes visible in any other region in the present scenario, landuse in the District also underwent notable spatial and temporal changes in the four decades. The highlight of the general trend on the landuse changes revealed the following facts:

- Settlement with mixed trees remained the prominent landuse in the District with a minor variation from 60.56 per cent (1966-67) (Fig. 2) to 61.16 per cent (2011) (Table 1) of areal coverage. This category of landuse is common in all parts of the District but accounted for more area along the eastern highland panchayats and also along the Thiruvananthapuram city corporation areas (Fig. 5).
- Built up land showed a high pace of increase in the District. From 1.42 per cent in 1966 it increased to 12.30 per cent during 2011 (Table 1).

Table 1. Area under different landuse categories in four time periods in Thiruvananthapuram District

Sl.No.	Land Use Categories	Area (sq.km.)	Area (%)	Area (sq.km.)	Area (%)	Area (sq.km.)	Area (%)	Area (sq.km.)	Area (%)
		1966-67		1991		2001		2011	
1	Settlement with mixed trees	1327.43	60.56	1425.90	65.07	1376.96	62.82	1340.63	61.16
2	Aerodrome	1.47	0.07	2.29	0.10	2.63	0.12	3.25	0.15
3	Built-up land	31.06	1.42	47.92	2.19	183.03	8.35	269.53	12.30
4	Paddy field	228.08	10.41	161.31	7.36	92.99	4.24	52.86	2.41
5	Forest	496.61	22.66	449.91	20.52	388.82	17.74	337.34	15.39
6	Scrub land	4.22	0.19	16.14	0.74	65.93	3.01	127.14	5.80
7	Grassland	5.79	0.26	1.76	0.08	0.30	0.01	0.36	0.02
8	Wasteland	23.57	1.08	22.01	1.00	33.77	1.54	20.31	0.93
9	Sandy area	19.86	0.91	19.31	0.88	10.61	0.48	6.07	0.28
10	Water bodies	53.84	2.46	45.38	2.07	36.89	1.68	34.44	1.57
	Total	2191.93	100.00	2191.93	100.00	2191.93	100.00	2191.93	100.00

Source: Compiled from Survey of India Topographic Sheets and Satellite Images

- Scrub land was another landuse category which showed considerable increase during the period under investigation. Simultaneously the area under forest cover decreased from 22.66 per cent (1966-67) to 15.39 per cent (2011) (Fig. 4).
- Paddy fields showed a notable reduction in area with -7.99 per cent decrease during the study period (Table 2). The rest of the landuse categories i.e. sandy area, wasteland, grassland and water bodies also showed significant reduction during the period.

Table 2. Changes in the Landuse Categories in Thiruvananthapuram District 1966-2011

Sl.No.	Landuse Categories	1966 - 2011	
		Area (sq.km.)	Area (%)
1	Settlement with mixed trees	13.20	0.60
2	Aerodrome	1.78	0.08
3	Built-up land	238.47	10.88
4	Paddy field	-175.22	-7.99
5	Forest	-159.27	-7.27
6	Scrub	122.92	5.61
7	Grassland	-5.43	-0.25
8	Wasteland	-3.26	-0.15
9	Sandy area	-13.79	-0.63
10	Water bodies	-19.40	-0.89

Source: Compiled from Survey of India Topographic Sheets and Satellite Images

Thus, the landuse variations, which are purely the indicator of the changing perspectives of the population strengthens that the District is becoming more and more urbanised and this simultaneously led to the reduction in area under paddy, settlement with mixed tree and other cultivated areas and paving way for increased built up areas.

Landuse Conversion Based on Landuse Matrix

The landuse change matrix performed with the landuse maps prepared for four different periods shows the details regarding landuse conversion that has been taken place in the District.

Change in Settlement with Mixed Trees

The landuse category of settlement with mixed trees constitutes the major portion of the District. The table 3 shows that, the area retained by this landuse category was 1,311.65 sq.km. in 1966-1991 and it became 1,279.86 sq.km (Table 4) and 1,288.96 sq.km in the next decades (Table 5). Based on the matrix, during 1966-1991, the major portion of this landuse was converted for built up uses (10.7 sq.km.). In the subsequent decade, along with the conversion to built up purposes (130.88 sq.km.), some portion of this landuse became wasteland (14.82 sq.km). This may be due to the increased mining reported in the District during these periods. The conversion for built up purposes continued in the recent decade also during which 85.54 sq.km. area was converted for built up purposes (Table 5). Thus in the four decades, a major portion of the settlements with mixed trees were converted for built up purposes.

Table 3. Landuse Conversion Matrix 1966-67 to 1991

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Scrub land	Grass land	Wasteland	Sandy area	Water bodies
Settlement with mixed trees	1,311.65	0.35	10.7	-	-	0.01	-	2.53	2.31	-
Airport	-	1.4	-	-	-	-	-	-	-	-
Built-up land	-	-	31	-	-	-	-	-	-	-
Paddy	63.59	-	2.44	161	-	-	-	0.99	-	-
Forest	35.73	-	2.22	-	445.56	10.83	-	2.49	-	-
Scrub land	-	-	0.08	-	0.59	3.56	-	-	-	-
Grassland	-	-	-	-	-	1.99	1.67	0.99	-	-
Wasteland	6.78	-	-	-	2.9	0.13	-	13.8	-	0.01
Sandy area	0.7	0.53	1.29	0.04	-		-	-	16.69	0.27
Water bodies	6.63	-	0.15	-	-	0.01	-	0.07	0.94	45.28

Source: Compiled by the Researcher

Table 4. Landuse Conversion Matrix - 1991 to 2001

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Scrub land	Grassland	Wasteland	Sandy area	Water bodies
Settlement with mixed trees	1279.86	-	130.88	-	-	-	-	14.82	-	-
Airport	-	2.29	-	-	-	-	-	-	-	-
Built-up land	-	-	47.90	-	-	-	-	-	-	-
Paddy	63.04	-	5.08	92.99	-	-	-	0.63	-	-
Forest	18.6	-	-	-	373.29	57.14	-	-	-	-
Scrub land	0.11	-	-	-	10.82	6.06	-	-	-	-
Grassland	-	-	-	-	0.76	0.8	-	0.2	-	-
Wasteland	4.15	-	-	-	-	0.69	0.28	17.59	-	-
Sandy area	8.7	0.57	-	-	-	-	-	-	9.99	0.09
Water bodies	1.56	-	-	-	3.89	0.53	-	0.12	0.02	36.5

Source: Compiled by the Researcher

Change in Area Under Built-Up and Airport

Built up land is one of the important landuse s showing notable progress in the District. It has not prone to conversion but area under other landuses was changed for this category of landuse. The conversions of airport area are nil.

Table 5.Landuse Conversion Matrix 2001 to 2011

Land use categories	Settlement with mixed trees	Airport	Built-up land	Paddy	Forest	Scrub land	Grassland	Wasteland	Sandy area	Water bodies
Settlement with mixed trees	1288.962	0.33	85.54	-	-	-	-	0.89	-	0.29
Airport	-	2.63	-	-	-	-	-	-	-	-
Built-up land	-	-	182.9	-	-	-	-	-	-	-
Paddy	38.81	-	1.01	52.86	-	-	-	0.08	-	-
Forest	3.28	-	0.03	-	322.63	62.89	0.03	-	-	-
Scrub land	0.05	-	-	-	12.97	54.95	0.01	-	-	-
Grassland	-	-	-	-	-	-	0.27	0.01	-	-
Wasteland	6.09	-	-	-	0.01	8.4	-	18.99	-	0.5
Sandy area	3.49	0.06	0.5	-	-	-	-	0.23	6.02	0.68
Water bodies	1.07	-	0.01	-	1.75	1.09	-	-	0.07	32.94

Source: Compiled by the Researcher

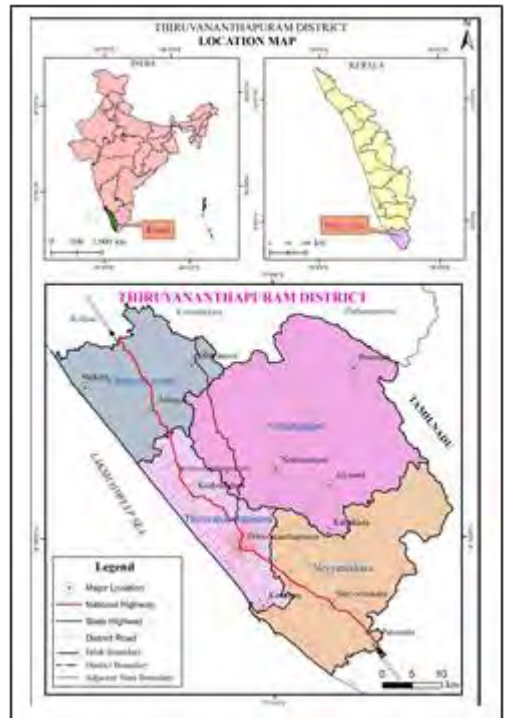

Fig. 1. Thiruvanathapuram District

Change in the Paddy Cropped Area

This is the most adversely affected landuse due to the increased urbanization and developmental activities. During 1966-91, 63.59 sq.km. area was changed to settlement with mixed trees (Table 3), 2.44 sq.km. was changed to built up and 161 sq.km. area was

retained under this landuse. During 1991-01, 63.04 sq.km. area under paddy was converted for settlement with mixed trees, 5.08 sq.km. for built up purposes and 92.99 sq.km was retained under paddy fields (Table 4). During 2001-11 period, 38.81 sq.km area under paddy was converted for settlement mixed with trees and 1.01 sq.km was used for built up purposes and about 52.86 sq.km area was retained (Table 5). It can be noted that the conversion of paddy fields for built up purposes was reduced in the last decade which can be seen as the impact of strict norms put forward by government which restricts conversion of agricultural land especially paddy fields for other purposes.

Changes in Forest

This category of landuse shows continuous decrease in area. During 1966-91, a major portion of the forest area was converted for settlement with mixed trees (35.73 sq.km.), rest for scrub land (10.83 sq.km.), wasteland (2.49 sq.km.), built up (2.22 sq.km.) and 445.56 sq.km. area was retained by the landuse class (Table 3). In 1991-01, conversion to settlement with mixed trees decreased to 18.6 sq.km., but an increase is seen in the conversion to scrub land area (57.14 sq.km) (Table 4). The conversion to scrub land (62.89 sq.km.) continued during the next decade also, but the conversion to other landuse s was considerably decreased (Table 5).

Change in Scrub Land and Wasteland

Scrub holds an important position in the District as this is one among the landuse types showing positive growth. Conversion to other types of landuse s is negligible during 1966-91(Table 3). During 1991-01 and 2001-11, 10.82 sq.km. and 12.97 sq.km. area (Table 4 and 5) of scrub forest was added to forest land respectively. Some portion of wasteland was converted for forest (2.9 sq.km) during 1966-91 while during 2001-11, conversion to scrub (8.4 sq.km) was prominent. Other conversions are negligible in case of waste land which is visible from the tables.

Changes in the Water bodies and Sandy Area

A decreasing trend is seen in the area under water body. Major conversion was for settlement with mixed trees (6.63 sq.km.) during 1966-91 (Table 3). This variation declined to 1.56 sq.km and 1.07 sq.km. respectively during 1991-01 and 2001-11(Table 4 and 5). Coastal sand also showed a reduction in area (Table 2). The main conversion of this landuse is for settlement purposes. During 1966-91, 0.7 sq.km was changed for settlement purposes (Table 3), became 8.7 sq.km during 1991-01 and to 3.49 in 2001-11 while conversion for built up was 1.29 sq.km in 1966-91 which became 0.5 sq.km during 2001-11 (Table 4 and 5).

Thus the landuse matrix revealed the following facts in the landuse of the District: hanges in the landuse are a common scenario in the District and the conversion of each type to other differ from place to place and period to period.

- The category of settlement with mixed trees was mainly changed for built up purposes.
- Area under paddy was mainly changed to settlement with mixed trees. This indicates that majority of area under paddy fields are now used for the cultivation of other commercial crops.
- Forest area were mainly changed to scrub land which can be attributed to the degradation of forest due to the variations in climate as well as human interventions at various levels.

Landuse Dynamic Degree Model

Based on the Landuse Dynamic Degree Model prepared for 1966-91 (Table 6), the annual conversion rate of grassland was highest (2.84%) followed by sandy area (1.65%). This is due to the fact that grassland occupied only very little portion in the District i.e. less than 6 sq.km, but it shows a noticeable reduction in 1991. Another category of landuse, which faced much conversion was paddy (1.17%), which was mainly converted for settlement purposes. During 1991-01, annual conversion rate was again highest for grasslands (10 %) followed by scrub (6.3%) and paddy (4.23%).

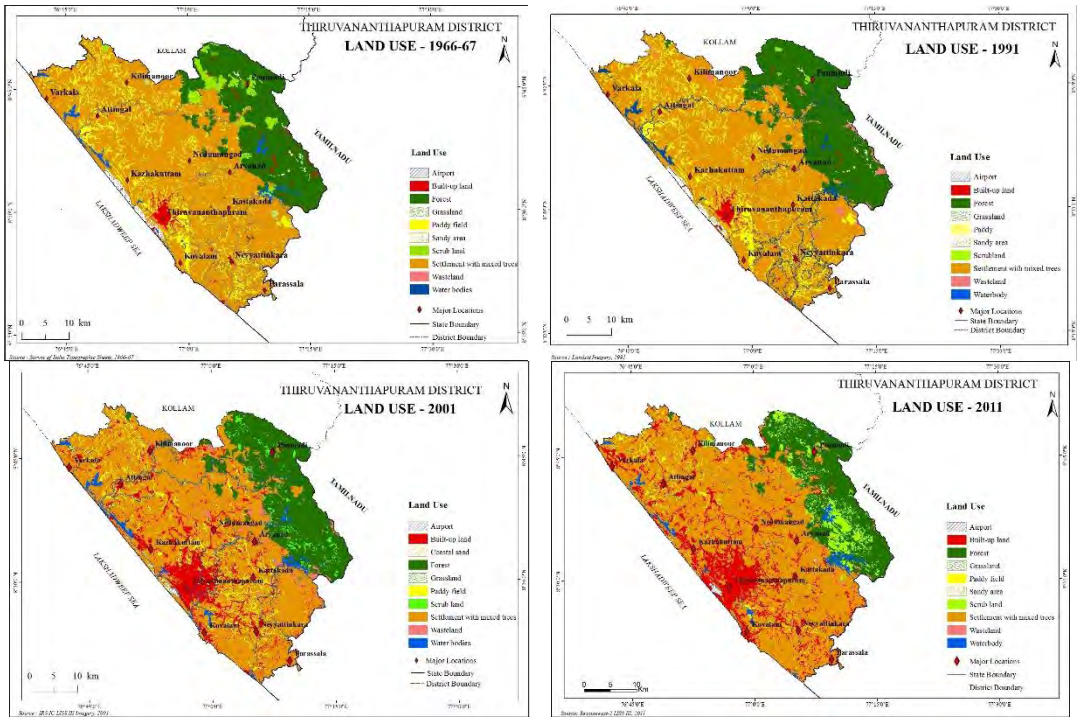

Fig. 2. Landuse Change

Majority of the areas under forest plantation and paddy were mainly converted for settlement purposes, whereas, scrub was changed to forest land. In 2001-2011, wasteland showed the highest conversion rate with 4.37 per cent along with sandy area (4.32%) and paddy (4.31%). The model revealed that, majority of the landuse s showed a rising and falling trend in the annual conversion rates during these four decades but scrub land is one category of landuse prone to high rate of annual conversion followed by sandy area and paddy fields. Low conversion rates were persistent for built up lands.

Conclusions

The driving force of landuse changes mainly includes natural and artificial forces. Some researchers also consider socio economics and policies as the major driving forces for landuse / cover change (Zhang et.al. 2009, Liu 2000). In the case of Thiruvananthapuram District, natural growth of population, urbanization and the government policies are the major forces behind the change in the pattern of landuse. The landuse change was accelerated with the establishment of India's largest IT hub in Kazhakuttom, along the suburbs of the city which led to the development of built up areas both for residential and commercial purposes. Thus it is evident that the continuous increase in the built up land and the decrease in the unused land were mainly due to the increased population pressure, industrial and the technological developments which in turn changed the occupational preference of the residence.

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Archives - 1

THE FIRST CONFERENCE OF THE MADRAS GEOGRAPHICAL ASSOCIATION, COIMBATORE

Formerly Known as The Journal of The Madras Geographical Association
(Volume V, 1930, pp. 37-53)

PROCEEDINGS OF THE FIRST CONFERENCE OF THE MADRAS GEOGRAPHICAL ASSOCIATION

The First Conference of the Madras Geographical Association was held on the 23rd and 24th May 1930, at the Freeman Buildings Agricultural College, Coimbatore under the Presidency of M.R.Ry., Rao Saheb T. S. Subramania Ayyar Avergal, M.A., L.T, Retired Vice Principal, Teachers' College, Saidapet. Besides the following members of the Association there was a large gathering of visitors:- Messrs. Rao Saheb T. S. Subramania Ayyar (Madras), N. Suhramania Ayyar (Madras), S. K. Devasikamani (Trichy), M. S.Sebhesan (Madras), S. Natarajan (Madras), V. K. Sourirajan (Madras), K. C. Ramakrishnan (Madras), S. Annantanarayanan (Trichy), V. Guruswami Sastri (Tirukkattupalli), C. S. Rangaswami Ayyangar (Villupuram), V. Jayarama Ayyar (Villupuram), T. R. Rajarathanam Pillai (Coimbatore), C. S. Ram Rao (Peelamedu), S. M. Rangaswami (Podanur), K. S. Srinivasa Ayyar (Dharapuram), T. K. Narayana Rao (Udumalpet), K. R. Sundaramurthi (Pollachi), M. Kalyanasundara Pillai (Tiruppur), M. P. Sitaraman (Madras), C. M. Gopal (Madras), K. Jogiah (Madras), C. Viswanadhan (Manamadurai), V. Sundaram (Bodinayakanur), A. L. Sundaram (Karur), S. T. Sreenivasan (Srirangam), C. M. Ramachandra Chettiyar (Coimbatore).

At 7-30 A.M, on the 23rd May 1930 Mr. T. R. Rajaratnam Pillai, B.A., L.T., Deputy Inspector of Schools, Coimbatore and Chairman of the Reception Committee delivered the Welcome Address.

M. R. Ry., Rao Saheb T.S. Subramania Ayyar Avergal then delivered his Presidential Address. The Secretary made a statement regarding the work of the Association. The following papers were then read and discussed on the two days:-

1. Geographical Control of Early Kongu History: by Mr. P.T. Srinivasa Iyengar , M. A.
2. The Geographical Limits of Kongunadu at various epochs:by Mr. C.M. Ramachandra Chettiar, B.A., B.L.
3. A Survey of the Recent History of Coimbatore District: by Mr. C. S. Srinivasa Chariar, M.A.

4. Some Place-names of Coimbatore District: (i) by Mr. S. Natesan, B A, (Hons.), L.T. (ii) by Mr. C. M. Ramachandra Chettiar, B.A ., B.L.
5. A Note on the Physical Geography and Geology of Coimbatore District: by Mr. T. N. Muthuswami, M. A, L.T.
6. Meteorology of Coimbatore District: by Mr. M. S. Subramaniam, B. A. (Hons.).
7. Agricultural Geography of Coimbatore District (with special reference to garden crops): by Mr. K. C. Ramakrishnan, M.A.
8. Cattle of Kongunad: by Mr. A. Swaminatha Ayyar, B.A.,
9. Home Industries of Coimbatore District: by Mr. R. Hari Rao, M.A., L.T.
10. Mill Industry of Coimbatore District: by Mr. C. V. Venkatramana Ayyangar, B.A., B.L.
11. Population of Coimbatore District: by Mr. S. S. Krishnaswami, B.A , L.T.
11. A Note on the Urban Geography of Coimbatore and its Environs: by Mr. R. Dann.
12. Towns Sites and Communications-lines of Coimbatore District: by Mr. N. Subrabmanyam, M.A., L. T.
13. Public Health of Coimbatore District in Relation to Physical Conditions: by Major A. V. Hesterlow, I. M. S.

At the close of the Conference Mr. Rajagopalachari, Vice-Principal of the Agricultural College addressed the Conference expressing his appreciation of the work of the Madras Geographical Association in stimulating an interest in original studies of the Home Region from various points of view. In the course of his speech, be deplored the lack of knowledge in the elements of Geography in students, who entered the Agricultural College. They lacked the synthetical and analytical processes, which ought to characterise the activities of students. He told them that in order to have a clear idea of soil conditions and climatology the students should have a good grounding in Geography. In conclusion, he said that the duty lay on teachers of high schools to impart such an education to the students and that the teacher himself should have he requisites of wide experience acquired by travel and observation to enable him to be a good teacher of Geography.

President's Concluding Address

Rao Saheb T.S. Subramania Ayyar in bringing the proceedings of the Conference to a close paid a tribute to the authors of the various papers contributed for the session, and said that after attending the conference they had now a good idea of the geographical, economic and industrial conditions of the Coimbatore District. He hoped that the Conference would assume a peripatetic character thereafter. In attaching themselves to the S. I. T. U., he said, they would be migrating from one place to another year after year and studying the local geography of each district in all its aspects. Regarding Coimbatore he said the district combined in itself all the features that made for national success. The economic and industrial possibilities of the district were immense.

Proceeding he said that India resembled Italy in physical configuration. Quoting Sgr. Mussolini, he said that by building their hope on agriculture industry would follow. Answering Mr. Rajagopalachari he said that the dignity of the subject would be clearly brought up only when the subject was included in the higher course and when special arrangements were made for the better teaching of the subject. Regarding the

characteristics of the people of this district, he said, he found more real fraternisation and unity in this district than, for example, in the east coast.

With a vote of thanks proposed by Mr. T. R. Rajarathnam Pillai the conference came to a close.

On the evening of the first day a visit was made to the Work-shop and Industrial school at Peelamedu. Small parties visited places of interest in and around the city such as the Rural Reconstruction Centre at Ramanathapuram, the Forest College and Perur Temple. After the conference several members made a flying trip to the Nilgiris.

Welcome Address by Mr. T. R. Rajaratnam, B.A., L.T.,

Deputy Inspector of Schools, Coimbatore & Chairman of the Reception Committee.

Dear President and Members of the Geographical Conference,

I take it to be a rare privilege and honour to have been called upon by the enlightened and experienced body of teachers here to be the Chairman of the Reception Committee and to invite you al1 to hold the Geographical Conference in this city to-day and to-morrow.

The mere fact that you are at Coimbatore is enough to prove that you are now more elevated than when you left your home in the different parts of this Presidency, for we are all at present about 1,1340 ft. above sea level. From here you can observe the mountainous arms of the western hills which are extended to embrace you in the Queen of the hill-stations. If you turn to the north you will be met by the rugged frown of the Kollegal hills relieved by the picturesque beauty of the sacred fall at Sivasamu dram and the future Mettur Reservoir. The Bhavani, the Noyyil and the Amaravathi will float you down to the Kauveri and the low-ly ing hot plains of the south-east. Your vanity may be satisfied by climbing to the top of Anaimudi to find yourself above every other man south of the Himalayas. Ladies and Gentlemen, to-day Pykara is labouring to beget power to electrify Southern India. The Sirnvani Tunnel will soon pour its perennial supply of water and quench the thirst and bathe the bodies of the citizens of Coimbatore. The Imperial Sugar-cane Breeding Station is sweetening India with its sugar of improved quality and promises eventually to liberate her from her dependence upon Java and other lands. The Ramanathapnram Branch of the Y.M.C.A. is attempting to vitalise the two thousand villages of this district by its work of reconstruction. The Cotton Mills are trying to emulate Manchester perhaps to the future detriment of India's national economic ideal. The Pollachi and Tirupur Markets help much of our raw-cotton and ground-nuts on their wings to distant Europe to return in altered form. In short, Ladies and Gentlemen, in welcoming you to Coimbatore we welcome you to a place which, with its monsoons and scrub flora and tropical fauna, with its not distant presence of hills and plateaus, with its salubrious climate with its.river capture at the head-waters of the Noyyil and Ponnani with its tank and well-irrigation, with its silk industry of Kollegal, with its cotton industry at Peelamedu and other

suburbs, with its hamlets of quiet, industrious but litigious riots, with its backward tribes and hill tribes such as, Muduvars, Irulars, Malasars and Todas, and with its sacred Perur of sculptural fame, is a mine of wealth for a Geographer to revel in. I am aware that this is the first Geographical Conference in South India, nay, in the whole of India, and this city with its fine environs and excellent climate as described above, is, I believe, best fitted to study human life in relation to nature which is the special function of Geography.

I confess I have no special qualifications to hold this privileged position and talk to you with anything like authority on the growing subject of Geography. Nor can I indicate to you a distinguished body of educationists the lines on which you will carry on your discussions in reference to that subject. But this much I should like to say, viz., that I have been long a secret votary of this hitherto neglected and down-trodden subject and have been looking eagerly for its uplift from the contemptible position it found itself in the school-room for over two decades. My love for the subject is, therefore, my only excuse for occupying this position.

It is a matter of common knowledge now among the public and particularly of the teachers that the Madras Geographical Association started by a few enthusiasts a few years ago has been progressing by leaps and bounds; and through its labours geographical knowledge is being disseminated, popular prejudice against the subject has been overcome and the overgrowing importance of the subject is becoming more; and more recognised by the public, the University and the Educational Department.

The Madras University has recognised it as one of the optionals of the Intermediate Examination and has taken steps for bringing into existence a Department of Geography. The inclusion of the subject in B.A., curriculum is only a question of time. It has ofcourse to be remembered that the mere inclusion of the subject in the University curricula is not a great thing by itself; for, its advance depends upon the public recognition of its importance.

Again in schools in the revised S. S. L. C. syllabus it has been given an important place both as a compulsory and as an optional subject. The old amphibious position it occupied as a subject of that notorious B. group which was for long working havoc on the character of the pupils and the tone of school-life is now fortunately at an end.

With the restoration of Geography to an important place in the S. S. L. C. curriculum and with the proper teaching of the same, I am sure that ere long a body of secondary and elementary grade teachers will spring up qualified to teach geography on right lines in the lower classes. As one closely in touch with schoolwork in the lower grades I know there is dearth of geographical knowledge everywhere in schools; and no geography teaching done in any school is worth the name.

I therefore thank the members of the Madras Geographical Association and in particular the learned and indefatigable Secretary Mr. N. Subramania Iyer, for the uphill work they have already done; but I beg leave to suggest to them that it is time that they take up the question of educating the secondary and elementary teachers by contributing

articles in their Magazines on what modern geography is and how best it can be taught in the school-room.

May I remind you that the organisation of District Branches of the Madras Geographical Association, the institution of annual refresher courses at different centres by turns with the recognition of the Educational Department, the provision of a separate Geography-room in every Secondary School with at least the minimum equipment of furniture, maps, charts and meteorological instruments - are some of the essential factors conducive to the efficient and interesting treatment of the subject and that these have therefore a claim on the serious attention of the Geographers?

Before I conclude I should like to bring to your notice that much of the popular distaste for Geography was the result of the Geographers not having settled once for all what Geography really is and by their including in it all odds and ends which are facts of other sciences and therefore non geographical. Too much of topography was at one time in vogue here; and that I call the Ancient Period of the teaching of Geography, about 30 years ago. Then topography gave place to Physiography for nearly 10 years and this I call the Middle Ages in the teaching of Geography. Because this association of Geography with all kinds of knowledge known to mankind it was blown out of existence and relegated to realms of darkness for nearly 20 years in the past and this I call the Dark ages of Geography. Fortunately it has now been re-claimed; but I am afraid that in the renovated Geography there is again a little too much of physiography which, I believe, will be beyond the comprehension of the teachers and pupils especially of the lower classes of the school-room. I presume it was because of this attempt to impart a little too much of this physiography that the now defunct syllabus of the revised S.S. L. C. Scheme was cried against by the teachers who demanded another in its place with less of physiography and more of human life in it. All Geography if it should be popular, should be human. The one attempt of Geographers should be to interpret the genius of human life in any place on the earth's surface in the light of its environment, physical and social.

With these my humble observations I heartily invite you all on behalf of the Reception Committee to hold the Conference under the able guidance of my learned and esteemed Professor Rao Saheb T. S. Subramania Iyer Avergal, M·A, L.T., discuss all matters of importance in relation to the subject and make all who have come here to attend the Conference wiser for having heard you.

Presidential Address by M. R. Ry., Rao Saheb T. S. Subramania Ayyar

While thanking the organisers of this first Conference of the kind in India for having given me an opportunity to associate myself with their commendable work of focusing thought and investigation upon a subject of such human interest as Geography, I cannot but be profoundly alive to my limitations in enjoying the privilege of directing the proceedings of this talented assembly. In your wonted and unbounded kindness a reference has been made to my official and post-official activities. Throughout my career it has been my privilege to work with colleagues that had to stimulate interest in the subject of

Geography not only in the alumni of our schools and colleges but also in the members of the public, educational legislatures and academic bodies. And it is a matter for genuine pride and congratulation that our Presidency should have thus far at least inaugurated a movement for placing the Muse of Geography on a worthy pedestal and claiming for her an adequate measure of attention and homage. The progress of this movement is bound to react upon the other parts of India and lead to a desirable co-ordination of effort.

Geography in the past. This improvement in the public attention to the subject may be said to be a new phase in the educational life of the East and the West as well. For it is only during the past quarter of a century that even in the advanced countries of the Globe that this subject has been receiving greater attention than any other subject in the school curriculum. It is a change in the outlook that has brought about a marvellous change in the methods and the personally also in the western countries. The same conditions are not found here and consequently the same necessities are yet to be felt here. Hence the greater need in the new orientation of our aims and methods to stimulate interest by organised effort, and it may be truly said that the Madras Geographical Association adequately fills a gap in the educational and academic activities of South India and serves to bring about a due co-ordination of effort on the part of the diligent workers in the field.

Till very recently Geography was the Cinderella amongst the subjects of the school curriculum. She was never given an independent and much less an honoured place in the academic family. It was always her lot to lean upon others. For a long time she had to be under the leading strings of History. The tie moreover was considered to be inalienable. Her relations to other subjects and sciences were but very feebly envisaged. Her ardent votaries were very few in number and even those few were not singing her praises adequately. She had always to quail before close-fisted managements, indifferent schooling and hostile alumni. More than other subjects the teaching of geography suffered for want of a qualified and capable fraternity of teachers and specialists. It is a fact well-known to us all that its teaching was always relegated to that amiable member of the staff who was handy enough for any kind of work in the school. Under these circumstances how could any enthusiasm be evoked and much less maintained. This condition was not peculiar to this country alone. Even in the West it was the wail of the educationists that an adequate measure of attention was not paid to it. According to the “Report on Geographical Education at Home and Abroad” published in 1885 the two great weaknesses in the position of Geography were want of knowledge in the teachers and want of organisation in the curricula and methods,” and the subject was never taken seriously by either teachers or taught. Geography was regarded merely as a species of general knowledge comprising a large number of unrelated and uninteresting fact about the earth. Physical and Political Geography were kept separate and distinct. While the former was in a measure scientifically treated, the latter consisted largely of long and wearisome lists of names which had to be memorised without associations or reason. This method of geography teaching was self-condemned as it afforded neither pleasure nor profit. Hence its growing unpopularity in schools and its utter absence from the higher courses of study. This was merely the information or the memorising stage in the genesis of the subject.

During the next transitional stage Geography had to prove its worth, even to maintain its meagre and inconspicuous place in the curriculum. It had to establish itself as a useful branch of knowledge and an effective instrument of mental discipline. This challenge and necessity led to important modifications both in matter and method.

Nature study and the object lesson came to be regarded as suitable avenues by which the study of geography could be approached. Due emphasis was laid upon physical factors and their influence upon the history of humanity; the commercial and economic factors came in for increased attention and investigation. Association was brought to the aid of memory and imagination, and an appeal was made to reason by teaching causal relations. These were the beginnings of a scientific outlook on Geography and a proper orientation of study and research in the much neglected field. But the progress in thought was rather tardy owing to the lack of a unifying principle, a principle which could afford a text as to the limit of the scope of the subject and link up its various departments like the mathematical, the physical, the commercial, the political and the historical aspects of the study.

This necessary work of co-ordination could be accomplished only when the subject was seriously taken up in the higher courses. And this consummation was possible only with the progress of enlightened enthusiasm on the part of teachers and scholars of repute engaged in geographical inquiry and research. Now it may be said that the position of geography as a definite science has been finally established and recognised. So the present stage in the progressive development has been due to organisation and co-ordination of effort on the part of the votaries of the science.

The New School and its Methods. The latest conception of this science of sciences is clearly brought out by its connotation as a study of the Earth as the abode of man. Thus the human factor is being more and more prominently brought out by the new school and this new conception determines the nature and scope of the matter to be taught and the point of view from which it is to be treated. The function of Geography is to see how far and in what way the various laws of the manifold sciences operate in determining or regulating human activities in general. Thus the new Geography does not focus its attention so much on phenomena of a local character as upon the distribution of similar phenomena over the whole world, and their action and reaction upon human progress and activities.

Consequently, the method of the new school is to divide the earth's surface for purposes of study into units or regions of definite or similar geographical characteristics. Till recently we could not get over he obsession of mere accidental political divisions and territorial boundaries alike in the study of Geography and History. The political is not necessarily the Geographical region. Even our country washed on two sides by the sea and cut off from the rest of the continent by the great rampart of the Himalayas has not been always a geographical as well as political unit. Thus the division of the world into regions on a rational basis to bring out clearly the relationship of natural environment to human activity has been the first endeavour of the new school. For is it not really illuminating and most educative to deal with Asia under the heads:-

1. The Great Plain of the North,
2. The Central Highlands,
3. The Western Highlands,
4. The South-Western Desert extending really from the Atlantic to the Aravallis,
5. The Monsoon lands,
6. The Island Fringe and the remnants of a lost continent?

Moreover, who can deny the inspirational character of a study of human nature as influenced by environment and the realisation of the ultimate causes of the vicissitudes of national life and glory. In this connection, I may cite a very remarkable study of the kind by Count Kaiserling in his book entitled ***Europe*** wherein all the nations of the continent and their evolution have been subjected to a most critical enquiry. Or, let us take this estimate of ourselves and our country by a foreign writer for illustrative purposes. “The outstanding facts with regard to India are its arrangement of physical regions into a pattern which has not favoured unity among its people; its avenues of approach by land and sea; the Khyber pass in the North-West and the forested path into China in the North-East, its invasion by different races; the political, religious and economic diversity of its peoples; the extreme fertility of its wide areas of good soils; the influence of its summer rain and of its constant high temperatures; a land that juts into the sea. but is not of the sea; a people who are land-minded and not sea-faring; a land crowded to the very margin of existence by a farming people, illiterate, weakened by their mosquito climate until their physical energy is scarcely three-fourths that of the European or American ; dominated politically by a small island kingdom of the temperate zone; with remnants of an ancient civilisation and culture in some lines unsurpassed, with leaders arising whose intellectual and spiritual leadership cannot be questioned; an ancient people difficult for the Western mind fully to understand, whose qualities of mind and soul we cannot but admire." With these prefactory remarks our foreign teacher of Geography, makes the following a basis for problem study. "India is the second most populous country in the world. Its territory is large and rich. Why is it not independent?" Such thought-provoking problems are taken up for discussion by the students themselves. In the particular problem above referred to the discussion will proceed on the following lines. What does a country need to be independent? It needs to have good boundaries and neighbours. It needs to have all its people united and working together. It needs good farming lands and a good climate. It ought to have good schools so that all its people can be educated. It ought to have good leaders. It ought to have good sanitation so that the people will be healthy. It ought to have an army, a. good navy and a merchant marine. Thus the teaching takes a practical turn and makes more appeal to reason and research than to memory. The true worth of the science is now being increasingly realised in all countries.

Reason for the Importance of the Subject Abroad

In the curricula of the Western countries the subject has been given an exalted place owing to its practical, educational and national values. Their prosperity is bound up with the prosperity of the world, especially because the overflow population of Europe has to find its sustenance in the other regions of the earth. Thus, a knowledge of the world and its resources has become indispensable for every young man. Now to solve the problem of unemployment England has to send almost weekly batches of young men soon after their compulsory education up to the 14th year to Canada and South Africa for employment in the farms and factories there in. And properly enough, several organisations have been formed in the West to encourage this migration; and even steamship companies had undertaken to tranship them almost free to the respective countries. So it is no wonder that in the educational system of these countries a due place should have been assigned to the science of earth-lore and fact-lore.

Growth of Geographical Knowledge and Literature

A marked feature of modern times is improvement in low motion in loco and the mobility of humanity. With this increase of locomotion comes an increase of knowledge of men and things and clarification of ideas about other places and countries. All this is evidenced in the numerous magazines and illustrated journals broadcasted under modern conditions for the delectation of the people. Appeals through the eye have become the order of the day. Now we cannot but admit that the Geographic spirit permeates every study related to man and earth. You have only to glance through foreign magazines to be impressed with the variety and profundity of the subjects dealt with therein in the most attractive manner. To cite only a few examples: distribution of invetiveness; road-making in the Tropics; France and her emigration problems; White capital and coloured labour; Cultural regions of India; Civilisation and disease ; Irrigation systems of Persia, Egypt and India. The educational survey of the League of Nations brought out the necessity for visual instruction in regard to national and international problems and that in the interests or the harmony of the world.

Geographical Associations and Organisations

Improvements in outlook and method are bound to be slow and lacking in initiative unless taken up by organisations, and groups of specialists and sympathisers. Such organisations have functioning properly in many countries like the Geographical Societies of England and America and ensuring the success of investigations in this vast field of research. Higher research work is not possible of achievement without a good financial backing. And such backing can come only from State organisations, Universities and specialised voluntary associations. It was only a few months ago, that I had the privilege of coming into contact with Mr. Hoadby, the leader of the Boy Scouts and Rovers of Australia, had taken part in more than one Polar expeditions to the South Pole. In an informing address on board the *Baradine* he discoursed on the expeditions and described very graphically his experiences and those of his comrades and wound up his address deep

expression of gratefulness to the Geographical Societies of Australia and the West that had done everything needful to ensure the success of the expeditions.

The Madras Geographical Association

Work of this kind in India should naturally rest with our indigenous organisations. Itineration and mobility are absolutely necessary for direct knowledge of men and things. And to stimulate this, public organisations have been brought about in England, Germany and America. The floating University of America is the latest phase of this modern craving. In Germany, rovering has been taken up as a function of local bodies. In England there are many associations and benefit organisations for encouraging outing, excursions and trips on the part of students. It cannot be said that our record in India has been a blank. In the Geographical Association under whose auspices we have met today we have a worthy rallying point for our further endeavours. I shall reserve for the secretary a detailed narration of the history and achievements of this organisation during the last five years. The potency of this organisation depends in a large measure upon the enthusiasm and co-operation of its members. The Secretary has done well to summon the conference under the protecting wings of the S.I.T.U. The aims of both the organisations are of a parallel nature. The peripatetic character of the Conference also will bring about a focussing of attention on the peculiarities and national setting of particular localities and districts, and contribute in a large measure to the growing literature of the Association.

The Work Before Us - But only the ground has been slightly broken. The work before the Association is of a stupendous character. Moreover one association of the kind for the whole country is but a dubious record. I look forward to a time when this country can boast of a federation of such organisations, scattered throughout the continent and ministering to the intellectual and moral uplift of its ardent humanity.

With these benedictory words, I have great pleasure in declaring this unique conference open for the first time in its history.

Statement by the Secretary N. Subrahmanyam

Mr. President and Gentlemen, I have been called upon to give an account of the work of the Association during the last four years of its existence. I shall try to do so by making a bare statement or outstanding facts without going into unnecessary details.

Five years ago, Geography had no place in the University or in the High School, and the teaching of the subject up to the fourth form was left in the hands of some odd teacher in the school to make up the full quota of work for him, while the boys themselves learnt to pay no heed to a subject which had no examination status. The ignorance of what the science stood for was colossal, while it came in for a good deal of ridicule and contempt.

It was under such conditions that the Madras Geographical Association was ushered in early in the year 1926. It started not only with the aim of advancing the position

of Geography in the educational systems, scholastic and collegiate, but also with the higher object of making original studies of South India from various points of view. Both the objects have been carried out in a good measure.

By means of lectures, leaflets, and interviews, important changes have been brought about, so that Geography is now one of the important subjects of the re-organised S.S.L.C. Course, as well as of the remodelled Intermediate Course. The University of Madras has decided to open a Department of Geography and to run a Diploma Course; while the question of the provision of Geography as a Degree subject has already been taken up. Not the least important of the changes is the change of outlook that has been brought about. No longer is Geography looked upon with contempt and ridicule, but it is recognised as an important subject in the map of knowledge, having its own function to discharge.

On the pedagogical side, besides offering notes and articles in the Journal on the teaching of Geography, the Association ran with success two Summer Schools to which teachers were deputed from all parts of the Presidency as well as from the Native states, while the Educational Department showed its recognition of the work done in this direction by making grants, besides rendering other kinds of help on the side of inquiry and investigation too, the Association has been having a good record. A series of original papers by specialists on different aspects of South India have been read and discussed, which have served to quicken and stimulate interest in the higher and detailed study of the Home Region.

The present Conference, the first of its kind in India, is itself a natural outcome of the activity of the Association in this particular direction. For, the work of the Conference is to read and discuss a series of studies of the Coimbatore District from various points of view. It is hoped that this will become an annual function of the Association so that while at the Headquarters papers concerning different localities may be read from time to time, at the Annual Conference studies of the particular region where it is held will form the main programme of work.

During all these five years the strength of the Association has been steadily maintained at over 200, while the quality of membership has been steadily improving, non-descript members and people who joined out of mere curiosity yielding place to members with genuine interest in Geography and in the higher study of the Home Area.

While the proportion of city and mofussil members has been nearly equal, the latter, unless they subscribed for the Journal also, got no adequate benefit from their membership. To avoid this drawback and to enable the mofussil members to contribute their share of effort for increasing the activities of the Association, a scheme of local and district branches has been inaugurated; and already three localities Trichy, Villupuram and Coimbatore have started their branches. The opening of a larger number of such branches will give scope for further development of Geographical studies in South India on right lines.

The Journal has been meeting a felt need and has been appreciated. Besides recording the proceedings and activities of the Association and serving as a clearing house of Geographic thought, it has also served as a link between the Head-quarters and the mofussil members. The steady increase recently in the number of subscribers, both among members and institutions, has been gratifying. But it has been a costly affair to run the Magazine owing to the large expense of the maps and illustrations that have to be included; and unless there is a further increase in the number of subscribers it will not be possible to improve the quality or increase the size of the Journal.

Financially, the Association has so far been able just to make both ends meet, and it has yet to build up a reserve fund. But it is strongly believed that it has created a place for itself in South India by filling a gap; and the question of finance is easily solved when people begin to feel that it is an institution which is serving a useful purpose, and that it ought to be supported. Some of us are sanguine enough to trust that the Association has reached such a stage.

This conference is a fresh venture in the history of the Association, and its success is foreshadowed in the immense interest that has been generally evinced.

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Volume 87 (2) June - 2012, p 60
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Archives - 2

SECRETARY OF THE MADRAS GEOGRAPHICAL ASSOCIATION BECOMES FELLOW OF THE ROYAL GEOGRAPHICAL SOCIETY (F.R.G.S.), LONDON

Formerly Known as The Journal of The Madras Geographical Association
(Volume VI, 1931, pp. 80-81)

We congratulate the energetic secretary of the Association Mr. N. Subrahmanyam on his being elected Fellow of the Geographical Society, London. Our readers will note with interest the following extract from the Madras Mail, dated 26th May, 1931:- "Mr. N. Subrahmanyam is the first Indian gentleman of South India who has been thus honoured. He has been a teacher of Geography for nearly a decade and half and Lecturer on the staff of the Teachers' College for more than six years. He was the Founder and has been Secretary (since its inception) of the Madras Geographical Association. Besides, he is the Chairman of the Board of Studies in Geography of the Madras University and also a member of the Board of Studies in History, Geography and Economics of the Andhra University. As such he has done yeoman service towards the promotion of the study of Geography. He is the author of a Text-book of Geography for Schools. He was mainly responsible in starting several Summer Schools of Geography in various parts of the Presidency under the auspices of the Madras Geographical Association as well as under the District Boards and District Guilds."

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Archives - 3

LIST OF MEMBERS
THE MADRAS GEOGRAPHICAL ASSOCIATION (1932)

Formerly Known as The Journal of The Madras Geographical Association
(Volume VII, 1932, pp. 8-23)

Mr. Abdul Hamid, B.A., (Oxon.), District Educational Officer, Calicut.
Mr. Abdul Khader, B.A., L.T., Headmaster, Govt., Muhammadan High School, Vellore.
Mr. M. Achyutan Nair, B.A., L.T., Headmaster, Board Secondary School, Chennimalai.
Mr. N. K. Adyantayya, B.A., (Hons.), University Lecturer in Statistics, Senate House, Triplicane, Madras.
Mr. R. Agoram, B.A., Teachers' College, Saidapet.
Miss P. S. Alie, B.A., L.T., Headmistress, Govt., Training School for Women, Palghat.
Mr. Syed Ameeruddin, B.A., L.T., Headmaster, Municipal High School, Cuddappah.
Miss T. Ammunni Ammal, Teacher, Lady Sankara Nair Board Girls' High School, Ottapalam.
Mr. A. Ananta Bhat, B.A., L.T., Teacher, St. Aloysius College, Mangalore.
Mr. M. S. Anantakrishna Iyer, B.A., Teacher, High School, Trichur.
Mr. L. A. Anantanarayana Iyer, B.A., L.T., Headmaster, Board High School Manjeri.
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Mr. V. Annaiyya, B.A., Asst., S. M. D. H. High School, Tirupati.
Mr. P. Appa Rao, Teacher, Board High School, Kollur (Guntur Dt.).
Mr. A Appadorai, M.A., L.T., Lecturer, Loyola College, Nungumbakkam, Madras.
Mr. T. Appalanarasayya, M.A., Asst., Govt., School of Commerce, Vizagapatam.
Mr. K. Appunni Kaimul, B.A., L.T., Teacher, Boys' High School, Kunnamkulam.
Mr. S. Balakrishna Iyer, B.A., L.T., Lecturer, Teachers' College, Saidapet.
Mr. A Balasundaram, B.A., Teacher, Board High School, Chengam.

Mr. V. S. Balasundaram, B.A., Teacher, R. C. Training School, Tindivanam.
Mr. E E. Berry, B.A., Headmaster, Stanes European High School, Coimbatore.
Mr. C Bhimasena Rao, B.A., L.T., Teacher, P.R. College School, Coconada.
Mr. Vishweswar N. Bijur, B.Sc., L.T., Asst., Ganapathi High School, Mangalore.
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Mr. J. Brito, B.A., L.T., Asst., St. Aloysius College School, Mangalore.
Rev. F. C. Browne, M.A., L.T., Principal, St. Joseph's Indian Section, Bangalore.
Mr. H. Champion, M.A., Principal, Teachers' College, Saidapet, Madras.
Mr. K R Chandrasekhar, B.A., Teacher, S. P. G. High School, Secundarabad.
Mr. C. D. S. Chetti, M.A., Registrar, Andhra University, Waltair.
Mr. A. S. Chidambaram Pillai, B.A., Teachers' College, Saidapet.
Srimathi C. Chinnammu Mannadissiyar, B.A., Headmistress, Board Moyan Girls' High School, Palghat.
Mr. K. Dakshinamurti, B.A., L.T., Deputy Inspector of Schools, Nellore.
Mr. Rao Saheb S. Dandapani Ayyar, B.A., Census Superintendant, Pudukkottah.
Mr. J. Daniel, B.A., L.T., Board High School, Chittoor.
Mr. R. Dann, Director of Town-planning, Chepauk, Triplicane, Madras.
Mr. V. Desikachari, M.A., L.T., Teacher, Municipal High School Gudiyattam.
Mrs. A. Devasahayam, 'Church View', Fort, Salem.
Mr. G. Devasahayam, B.A., L.T., Asst., C. M. High School, Megnanapuram.
Mr. S. K. Devasikhamani, B.A., L.T., Headmaster, Bishop Heber High School, Trichy.
Mr. S. Devasirvatham, B.A., L.T., Supervisor of Schools, American Advent Mission, Saidapet.
Mr. N. Divakara Rao, M.A., Teachers' College, Saidapet.
Mr. P. Doraikannu, B.A., Asst., Chintadripet High School, Madras.
Miss V. K. Droupathi Ammal, B.A., L.T., Headmistress, V. G. School, Trichur.
Mr. W. Duraiswami Ayyangar, Manager, Messrs. Longmans, Green & Co., Mount Road, Madras.
Mr. S. Duraiswami Iyer, M.A., B.L., Advocate, "Palm Grove", Mylapore, Madras.
Mr. D. Ebenezer, Asst., Training School, Pasumalai.
Miss H. A. Edington, Churchpark Training College, Cathedral, Madras.
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News and Notes

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VARIATION IN NORMALISED DIFFERENCE VEGETATION INDEX IN RELATION TO RAINFALL DISTRIBUTION OF CUDDALORE DISTRICT, TAMIL NADU

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Abstract

An attempt is made in this paper to study the variability of Normalised Difference of Vegetation Index (NDVI) over Cuddalore District during the period 1991, 2005, 2008 and 2010 using Landsat images. The rainfall distribution has been generated to correlate both NDVI and Rainfall. The study area in the Northern part, which has high vegetation cover due to the presence of Agricultural land and plantation. In Cuddalore, rainfall has less impact on vegetation, rainfall increase, but still, vegetation coverage is lower due to the high percentage of fallow land, which increases the risk of flood.

Keywords: NDVI, Rainfall distribution, Remote sensing and GIS techniques

Introduction

Nowadays, remote sensing has become a powerful monitoring tool for many aspects of global monitoring for its convenience and high efficiency. This technology has been widely employed for descriptive and statistical studies between satellite-derived vegetation conditions and various climatological variables over different regions with various geographical scales. Vegetation change plays a major role in the environmental processes. Vegetation indices serve as a sensitive indicator of climate and anthropogenic influences by altering energy balance, climate, hydrologic and biological cycles. The Normalised Difference Vegetation Index is the most commonly used satellite-based vegetation indices for monitoring vegetation changes and its interaction with various climatic variables. The NDVI is associated with variety of vegetative parameters and the index is calculated from the following relation:

$$\mathbf{NDVI = (NIR – RED) / (NIR + RED)}$$

where, NIR is the reflectance in the near-infrared channel and Band RED is the reflectance in the red channel. More than 90% of vegetation information are contained in these two channels. The underlying principle of the above formula is that the radiation from visible red light is considerably absorbed by chlorophyll in green plants. The radiation from

near-infrared light is strongly reflected by the spongy mesophyll leaf stricter. Environmental variations often modify the vegetation pattern. Rainfall is one of the most important parameters for vegetation growth. Soil moisture is one of the crucial parameters for investigation of vegetation condition over a region.

Study Area

Cuddalore District is bounded in latitude 11°11" to 12° 5"N and longitude78° 38" to 80° 00" E covered in an area of 3,678 sq.km. It shares its boundary with Villupuram District in North, 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.

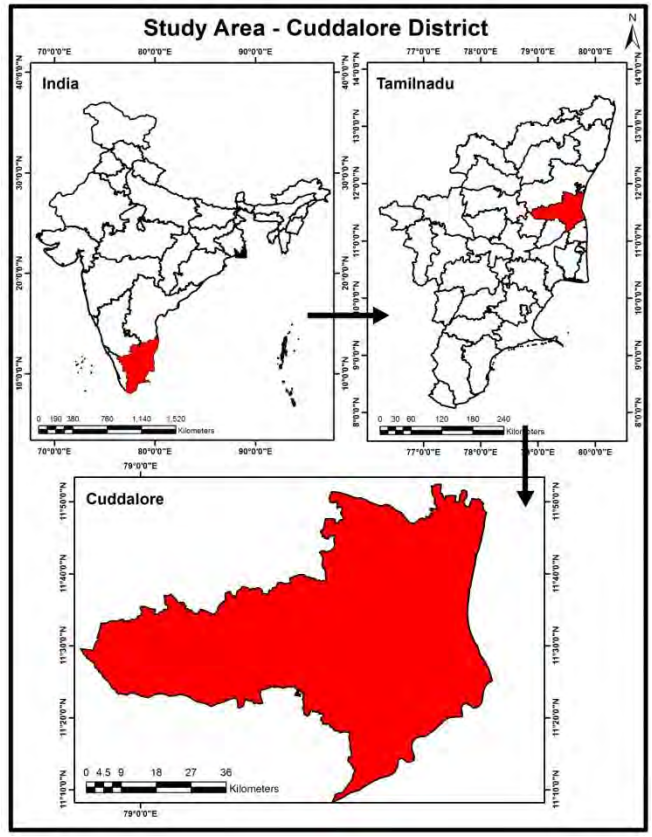

Fig. 1. Cuddalore District

As per the 2001 Census, Cuddalore had a population of 2,285,395 of which males are constituted as 1,150,908 and the remaining 1,134,487 are 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 the State with lignite, electricity, fertilisers, loco and washed clay. The sugar industry is the next primary industry in the 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).

To Examine the NDVI and Rainfall Distribution in a high flooded year of Cuddalore District the major objectives are to study the NDVI; to study the rainfall distribution and to assess the relationship between NDVI and Rainfall in Cuddalore District for the years of 1991, 2005, 2008, and 2010.

Database and Methodology

The main goal of the study is to do the quantitative assessment of vegetation cover change of a part of Cuddalore District tracts using the Normalized Difference Vegetation Index (NDVI). For digital image processing, remote sensing and GIS-based softwares (ERDAS Imagine and ArcGIS 9.3) were used for image processing, classification, analysis and NDVI map generation to achieve the objectives of this study. The ERDAS imagine was used to generate the false-color composite, by combining near-infrared (NIR), red and green which are bands 2,3,4 together for all of the four (4) imageries (1991, 2005, 2008 and 2010). This false-color composite was used for vegetation recognition; classification because the chlorophyll in plants reflects very well in the near-infrared rather than the visible band. Then four individual NDVI Maps (1991-2010) were prepared. The concept of NDVI was applied to detect areas of forest cover change and to generate year-wise NDVI derived quantitative data. Finally, NDVI derived maps of 1991, 2005, 2008 and 2010 were prepared and they were compared to generate the change detection of vegetation cover over the study area and these are further been categorised differently as decreased, some decreased, some increase and increased.

The NDVI Calculations Using Landsat TM Satellite Imageries (1991 - 2010)

The NDVI from reflectance images is obtained through channels 3 (0.63-0.69 μm) and 4 (0.78-0.90 μm). The formula for NDVI calculation is shown in equation 1.

$$\mathbf{NDVI} = \frac{\mathbf{Band\ 4 - Band\ 3}}{\mathbf{Band\ 4 + Band\ 3}}$$

Vegetation indices have long been used in remote sensing for monitoring temporal changes associated with vegetation. Soil and rock have a broadly similar reflectance giving NDVI close to ‘0'. The positive NDVI values zero indicates the presence of vegetation

classes, moderate and high values indicate stressed vegetation and healthy vegetation, respectively. Whereas, near zero and negative values indicate non-vegetation class such as water body, snow cover, built-up areas and barren land. Active vegetation has a positive NDVI being typically between about 0.1 and 0.6 values at the range indicating increased photosynthetic activity and a higher density of the canopy (Tarpley et al., 1984).

Results and Discussion

Variations of NDVI

The spatial distribution of NDVI in the Cuddalore District during the period for four selected years for 1991, 2005, 2008, 2010 is presented. It can be seen that higher NDVI was observed in Northern parts of the District where relatively higher NDVI is observed. Some regions in western region divisions along with a tiny region have experienced lower NDVI which may be due to human actions. Again in the south, the regions towards the Bay of Bengal reported in NDVI. The variation of NDVI was assessed over Cuddalore from the year 1991 to 2010.

Association of NDVI with Rainfall

Water is a crucial component in the growth of vegetation and hence, the link between water availability and vegetation growth is essential. Summer and winter rainfall showed significant variations on different scales, which has a substantial impact on crops. Many studies were reported that decreasing vegetation over India was during drought years while contrary results were shown during flood years. Many studies were done over the Indian subcontinent on vegetation variability and its relation to meteorological parameters. In order to understand the association of NDVI and rainfall over Cuddalore inter-annual variations, spatial correlation, scatter plot and annual correlation analysis is observed.

The NDVI value-based statistics are categorised in the following manner, i.e., no vegetation, moderated vegetation, dense vegetation, highly dense vegetation and these NDVI values differ significantly from 1991-2010. The NDVI derived values of the 1991 image show northern, north-eastern and few areas of central regions of the study area. During 1991 the total vegetation was around 2,006.32 km^2 and the coverage of Vegetation (Fig. 2a) was more in the Eastern and Central part of the study area. The distribution of rainfall (Fig. 2b) has less impact on vegetation growth due to deforestation and poor soil conditions, which resulted due to a flash flood in the study area. In the year 2005 (Fig 3a), the vegetation cover has decreased very rapidly, with total coverage of 2110.967 km^2. The northern and central part has thick vegetation coverage, remaining has No to Less Vegetation coverage. In 2008 the only the northern part of the study area had thick vegetation coverage remaining area has less to moderate vegetation coverage, with an area of 2,120.683 km^2. In 2010 the only the northern part of the study area had thick vegetation coverage with 2,156.4 km^2 remaining area has very less. Overall Rainfall in

Cuddalore has less correlation with the vegetation coverage. The Cuddalore District is a high flooded region.

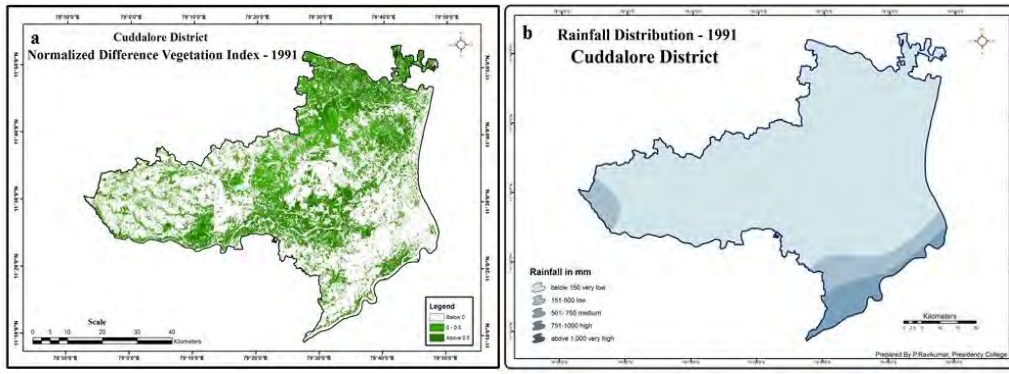

Fig. 2. The NDVI and Rainfall Distribution for 1991

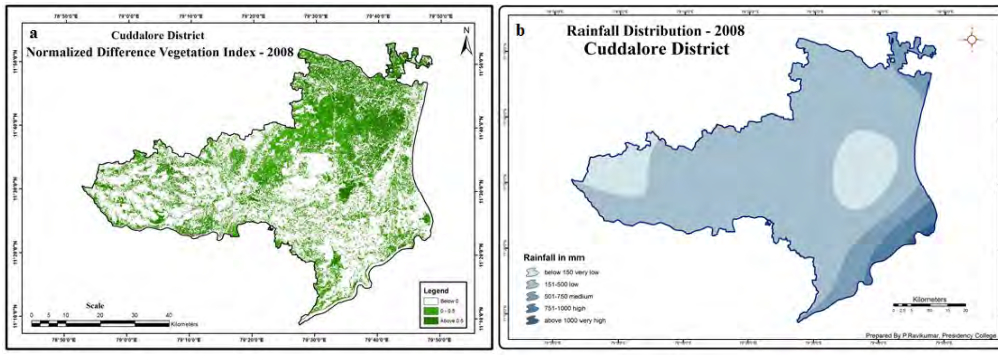

Fig.3. The NDVI and Rainfall Distribution for 2005

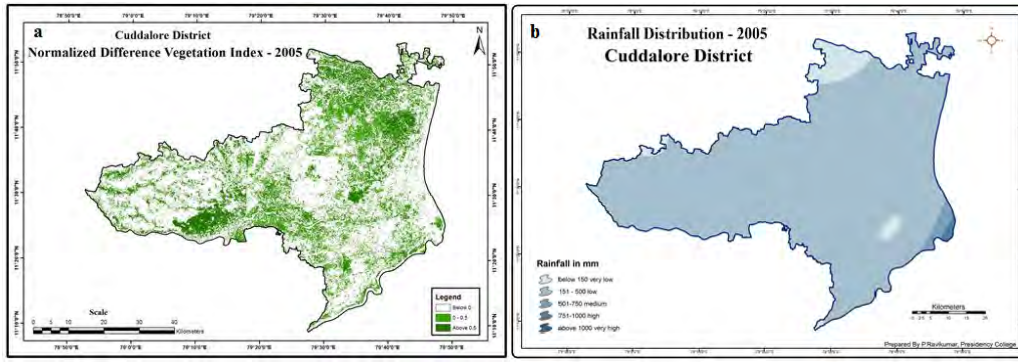

Fig. 4. The NDVI and Rainfall Distribution for 2008

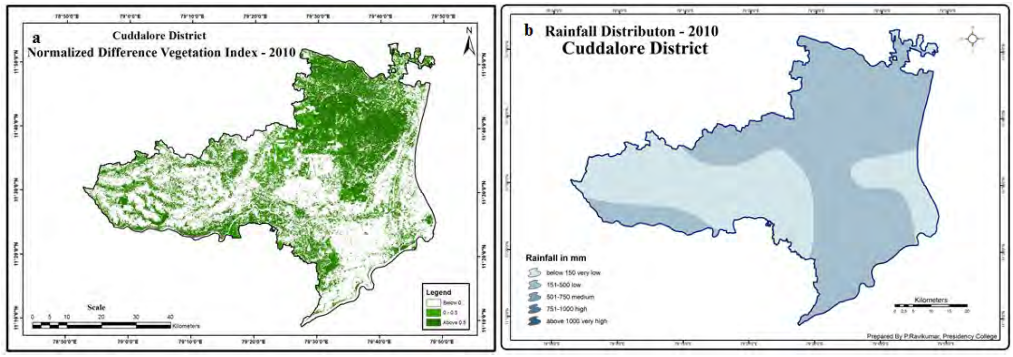

Fig. 5 The NDVI and Rainfall Distribution for 2010

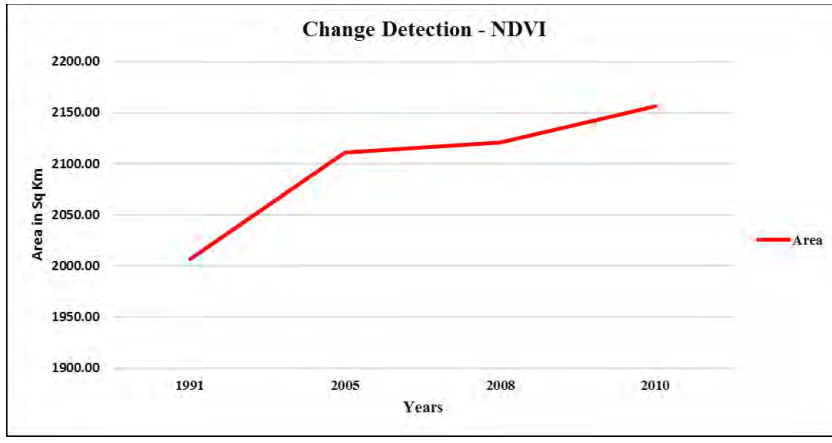

Fig. 6. Change Detection NDVI

The above image Fig. 6 shows change detection using NDVI which indicates the growth of vegetation coverage in the Cuddalore District. Due to a positive correlation with rainfall, the coverage area is increased from 1991 to 2010.

Conclusions

One of the most widely used vegetation indices is Normalised Difference Vegetation Index (NDVI) and have been reliable in monitoring vegetation change among other methods. Data on vegetation biophysical characteristics can be derived from Visible, NIR and Mid-Infra-Red portions of the electromagnetic spectrum (EMS). Here in the present study, low reflectance of vegetation was observed in the 1991 in the Cuddalore District, with an increase in NDVI values, but the vegetation reflectance was very high in 2010.

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APPLICATION OF GEOSPATIAL TECHNOLOGY IN MORPHOMETRY: A CASE OF SURULI AR BASIN, THENI DISTRICT, TAMIL NADU, INDIA

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Abstract

Geomorphometry is an interdisciplinary field that has evolved from mathematics, the earth sciences, and most recently computer applications. This analysis can be done through measurement of linear, aerial, and relief aspects of a watershed. In the present study, quantitative relief Morphometric analysis is carried out for Suruli Ar, a basin located in Theni district, Tamil Nadu. The Relief aspect of drainage basins plays a significant role in drainage growth and development, surface and sub-surface water flow, permeability, landform development and associated features of the terrain. The study analyzes the relief parameters, viz., absolute relief, relative relief, dissection index, roughness index and slope also analyzes the Bivariate relationships with each other for a better understanding of the hydrological processes operating in the drainage basin. The present study involves the applications of RS/ GIS techniques and SPSS to evaluate and compare the relief aspects of the drainage basin. After the evaluation, it was found that the above relief parameters have a strong and positive relationship with each other.

***Keywords**:* Relative relief, Absolute relief, Dissection Index, Slope, Bivariate analysis

Introduction

At present, drainage basins are mainly analysed quantitatively. The quantitative measurement of landforms is mainly the subject thrust of the morphometry. It has been well studied by various workers. Particular mention may be made of Horton (9145), Strahler (1950, 52, 54, 56, 58), Miller(1953),Schumm (1956),Melton (1958), smith (1958) Leopold (1960) and others. According to Gardiner (1982 p131), morphometry is potentially a most important approach to geomorphology. Since it offers quantitative information on large scale-fluvial landforms. It makes up a vast majority of earth configuration. Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimensions of its landforms (Clarke, 1966). Morphometric analysis provides a quantitative description of the basin geometry to understand the initial slope or inequalities in the rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin (Strahler, 1964). The Morphometric analysis can be achieved

through measurement of linear, aerial and relief aspects of basin and slope contributions (Nag and Chakraborty, 2003). It has two distinct branches (i) Relief Morphometric and (ii) Fluvial Morphometry. The present study deals with the relief morphometry, and employs the techniques of Horton (1945), Schumm (1954) and Strahler (1964).

Generally, relief is considered as the physical landscape, the actual configuration of the earth's surface; differences in altitude and slope, inequality of surface, shapes and forms. (Monkhouse,1977). In geomorphological study, the relief analysis is an initial step to understand the terrain characteristics of an area. Relief is the function of geology, drainage, climate, soil, vegetation etc. Variations of the earth's surface or part thereof which form an important aspect of terrain analysis. Differences in elevation ,resulting in variation on relief and other geomorphic attributes including absolute relief ,relative relief, dissection index, drainage frequency, drainage density, slope etc. help to classify the terrain into morphological units. Consequently an attempt has been made here to analyse the relief and slope parameters of the Suruli Ar basin. The major aim and objectives of the study are to maximum utilisation of the Geospatial Technology to understand and analyse the terrain characteristics, Grid based morphometric analysis to study the relief parameters of the Suruli Ar basin and to examine the nature of relationship between Slope, Absolute relief, Relative relief and Dissection Index.

Study Area

The present study area is Suruli Ar (Ar – River in Vernacular) which covers a major portion of Kambam valley. It lies between the Cardamom hills in the west, High wavy mountain range in the southeast, Theni-Allinagaram in the east and the Palani hills in the north. It is located between 9°34' N and 10°9' N latitudes and 77°10' E and 77°30' E longitudes with an area of 650 km^2. It consists of 3 Taluks, Bodinayyakkanur, major portion of Uthamapalayam and Theni taluk and 3 blocks with 56 villages (Fig. 1).The major river is Suruli Ar, which forms the Suruli Ar basin. The elevation of the basin ranges from 248 m to 2637 m. In general, the slope runs roughly from SW-NE direction and ends at the junction of the Suruli and the Vaigai rivers. The soils are river alluvium, forest humic soil, sandyloam, sandyclayloam and silty clay. The temperature ranges between 15o C in January and 40.5o C in May. The mean annual rainfall is about 870 mm. About 28 types of crops are being cultivated, of which paddy, maize, groundnut, cholam, vegetables and coconut are the major crops.

Database and Methodology

The present study is based on the topographic sheets published by Survey of India on the scale of 1:50,000 (for the preparation of study area map), STRM DEM(for relief analysis) and Landsat Satellite Imagery for verification. Absolute Relief (AR), Relative Relief (RR), Dissection Index (DI), Average Slope (AS) and roughness Index are the different relief parameters which have been analyzed in the study area with the help of

reprojected SRTM DEM and Arc GIS 10.2 to differentiate the physiographic characteristics and to prepare the various thematic maps elevation of a unit area. It provides an idea about the distribution of relief over the earth's surface. Generally, the absolute relief used in the delineation of terrain morphology throws light on the structural and erosional characteristics of the region. In applied geomorphology, it has received much attention particularly, in land use investigation and planning. Absolute relief of the Suruli Ar basin was obtained using the quantitative method. The contour of the study area was divided into 748 equal grids of the size of one sq km^2 and the maximum height of each grid was computed in the GIS background. The absolute relief of the Suruli Ar sub basin varies between below 300m to above 1900m. The height increases rapidly from north to south and the southeastern side. The obtained values of Suruli Ar sub basin have been classified into five categories.

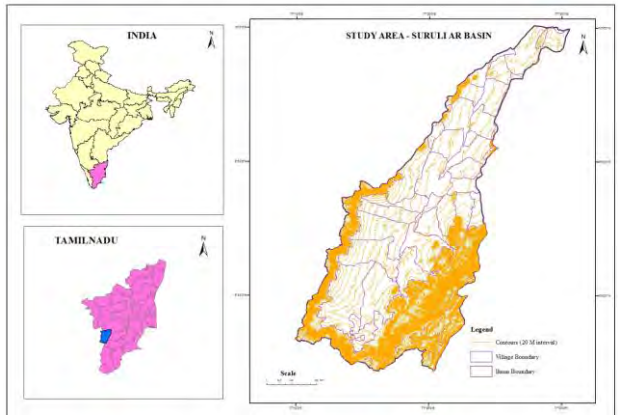

Fig. 1. Suruliar Basin

Absolute Relief

The term Absolute relief may be defined as the maximum

Table 1. Absolute relief

S.No	Absolute relief	Area	Area %	Explanation
1	0-300	297	41.29	Very Low
2	300-700	191	29.42	Low
3	700-1000	108	16.64	Moderate
4	1000-1500	32	4.93	High
5	1500-1900	50	7.70	Very High

(Source: Compiled by Author)

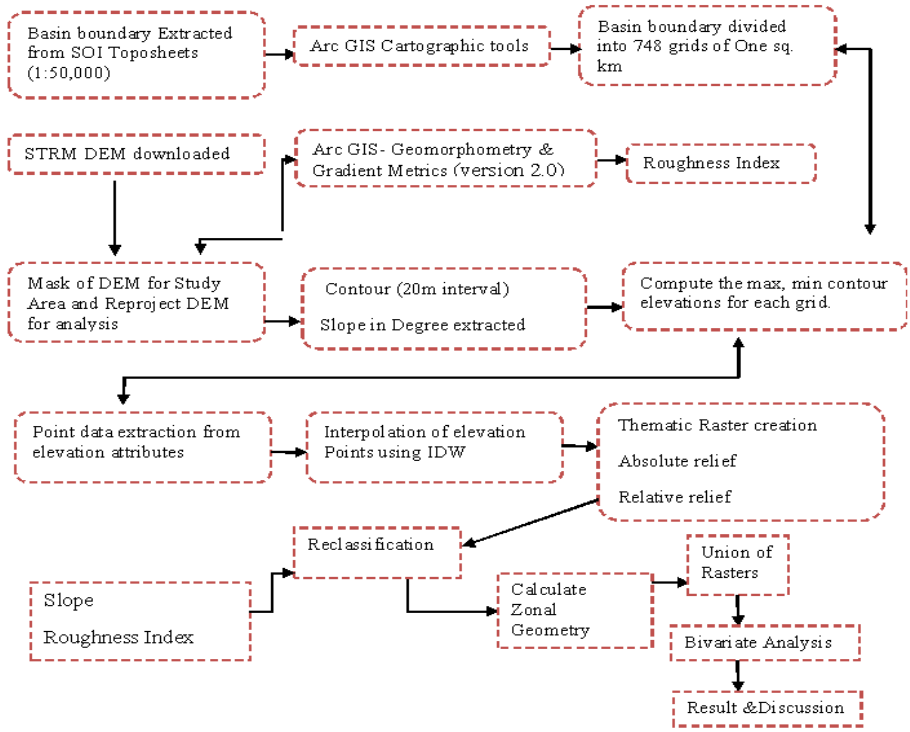

Fig. 1. Methodology Flow Chart

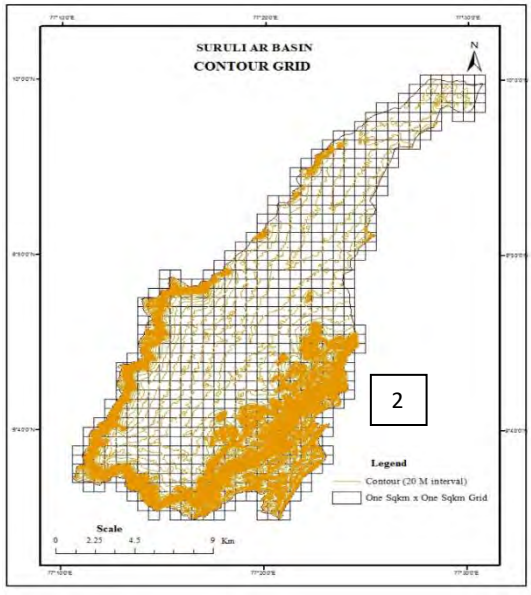

Fig. 2. Digital Elevation Model

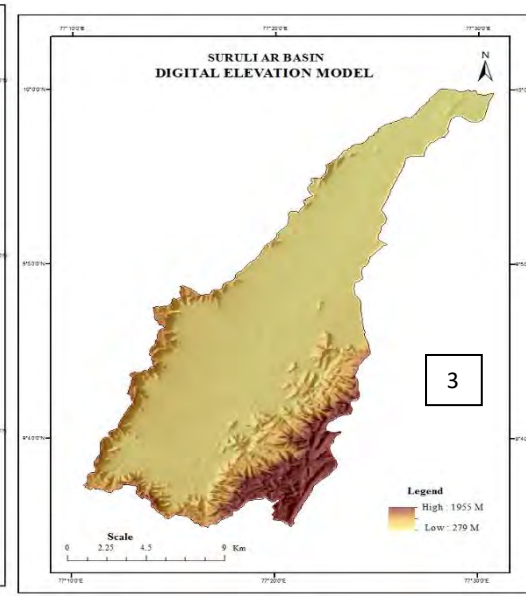

Fig. 3. Contour Grid

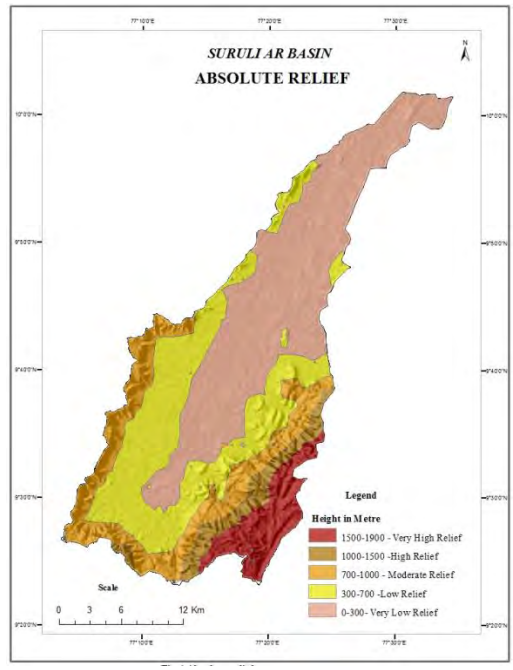

Fig. 4. Absolute Relief

The high and very high absolute relief categories have inconsequential spatial distribution from4.93%, to 7.70 % respectively. On the other hand the major part of the study area has low to very low absolute relief groups lies in between 29.42% and 41.29 % . (Table.1 and Fig 4)

Relative Relief

Relative relief is one of the most significant Morphometric as well as geomorphic variables. It is used for the overall assessment of the morphological characteristics of the terrain and for assessing the degree of dissection of the terrain. This technique has frequently been applied since the time of Smith, particularly for landform and land use analysis. In the present study, Smith's (1935) method has been adopted to calculate the relative relief. The study area has been divided into 748 equal grids of one sq km^2 for obtaining the relative relief. The methodology involves the noting of elevation differences between the highest and the lowest contours of *20 m* interval of each and every grid. Finally, the relative relief is computed for the study area, The Suruli Ar sub basin has relative relief values between 100 m to 1000 m. The range of relative relief of the study area has been divided into six categories. Table 2 indicates the relative relief that has not progressed to any great extent because the area is still largely characterized by flat or gently undulating terrain surfaces.

Table 2. Relative relief level of Suruli Ar basin

S.NO	Relief Interval	Explanation	Area in sq km	Area in%
1	0-100	Very Low	381	58.62
2	100-200	Low	80	12.31
3	200-300	Moderate	93	14.31
4	300-400	Highly Moderate	54	8.31
5	400-550	High	37	5.69
6	550-1000	Very High	4.9	0.75

(Source: Compiled by Author)

Distributional Pattern of Relative Relief

According to Table 2 and Fig 5 the very low relative relief of 381 Sqkm (58.62%) dominates the entire sub basin, Moderate relief covers an area of 90 sqkm (14.31 %) and comes in the second place. Low relief of 80 sq km (12.31%) comes in the third place. High and very high reliefs (5.69% and 0.75%) occupy only a very insignificant portion of the study area. This low relative relief indicates that the region is almost a flat land appearing in the mature stage of geomorphic evolution.

Dissection Index

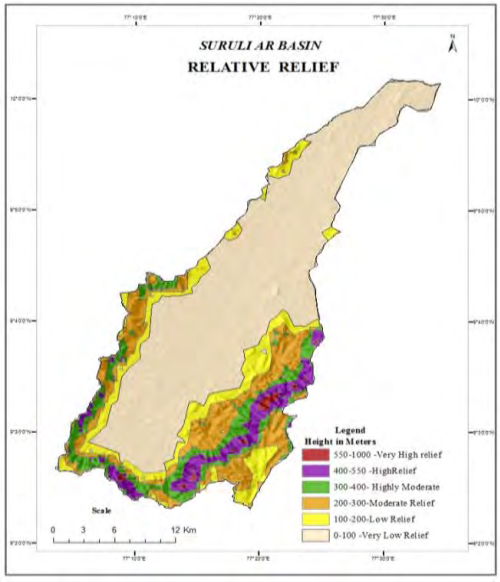

Fig. 5. Relative Relief

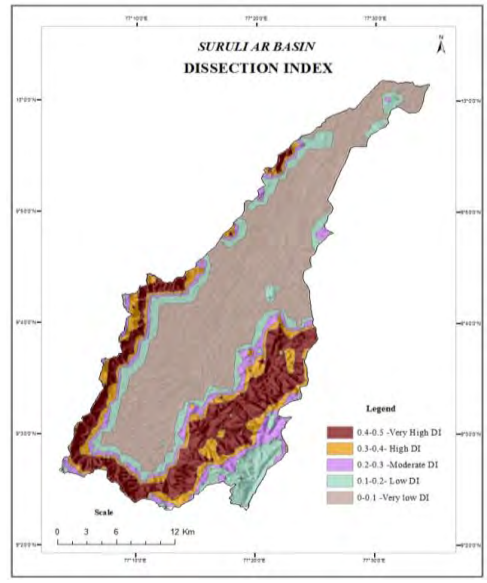

Fig. 6. Dissection Index

Drainage dissection is a significant Morphometric tool and acts as an indicator for estimating the nature and magnitude of dissection in relation to vertical exaggeration of the terrain. It is expressed as the ratio between the maximum relative altitude and absolute height. It is dimensionless because it is always expressed in terms of ratio or percentage.

The sharpness of terrain character of an area cannot be expressed adequately by interpreting the absolute relief and relative relief separately .Dov Nir(1957,p.568) states that "as a perfect criterion of relief energy, the concept of relative altitude is not entirely satisfactory. Equal relative altitudes are not always of equal importance, since their absolute altitudes may differ". Various methods of drainage dissection computation have been introduced i.e., Slaucitays (1936) and Desmet (1961) have proposed dissection index formulae but it is not an easy process. Devnir (1957) suggested as quick method which has been used in the present study. According to Devnir (1957), DI was derived with the help of the following formula:

$$\text{Dissection Index (DI)} = \frac{\text{Relative Relief } (R_{R)}}{\text{Absolute relief } (A_{R)}}$$

Table 3. Dissection Categories of Suruli Ar Basin

S.No	Dissection Categories	Area in sq km	Area %	Taxonomic Explanation	Stages of development
1	0.0-0.1	323	49.69	Very low dissection Index **D_{EL}**	Initial
2	0.1-0.2	95	14.61	Low dissection Index **D_L**	Early Youth
3	0.2-0.3	50	7.69	Moderate dissection Index **D_M**	Youthful
4	0.3-0.4	59	9.07	High Dissection Index **D_H**	Maturity
5	0.4-0.5	123	18.92	Very High Dissection Index **D_{VH}**	Late Maturity

(Source: Compiled by Author)

Very low percentages of 7.69 and 9.07 come under the category of moderate and high dissection indexes. Whereas 14.61 and 18.92 percentage areas occupy low and very high dissection Indexes. This low dissection index value suggests that the river erosion is very low and the total area is growing towards the mature stage of development in the cycle of erosion. (Table 3 and Figure 6).

Roughness Index

The term roughness index is used to express the total characteristics of land surface configuration that comes as a result of all the other individual landform characteristics like average relief relative relief, dissection index, average slope and so on. The degree of unevenness of the surface may be measured by roughness index. The value of roughness index will be greater with increasing number of contour intersection. So the maximum values of roughness index is obtained in the mountainous areas or bad land areas.

According to table 4 and Fig 7 (a) Nearly 90.15 % area of the basin comes under the low roughness index, for the reason that most part of the Basin is almost flat. (b) The high roughness index is concentrated in and around hills and hillocks. It covers 0.81% area of the Basin. (c) The moderate roughness index areas are the intermediate zone of high and low roughness index. It covers 9.03% area of the total Basin as the Basin is under low roughness index, it is lies in between youth and maturity stage.

Table 4. Roughness Index of Suruli Ar Basin

Sl. No	Roughness Index	Area in sq.km.	Area %	Explanation	Stages of Development
1	0-1	504.7	77.68	Low	Very smooth
2	1-2	81.005	12.47		
3	2-3	42.86	6.597	Moderate	Smooth
4	3-4	15.87	2.443		
5	4-5	4.49	0.691	High	Rough
6	5-6	0.79	0.122		

(Source: Compiled by Author)

Slope

Slope is an important element of the landscape which deserves micro –level analysis. It is a measure of the rate of ascent or descent per unit horizontal distance (gradient) expressed in degrees. It is directly affected by several environmental factors and also influences a few of them. It is related to almost all the Morphometric variables acting sometimes as an independent and sometimes as dependent variable. In the present study, the slope map has been prepared from the SRTM DEM using Arc GIS 10.2 and classified in to five categories (Table 5). The table depicts that the Suruli Ar basin is dominated by Level slope (66.81%) of the total area.

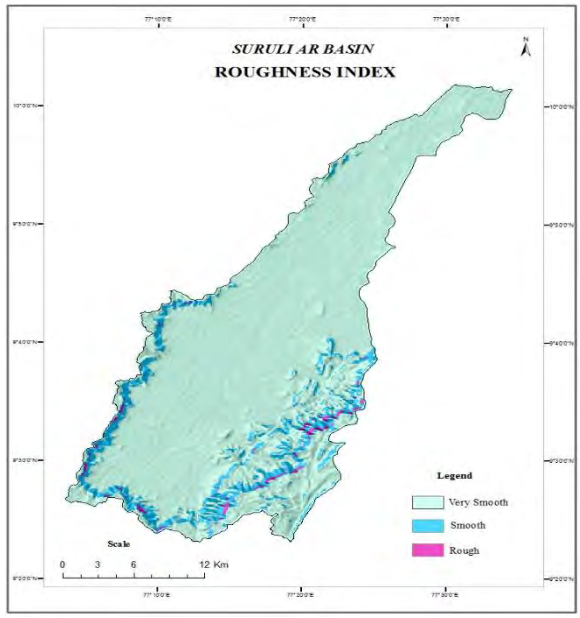

Fig. 7. Roughness Index

Table 5. Slope Level and Area of Suruli Ar Basin

S.No.	Slope in Degree	Area sq.km.	Area %	Explanation
1	0°-5°	434	66.81	level
2	5°-10°	72	11.09	gentle
3	10°-20°	64	9.86	moderate
4	20°-30°	56	8.6	Moderately steep
5	Above 30°	23	3.54	Steep slope
	Total	**649**	**100**	

Correlation Analysis Between Absolute Relief and Relative Relief

The areal distributional pattern of relative relief in various groups of absolute relief categories is shown in table 6. It is evident that the low relative relief areas are mainly occupied by absolute relief up to 700 m. Also it is noted that the low relative area does not fall in the High absolute relief area i.e. above 1000m. The general distributional pattern shows that the low relative relief area is found low in the low absolute relief area, whereas moderate and high categories of relative relief are located along the moderate and high

absolute relief zones respectively. A quantitative analysis of the relationship between the absolute relief and relative relief has also been done from the data with the help of a Table. The coefficient of correlation between absolute relief and relative relief is obtained as + 0.83. The correlation value supports the hypothesis that if the absolute value increases, the relative relief value also increases. The value also indicates that the upper Vaigai basin has attained the late mature stage of geomorphic development.

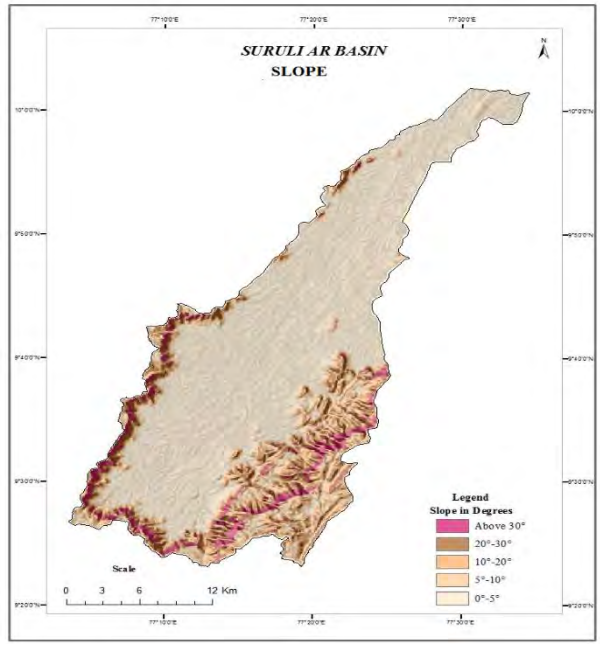

Fig. 8. Slope

Table 6. Areal Distributional Pattern of Relative Relief and Absolute Relief

Relative Relief	Absolute Relief					Total area in sq.km.
	0-300	300-700	700-1000	1000-1500	1500-1900	
0-100	264.9	114.6	0	0	0	**379.5**
100-200	0.72	59.4	4.7	0	14.2	**79.02**
200-300	0	19.91	51	0.45	24.5	**95.86**
300-400	0	0	37	8	7.02	**52.02**
400-550	0	0	11	20.1	6.76	**37.86**
550-1000	0	0	0.36	4.05	0.54	**4.95**
	265.62	**193.91**	**104.06**	**32.6**	**53.02**	**649.21**

Correlation Analysis Between Relative Relief and Dissection Index

It is clear from the Table 7 that there is a well-defined pattern of distribution of dissection index according to relative relief categories. The low values of dissection index are found in between less than 0-200 m relative relief categories, while the moderate and highly moderate dissection indexes are occupied by 200-300m.

The highly dissected areas are found at 550-1000m. The coefficient of correlation between dissection index and relative relief has also been observed high positive i.e., + 0.92. The correlation value supports that the hypothesis the higher positive value indicates the higher dependency of dissection index on relative relief.

Table 7. Areal Distributional Pattern of Relative Relief and Dissection Index

Relative Relief	Dissection Index					
	0-0.1	**0.1-0.2**	**0.2-0.3**	**0.3-0.4**	**0.4-0.5**	**Area in sq.km**
0-100	323.58	51.16	1.89	0	0	**376.63**
100-200	0.18	27.47	30.96	20.53	2.07	**81.21**
200-300	0	13.7	11.34	24.84	45.65	**95.53**
300-400	0	0	3.6	8.1	41.41	**53.11**
400-550	0	0	0	8.75	29.25	**38**
550-1000	0	0	0	0	4.95	**4.95**
Total	**323.76**	**92.33**	**47.79**	**62.22**	**123.33**	**649.43**

Correlation Analysis Between Absolute Relief and Dissection Index

It is understandable that the low and very low dissection indexes are located below 700m absolute category. The moderate dissection index areas are found between 700-1000m absolute category. The high dissection index (0.4-0.5) areas are found in moderate absolute category.

The correlation coefficient between the two variables has been obtained as **0.76**. The positive value indicates the direct relationship between these two variables obtaining the late mature stage of geomorphic development. (Table 8)

Table 8. Areal Distributional Pattern of Absolute Relief and Dissection Index

	Dissection Index					
Absolute Relief in metres	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	**Area in sq km**
0-300	247.9	19.58	0.72	0	0	**268.2**
300-700	75.28	48.64	29.6	22.4	15.33	**191.25**
0-1,000	0	0.96	4.33	22.8	79.73	**107.82**
1,000-1,500	0	0	0.19	6.94	24.72	**31.85**
1,500-1,900	0.21	25.62	14.6	7.2	2.82	**50.45**
Total	**323.39**	**94.8**	**49.44**	**59.34**	**122.6**	**649.57**

Correlation Analysis Between Slope and Absolute Relief

The low slope values are occupied by < 700m absolute relief zone. Moderate slope categories are in between700-1000 m of absolute relief zone. The maximum slope 40.90 % of the study area lies between 0-300 m absolute zone. The correlation coefficient between the two variables has been obtained as **+0.82**. A The positive value indicates the direct relationship between these two variables. It also gives the late mature stage of geomorphic development of the study area. But it should not be inferred that the higher absolute relief always carries the higher angle of slopes. (Table 9)

Table: 9.Areal Distributional Pattern of Slope and Absolute Relief

	Absolute Relief					
Slope in degree	0-300	300-700	700-1000	1000-1500	1500-1900	**Area in sq km**
0°-5°	265.97	153.9	8.3	0.155	5.44	**433.765**
5° - 10°	2.11	20.52	29.53	2.26	17.43	**71.85**
10°-20°	0.24	10.87	27.91	8.18	15.83	**63.03**
20°-30°	0.044	7.22	29.35	13.45	7.91	**57.974**
Above 30°	0	0.4	11.65	7.51	3.4	**22.96**
Total	**268.36**	**192.91**	**106.74**	**31.55**	**50.01**	**649.5**

Correlation Analysis Between Slope and Relative Relief

The low slope values are found up to 200 m of relative relief categories. The low relative relief categories include insignificant amount of high slope categories. The high slope categories are found mainly from 300-400 m relief zone. The higher relative relief categories are mainly experienced with higher slope categories. (Table 10). The correlation coefficient between slope and relative relief is highly positive as **0.99.** This positive value indicates that there is a direct relationship between these two variables, viz., with the increase of one variable, the other variable also increases.

Table 10. Areal Distributional Pattern of Slope and Relative Relief

Slope in degree	Relative Relief						Area in sq.km.
	0-100	100-200	200-300	300-400	400-550	550-1000	
0°-5°	375.50	40.68	12.23	1.98	0.44	0	**430.86**
5° - 10°	4.493	25.64	35.75	0.09	0.29	0.02	**66.30**
10°-20°	0.424	15.06	29.34	17.49	10.93	0.05	**73.31**
20°-30°	0.067	4.40	19.04	19.59	13.84	1.34	**58.29**
Above 30°	0	0.22	2.92	0.69	13.64	3.39	**20.87**
Total	**380.49**	**86.023**	**99.30**	**39.86**	**39.16**	**4.80**	**649.65**

Correlation Analysis Between Slope and Dissection Index

It is observed from the table 11, that low slope categories are characterized by less than 0.3 DI zone. Also the low Dissection Index does not have the high slope values. On the other hand, the high dissection index zone (0-4-0.5) have high slope values. So the general pattern states that the slope values are increasing with the increase of dissection index in the study area. Also the coefficient correlation between two variables is positive (+0.9) and strong.

Table 11. Areal Distributional Pattern of Slope vs Dissection Index

Slope in degree	Dissection Index					
	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	Area in sq.km.
0°-5°	323.58	51.16	1.89	0	0	433.4
5° - 10°	0.18	27.47	30.96	20.53	2.07	71.77
10°-20°	0	13.7	11.34	24.84	45.65	64.24
20°-30°	0	0	3.6	8.1	41.41	57.31
Above 30°	0	0	0	8.75	29.25	23.03
Total	0	0	0	0	4.95	**649.75**
	323.76	**92.33**	**47.79**	**62.22**	**123.33**	

Table 12. Correlation Matrix of Relief Parameters

	Slope	***AR***	***RR***	***DI***
Slope	1	0.821044	0.996637	0.9411
AR		1	0.836975	0.761315
RR			1	0.928912
DI				1

Conclusions

The present study has proved that Geospatial application is a valuable technique for analysis of relief morphometric parameters. From the above morphometric analysis it is observed that Suruli Ar basin has high altitude in the south and southeastern side and has low altitude in south-western to northeastern side. From the correlation analysis it is observed that the four parameters viz, slope, relative relief, absolute relief and Dissection Index have strong and positive relationship with each other. Also the low slope value is characterized by low absolute value, low relative relief value and low dissection index value and the higher absolute relief do not carry the higher angle of slope values.

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DISTRICT-WISE ANALYSIS OF DECADAL VARIATION IN POPULATION AND SEX RATIO OF TAMIL NADU FROM 1901 TO 2011

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Abstract

The population factors like decadal variation and sex ratio play an important role in the development activities of any region. The natural growth exposes the prosperity of the particular region. This study relationship of decadal variation in population and sex ratio provides the current demographic scenario of Tamil Nadu. The correlation method is used to analysis the relationship and the values tabulated and represented in thematic maps. The districts under various categories of relationship are classified and changes are discussed.

Keywords: Decadal variation, Sex ratio, Development, Demographic scenario, Thematic maps

Introduction

In population geography, the main focus of study is the human population. Clarke observed that the main task of population geography is to study areal variations in population and their relation with physical, cultural, and economic phenomena. Population is one of the valuable resources for the growth and development of a country. Man utilizes his natural resources and develops his cultural environment. By utilizing various natural resources he develop agricultural industry, trade and transport which in turn help man in his social organisation, political management and cultural development. In the absence of population no development occurs. The size, distribution and structure of the population within a country must be viewed in relation to its natural resources and the techniques of production used by the people. A country is said to have an optimum population when the number of people is in balance with the available resources.

In a demographic study, the change of total population size seems to be one of the first fact facts to gain major attention. More over this type of change is easy to measure. It can approach in two ways. One is to find difference between the number of people present at two different date (an absolute number), and from this to calculate the annual rate of change during the intervening period (a relative number); the other is to be reckon the rate of change from the records of individual changes as they occurred - births, deaths and

migration- based on vital statistics. In the first approach only two numbers are needed; the total population as determined at each of two dates, either by censuses of registration. If two censuses cover the same territory, and follow similar rules of enumeration, the change in size of the population may be measured as the total determined in the second census (P_2) minus the total in the first census (P_1). The relative change is measured by the ratio P_2-P_1/ P_1or the observed change in numbers divided by the number of people at the beginning of the period.[1] The growth of population in terms of percentage is generally calculated by dividing the absolute change by the population at an earlier date and multiplying it by hundred. Logically, the denominator should be mid-period population, but since the mid-period population will have to be estimated, therefore, the growth rate is normally calculated by using the actual population size at the beginning point of the period under review.

In demography, *population growth* is used informally for the more specific term *population growth rate* and is often used to refer specifically to the growth of the human population of the world. Whether a population grows or declines is controlled by the relative balance or mortality, fertility and migration, which are in turn influenced by six groups of factors: biological, environmental, economic, social, political and technological.

Population growth is determined by four factors, births (**B**), deaths (**D**), immigrants (**I**), and emigrants (**E**). In other words, the population growth of a period can be calculated in two parts, natural growth of population (B-D) and mechanical growth of population (I-E), in which mechanical growth of population is mainly affected by social factors, e.g. the advanced economies are growing faster while the backward economies are growing slowly even with negative growth. Growth can be both positive and negative i.e. growth can be increasing or decreasing. Globally, the growth rate of the human population has been declining since peaking in 1962 and 1963 at 2.20% per annum. In 2009, the estimated annual growth rate was 1.1%. The CIA World Fact book gives the world annual birthrate, mortality rate, and growth rate as 1.915%, 0.812%, and 1.092% respectively[5]. The last 100 years have seen a rapid increase in population due to medical advances and massive increase in agricultural productivity made possible by the Green Revolution.

The actual annual growth in the number of humans fell from its peak of 88.0 million in 1989, to a low of 73.9 million in 2003, after which it rose again to 75.2 million in 2006. Since then, annual growth has declined. In 2009, the human population increased by 74.6 million, which is projected to fall steadily to about 41 million per annum in 2050, at which time the population will have increased to about 9.2 billion. Each region of the globe has seen great reductions in growth rate in recent decades, though growth rates remain above 2% in some countries of the Middle East and Sub-Saharan Africa, and also in South Asia, Southeast Asia, and Latin America.

Some countries experience negative population growth, especially in Eastern Europe mainly due to low fertility rates, high death rates and emigration, as well as abortion. In Southern Africa, growth is slowing due to the high number of HIV-related deaths. Some Western Europe countries might also encounter negative population growth.

Japan's population began decreasing in 2005. The population growth is major factor to study the trend and to analyse availability of resources. The population and its growth trend are important economic factors in a developing economy. As the development programme and policies depend on its growth, trend in the growth of population and its constituents are analysed here.

Sex ratio signifies the number of females per thousand males. An inverse enunciation of the ratio (i.e., the number of males per 1000 females) is also given sometimes. The primary sex ratio is the ratio at the time of conception, secondary sex ratio is the ratio at time of birth, and tertiary sex ratio is the ratio found at the time of enumeration[6]. The human sex ratio is of particular interest to anthropologists and demographers. In human societies, however, sex ratios at birth may be considerably skewed by factors such as the age of mother at birth, and by sex-selective abortion and infanticide. The CIA world fact book estimates that the current world wide sex ratio at birth is 107 boys to 100 girls. In 2010, the global sex ratio was 986 females per 1,000 males and trended to reduce to 984 in 2011. The main aim and objectives of the study are to identify relationship between decadal variation in population and sex ratio in district wise and its comparison with state average.

Study Area

Tamil Nadu State is situated at the South Eastern extremity of the Indian Peninsula bounded on the north by Karnataka and Andhra Pradesh on the east by Bay of Bengal, on the South by the Indian Ocean and on the West by Kerala State. Tamil Nadu covers an area of 130,058 km^2 (50,216 sq. mi), and is the eleventh largest state in India by area and the seventh most populous state. It is the second largest state economy in India as of 2012.

The State can be divided broadly into two natural divisions (a) the Coastal plains of South India and (b) the hilly western area. The State has an uninterrupted coastline of 922 Km. The Western Ghats averaging 3,000 to 8,000 feet height run along the western part with the hill group of the Nilgiris and Anaimalai on either side of it. The Western Ghats form complete water shed and no river pierces through them. The main stream viz., Paralliyar and Vattaseri Phazhayar are 37 and 23 miles respectively in length and fall in the Arabian Sea. All the other rivers are east flowing rivers.

The State of Tamil Nadu is divided into 32 administrative districts, which in turn are further bifurcated into smaller divisions and sub-divisions, including a total of 226 Taluks 1127 revenue blocks and 16,564 revenue villages. The state capital, Madras now renamed, as Chennai is the fourth largest city in the Indian Sub-continent and 30th largest city in the world. The state ranked 6th among states in India according to the Human Development Index as of 2011.

Database and Methodology

The present study shows the district wise comparative analysis of decadal variation in population, and sex ratio from 1901 to 2011. The statistical technique, correlation is carried out for data analysis. In correlating data we seeks to show how a mass of items is related quantitatively in its up and downs to the ups and downs of another mass of items with which it is connected. Correlation analysis between year and sex ratio, year and decadal variation in population, and decadal variation in population and sex ratio carried out. The result was classified, tabulated and mapped in district wise for spatial-temporal analysis. The correlation value between variable are categorised as follows.

Correlation Interval	*Correlation Category*
-1.0 to -0.5	High Negative
-0.5 to 0.0	Low Negative
0.0 to 0.5	Low Positive
0.5 to 1.0	High Positive

Results and Discussion

Changes in Decadal Variation in Population and Sex Ratio from 1901 to 2011

The Figure 1and Table 1 shows the distribution of decadal variation in population in percentage from 1901 to 2011. The average growth population of Tamil Nadu is 27.21% for 11 decades. Negative growth occurred in six districts (Dharmapri, Krishnagiri,Viluppuram, Cuddalure, Nagapattinam, Thiruvarur, amd Thanjavur) during 1911 to 1921, and it was decreased to one district (Pudukkottai) in 1931. Beside this negative growth occurred in Ramanathapuuram during 1941 to 1951. In all other district the decadal variation was in positive growth instead of natural growth.

Population

The Figure 1 shows changes in sex ratio during the period of 1901 to 2011. In year 1901 the sex ratio of Tamil Nadu was 1,044 and it decreased to 974 in the year 1991 again it started to rise to 995 in 2011. Except Kaniakumari, Nilgiris and Chennai, all other district shows a decreasing trend in sex-ratio. In 1971 onward the range of sex-ratio ranging in between 900 to 1,100, later it was 800 to 1,200. In most of the district the decadal growth of population is increasing but the sex ratio are considerably decreases. It will result social inequalities in the society and it will create disparities in the developmental activities.

Table 1. District wise Decadal variation in population and sex-ratio of Tamil Nadu 1901 to 2011

ID	Districts		1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001	2011	Co
1	Thiruvallur	*SR*	986	994	986	981	970	966	948	940	953	957	971	983	-0.44
		DV		7.2	5.08	8.52	9.8	7.69	10.7	30.01	30.5	31.53	23.1	35.25	
2	Chennai	*SR*	983	949	913	901	911	922	901	904	934	934	957	986	-0.42
		DV		3.9	3.04	23.9	20.3	59.8	22.09	45.2	27	17.24	13.1	7.77	
3	Kancheepuram	*SR*	986	994	986	981	970	978	973	956	961	962	975	985	-0.49
		DV		7.2	5.08	9.16	9.8	7.69	13.13	30.32	28.2	26.14	19.2	38.69	
4	Vellore	*SR*	1035	1033	1019	1006	991	1000	986	973	979	978	997	1004	-0.70
		DV		9.3	2.88	12.9	17.2	16.4	8.44	22.74	17.8	15.14	14.9	12.96	
5	Dharmapuri	*SR*	1016	1014	1003	994	982	987	982	970	959	933	932	946	-0.61
		DV		4.65	-4.45	16.73	15.65	12.69	10.45	29.82	17.78	24.51	15.27	16.04	
6	Krishnagiri	*SR*	1016	1014	1003	994	982	972	958	968	959	949	944	956	-0.75
		DV		4.65	-4.45	16.73	15.65	12.53	32.98	22.85	20.08	19.22	19.62	20.67	
7	Tiruvannamalai	*SR*	1011	1009	1007	1000	993	1006	993	968	979	983	995	993	-0.49
		DV		16	7.69	13.6	9.62	4.25	8.6	14.75	17.2	14.4	7.01	12.94	
8	Viluppuram	*SR*	1014	1014	1013	1004	992	992	986	967	972	969	984	985	-0.70
		DV		12.2	-1.8	5.79	6.28	6.44	7.13	17.22	15.9	16.08	7.43	16.99	
9	Salem	*SR*	1037	1023	1013	1017	1001	989	969	953	939	925	929	954	-0.44
		DV		3.51	7.93	12.6	19.1	20.34	12.19	24.35	13.7	13.43	17.2	15.37	
10	Namakkal	*SR*	1037	1023	1013	1017	1001	1021	1008	983	969	960	966	986	-0.31
		DV		3.51	7.93	12.6	19.1	20.34	2.12	14.99	17.7	12.79	12.9	15.25	
11	Erode	*SR*	1032	1029	1009	1009	996	994	976	958	949	952	968	992	-0.63
		DV		7.14	6.31	11.38	15.01	17.21	9.49	22.47	17.15	13.56	11.85	12.05	
12	The Nilgiris	*SR*	840	868	888	842	858	902	914	944	957	983	1014	1041	-0.48
		DV		5.08	6.66	33.8	23.9	48.65	31.3	20.7	27.6	12.7	7.31	-3.55	
13	Coimbatore	*SR*	1014	1012	992	992	979	977	944	943	946	952	968	1001	-0.64
		DV		7.14	6.31	11.38	15.01	17.21	19.22	25.70	17.47	12.50	16.96	19.06	
14	Tiruppur	*SR*	1050	1048	1027	1027	1014	1012	989	978	966	960	963	988	-0.61
		DV		7.14	6.31	11.38	15.01	17.21	7.38	19.08	17.09	15.67	25.34	28.69	
15	Dindigul	*SR*	1049	1048	1039	1036	1025	1014	1002	990	980	976	986	998	-0.56
		DV		9.29	4.25	5.68	13.4	11.2	8.71	18.64	11.9	12.54	9.22	12.39	
16	Karur	*SR*	1053	1061	1042	1046	1025	1022	1012	1005	996	999	1010	1015	-0.46
		DV		8.52	4.12	0.68	12.8	14.31	6.69	7.54	10.1	12.87	9.54	15.06	
17	Tiruchirappalli	*SR*	1053	1061	1042	1046	1025	1008	999	978	981	982	1001	1013	-0.76
		DV		8.52	4.12	0.68	12.8	14.31	10.12	26.59	15.1	15.57	10.1	12.22	
18	Perambalur	*SR*	1053	1061	1042	1046	1025	1016	1012	995	999	975	1006	1006	-0.76
		DV		8.52	4.12	0.68	12.8	14.31	7.57	18.68	12.4	17.92	9.45	14.36	
19	Ariyalur	*SR*	1053	1061	1042	1046	1025	996	995	984	975	975	1006	1016	-0.67
		DV		8.52	4.12	0.68	12.8	14.31	9.91	17.37	11.5	11.16	9.29	8.19	
20	Cuddalore	*SR*	1014	1014	1013	1004	992	1004	982	973	972	967	986	984	-0.77
		DV		12.2	-1.8	5.79	6.28	6.44	13.53	20.67	16.5	16.13	7.66	13.80	
21	Nagapattinam	*SR*	1110	1104	1082	1085	1055	1050	1026	999	992	993	1014	1025	-0.70
		DV		5.43	-2.02	2.86	7.43	15.93	10.38	14.1	13.4	11.68	8.07	8.41	
22	Thiruvarur	*SR*	1110	1104	1082	1085	1055	1032	1020	996	984	987	1014	1020	-0.74
		DV		5.43	-2.02	2.86	7.43	15.93	9.42	16.43	12.9	12.04	6.31	8.43	
23	Thanjavur	*SR*	1110	1104	1082	1085	1055	1016	1005	988	988	996	1021	1031	-0.79
		DV		5.43	-2.02	2.86	7.43	15.93	7.29	20.87	16	11.13	7.91	8.42	
24	Pudukkottai	*SR*	1087	1097	1085	1098	1063	1051	1032	1011	1007	1005	1015	1015	-0.76
		DV		6.54	4.2	-5.64	8.55	13.07	6.58	26.24	22.1	14.72	9.98	10.90	
25	Sivaganga	*SR*	1180	1161	1151	1145	1118	1112	1079	1058	1046	1033	1038	1000	-0.64
		DV		6.79	3.13	6.31	8.68	3.87	11.4	18.6	12.4	10.72	4.74	16.09	
26	Madurai	*SR*	1043	1038	1028	1026	1015	1010	997	981	972	964	978	990	-0.38
		DV		15.4	4.09	12	13.1	20.6	12.68	25.49	18.1	17.51	7.41	17.95	
27	Theni	*SR*	1043	1038	1028	1026	1015	998	993	989	974	964	978	990	-0.12
		DV		15.4	4.09	12	13.1	20.6	11.96	23.81	14.7	12.98	4.25	13.69	
28	Virudhunagar	*SR*	1036	1036	1025	1038	1037	1035	1024	1012	1002	994	1012	1009	-0.69
		DV		12.1	5.54	6.93	3.93	11.94	13.08	18.43	16.5	16.71	11.9	10.96	
29	Ramanathapuram	*SR*	1158	1156	1166	1171	1121	1154	1091	1068	1030	1011	1036	977	-0.48
		DV		8.07	0.31	7.99	11.7	-4.62	27.41	17.15	21.4	12.11	6.12	12.63	
30	Thoothukkudi	*SR*	1056	1064	1064	1075	1063	1074	1064	1053	1055	1051	1050	1024	-0.35
		DV		8.09	3.22	6.80	8.34	5.16	9.94	16.65	11.56	7.71	7.92	9.14	
31	Tirunelveli	*SR*	1065	1069	1041	1070	1052	1047	1045	1035	1037	1034	1042	1024	-0.48
		DV		8.10	8.72	7.62	10.79	12.40	8.40	17.58	11.72	12.64	8.93	13.66	
32	Kanniyakumari	*SR*	996	990	981	993	992	980	979	972	985	991	1014	1010	-0.91
		DV		17.5	17	17.8	16.4	22.07	20.67	22.63	16.4	12.43	4.73	11.17	
	Tamil Nadu	***SR***	**1044**	**1042**	**1029**	**1027**	**1012**	**1007**	**992**	**978**	**977**	**974**	**987**	**995**	**-0.80**
		DV		**8.57**	**3.47**	**8.52**	**11.9**	**14.66**	**11.85**	**22.3**	**17.5**	**15.39**	**11.7**	**15.60**	

(Source for Table 1: http://censusindia.gov.in/2011-prov-results/data_files/Tamil Nadu ***SR****-Sex Ratio,* ***DV****-*Decadal Variation of Population in Percentage, **Co**-*Correlation of decadal variation in percentage and Sex ratio)*

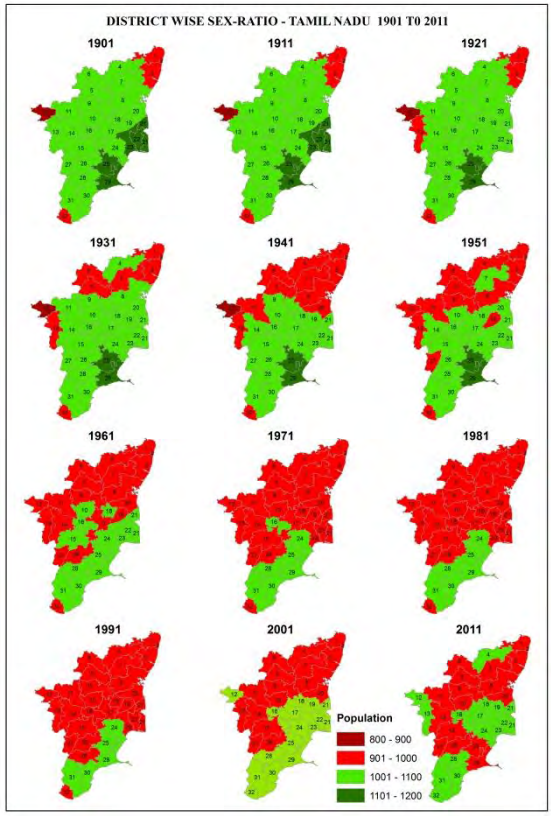

Fig. 1. Sex Ratio

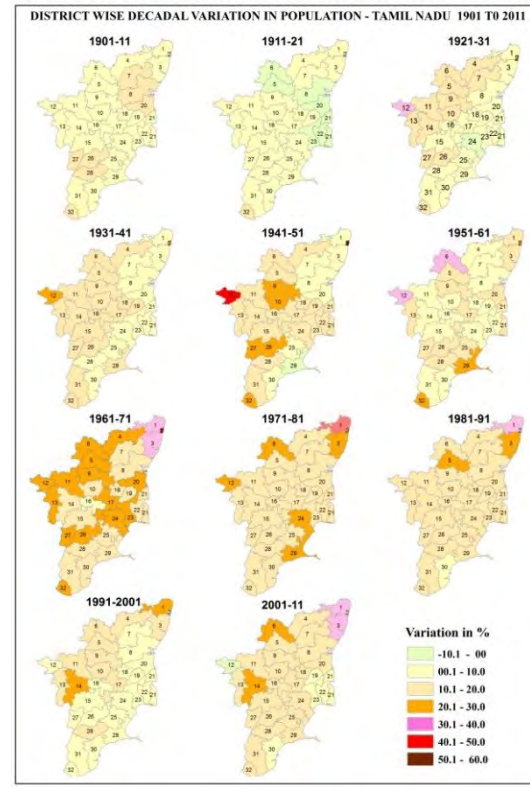

Fig. 2. Decadal Variation

Correlation of Decadal Variation of Population and Sex-Ratio from 1901 to 2011

The Table 2 and Figure 3 show the relationship between decadal variation in population and changes in the sex ratio. The entire Tamil Nadu has perfect negative correlation with decadal growth of population and changes in sex ratio. Among the 32 districts 19 districts has high negative correlation.

After the 110 years of changes in population growth and changes in sex ratio are perfectly negative in whole districts of Tamil Nadu. The Kanniyakumari (-0.91), which is the highest negative relation state. When the total population growth rate of the Kanniyakumari is decreasing the sex ratio is increasing.

Table 2. Correlation Class

Correlation Category	Correlation Class Interval	No. of Districts	Name of the District
High Negative	-1 to -0.5	19	Dindugal, Dharmapuri, Tiruppur, Erode, Coimbatore, Sivaganga, Ariyalur, Virudhunagar, Vellore, Vilupuram, Nagappattinam, Thiruvarur, Krishnagiri, Trichy, Perambalur, Pudukkottai, Cuddalore, Thanjavur, Kanniyakumari
Low Negative	-0.5 to 0	13	Theni, Namakkal, Tuticorin, Madurai, Chennai, Thiruvallur, Salem, Karur, The NiLgiris, Ramanadhapuram, Thirunelveli, Kancheepuram, Thiruvannamalai
Low Positive	0 to 0.5	0	NIL
High Positive	0.5 to 1	0	NIL

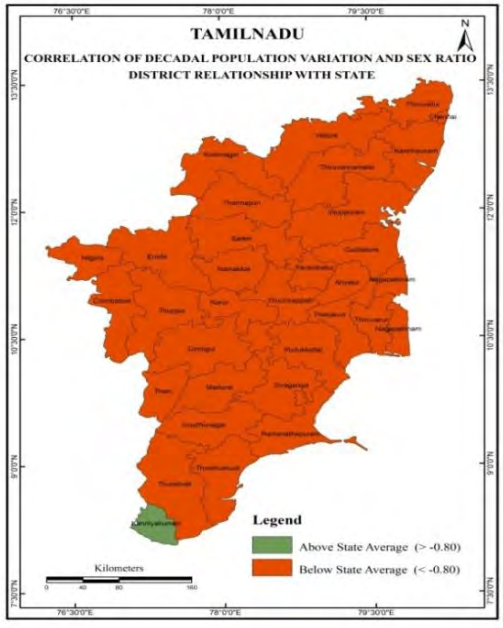

Fig. 3. Correlation of Population, 1901-2011 and Sex Ratio

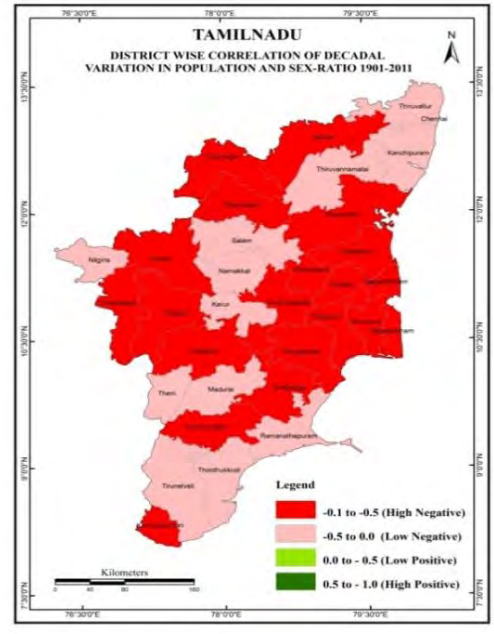

Fig. 4. Correlation of Decadal Population

Positive growth in sex ratio and a negative growth in population in Kanniyakumari resulted high negative correlation, and these changes occurred in last decades that is after 1981. There are 13 districts out of 32 is low negative growth. Theni (-0.12) has lowest negative growth, may presume a positive correlation in the next decade.

Changes in Sex Ratio and Decadal Growth of Population of district and its Relationship with State

The Table 3, and Figure 4 shows the relationship of change in sex ratio and decadal growth of district with state. There 31 districts among 32 is below the state value. Tamil Nadu have perfect negative correlation with changes sex ratio and decadal growth of population. It means when the population of state increasing the sex ratio of the state decreasing.

Table 3. Correlation Category

Correlation Category	No. of Districts	Name of the District
Below the State *(Value below - 0.80)*	1	Kanniyakumari
Above the State *(Value above - 0.80)*	31	Theni, Namakkal, Tuticorin, Madurai, Chennai, Thiruvallur, Salem, Karur ,The Nilgiris, Ramanadhapuram, Thirunelveli, Kancheepuram, Thiruvannamalai, Dindugal, Dharmapuri, Tiruppur, Erode, Coimbatore, Sivaganga, Ariyalur, Virudhunagar, Vellore, Vilupuram, Nagappattinam, Thiruvarur, Krishnagiri, Trichy, Perambalur, Pudukkottai, Cuddalore, Thanjavur

Kanniyakumari is the only district has high negative correlation where the rate of decadal growth of population is decreasing while the sex ratio is increasing. Cuddalore (-0.77) and Thanjavur (-0.79) are other districts which shows high negative correlation.

Conclusions

The population can be change, not only their size, but also their characteristics. This certainly impresses on of the dynamic nature of demographic process.[10] It is the expectation of every developing countries, an optimum population. Some awareness of a need for family planning was apparent in India as early as the 1920s when the first family planning clinics were opened, but the population of India has continued to grow rapidly throughout the twentieth century. Unless the Indian constitution, individual states are responsible for the administration and implementation of family planning programmes through state family planning bureaux, but virtually the entire cost is borne by the central government. Sex ratio and its decadal changes in population have strong negative relation in Tamil Nadu state. After analysing the 110 years of changes in population growth and changes in sex ratio by district wise of Tamil Nadu has negative relationship. Major findings are as follows.

1. There are 19 districts has found strong negative relation in sex ratio with decadal growth of population. Remaining 13 districts found low negative relationship.
2. In the Nilgiris district decadal variation of the population was increased up to 48.65% in the year 1951 and thereafter it was decreased to -3.55 in the year 2011.
3. Theni district shows low negative relationship (-0.12) with sex ratio and decadal growth of population, the sex ratio is considerably decreased from 1,043 in the year 1901 to 990 in the year 2011. The decadal change in the growth of population was also found fluctuated in Theni district from the year 1901 to 2011.
4. The districts Thiruvallur, Chennai and Kancheepuram never attained equal sex-ratio.
5. The decadal growth of population of Tamil Nadu is increasing while the sex-ratio is decreased from 1044 in the year 1901 to 987 in the year 2001 and thereafter it increased to 995 in the year 2011.
6. Kanniayakumari district has strong negative relation (-0.91) between sex ratio and decadal growth of population. The sex ratio is increased from 996 in the year 1901 to 1010 in the year 2011, but the trend of change in decadal growth of population is declining from the year 1971.
7. The sex ratio of Tamil Nadu was 1044 in the year 1901 and it was decreased to 995 in the year 2011. The trend of rate of decadal variation in population was decreasing from 1910 to 2011. Tamil Nadu experiencing strong negative relationship of sex ratio and decadal growth of population from the year 1901 to 2011.

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SAVINGS AND WEALTH TRANSFERS TO CHILDREN: AN ECONOMETRIC ANALYSIS OF INTERGENERATIONAL TRANSFERS IN INDIA

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Abstract

Households save their earnings during working age and dissave during old age and accumulate physical and financial wealth over their life. With uncertain life, the elderly continue to save and dissave at a slower pace. The wealth so accumulated passes to the next generation either as inheritance or as transfers. If household motives for such transfers are either altruistic or exchange for child services. This paper empirically analyses the motives and determinants of household savings and transfers to children in Indian households using a primary survey data. Econometrically probit method is used to analyse the savings and transfers decisions and Tobit model is used to analyse the amount of savings and transfers. The estimated results show that the Indian household savings behaviour is motivated by bequest concerns and the intergenerational transfers is largely in exchange for the child services like old age care and support provided by children. The paper also observes that there is no difference in savings and transfers behavior of parents with single or more than one child families.

Keywords: Household savings, Wealth accumulation, Bequest motive, Child services, Strategic behavior, Intergenerational transfers

Introduction

Across the world, people save their earnings substantially for various purposes and in many forms, primarily for future consumption. In the life course, people have some concern for their future standard of living and therefore want to ensure smooth flow of consumption in the old age. Therefore, people save during the working age and dissave in the retired life or old age. According to the classical definition savings is “income minus consumption”. Alternatively, savings is sometimes identified with “earned surplus”. As a third possibility, savings can also be defined as “increase in all assets less increase in all liabilities”. Savings is also equated in some sense with the idea of “not consuming” (Boulding, 1969). John Maynard Keynes (1936) defines savings as the excess of income over consumer’s expenditure, not as the excess of income (production) over consumption. Yet another aspect of the concept of savings is the notion of savings as “postponed consumption”. Generally, savings takes two different forms: financial and non-financial, and

hence savings in general is the accumulation of net worth or assets. The main factors that determine individual savings are (1) income, (2) life cycle, (3) psychological attitudes, (4) social environment, and (5) government policy.

John Maynard Keynes (1936) lists eight motives for savings: (1) precautionary motive – "To build up a reserve against unforeseen contingencies", (2) life-cycle motive – "to provide for an anticipated future relationship between the income and the needs of the individual", (3) intertemporal substitution motive - "to enjoy interest and appreciation", (4) improvement motive – "to enjoy a gradually increasing expenditure", (5) independence motive – to enjoy a sense of independence and the power to do things, though without a clear idea or definite intention of specific action", (6) enterprise motive – "to secure out of speculative gain or business projects", (7) bequest motive – "to bequeath a fortune", and (8) avarice motive – "to satisfy pure miserliness i.e. unreasonable but insistent inhibitions against acts of expenditure as such". Browning and Lusardi (1996) add another motive, the "down payment motive" which refers "to accumulate deposits to buy house, cars and other durables".

Horioka and Watanable (1997) provide extensive information on motives for savings, dissavings and borrowings and identify the following twelve savings motives: (1) retirement motive – for living expenses during retirement, (2) illness motive – for illness, disasters and other unforeseen expenditure, (3) education motive – for one's children's educational expenses, (4) marriage motive – for one's children's marriage expenses, (5) housing motive – for the acquisition including rebuilding and replacement purchase, (6) consumer durable motive – for the purchase of consumer durables, (7) leisure motive – for leisure expenses, (8) tax motive – for the payment of taxes, (9) business motive – for an independent business, (10) peace of mind motive – no specific motive but for peace of mind, (11) bequest motive – In order to leave a bequest, and (12) other motives.

At the aggregate level, savings have been classified into three main sectors: the household sector, the private corporate sector and the public sector. In India, the savings rate gradually moved up from a low level of 10.4 per cent of GDP in 1950-51 to 31.4 per cent in 2007-08. The household sector contributes the bulk of national savings, more than four-fifths of the total savings in India, as in most other countries. The government sector and the corporate sector contribute the balance. The share of household sector savings in the gross domestic savings (GDS) was 85.18 in 1999-2000.There are several forms and sources of savings for a household in India. Households save in the form of financial savings which include currency, bank deposits, shares and debentures, life insurance funds, chit funds, provident and pension funds, etc. Also, households save in the form of physical savings like land, house, buildings, plots, flats, gold and jewels, and durable goods. The savings pattern of the household sector in India in 1999-2000shows that 50 per cent are in the financial form and 49.99 per cent account for physical form of household savings.

Savings and Wealth Transfers

In general, households accumulate wealth from two sources: households save out of income they earn – the life-cycle savings, or receive transfers from other people which involves either – inheritance, gifts, inter-vivos or bequest. The inter-vivos transfers and bequest will arise in a dynastic family where preferences include a taste for the well-being of one's descendants concerned. Evidence on wealth transfer pattern of households is fairly consistent. Wedgwood's (1929) study of wealthy Britons indicates that most had received large inheritances, nearly one-third owned their position in the wealth distribution entirely to inheritances. Projector and Weiss (1966) report that 17 per cent of families in the US had received inheritance. Menchik and David (1983) estimate that the average intergenerational bequest in the US amounted to one-fifth of average household wealth in 1967 and 10 per cent of the average household wealth of families 65 or over in age. Hurd and Mundaca (1989) find that 12 per cent of households in the top 10 per cent of the income distribution reported that more than half their wealth came from gifts or inheritances.

Gale and Scholz (1994) estimate that at least 51 per cent of household wealth is accounted for by inheritances and intentional wealth transfers. Wolff (1996) estimates that the top 5 per cent of wealth-holders account for 56 per cent of private U.S net worth and the top 1 per cent alone hold 35 per cent. Even after adjusting for private pensions and consumer durables, Laitner (2001) finds the shares as 48 per cent and 28 per cent respectively. Kotlikoff and Summers (1981) estimate that a large fraction of the U.S. capital stock was attributable to intergenerational transfers. De Long (2003) performs an accounting exercise and finds that inherited wealth comprised roughly 91 per cent of aggregate wealth in the US compared to his estimate of 43 per cent for a modern developed economy.

Some interesting questions are whether such household intergenerational transfers are intended or accidental, whether the wealth is equally or unequally transferred among children and whether there is any reverse transfers among families and generations. Parents normally appear to play favorites when distributing financial resources among their adult children. The incidence of equal division of estates is high in practice. The equal estate division was reported to be 21 per cent by Tomes (1988), 62.5 per cent by Menchik (1980) and 84.3 per cent in Menchik (1988). Even where equal division of the bequest is the norm, as many as 20 per cent parents treat their children unequally. Light and McGarry (2004) indicate that approximately 75 per cent of parents who make inter-vivos transfers to their children give unequal amounts. McGarry and Schoeni (1997) and McGarry (1999) find that 17 per cent of parents aged 70 and older who name children in a crisis intend to divide their estates unequally. Wilhelm (1996) finds that 23 per cent of the estates are divided unequally.

There exists only scanty evidence in developing countries on the nature and size of inter-and intra-household transfers. Kazianga (2006) report that Burkina Faso about 39 per cent of rural households surveyed in 1994 and 42 per cent of those surveyed in 1998

report some transfer activity either as donor, recipient or both. About 40 per cent and 43 per cent of urban households were involved in some transfer activity in the same period. Inter-household transfers are common in developing countries. According to Park (2003), 20 to 90 per cent of households in developing countries receive private transfers and transfers received comprises 2 to 20 per cent of household income on average in developing countries.

In India, intergenerational transfers assumes significance in household savings and wealth accumulation decisions. From wealth tax on transfers in India, it is noted that intergenerational transfers should be very substantial and such transfers are frequently practiced in India. According to economic survey 2007-08, the wealth tax collected is Rs.315 crores in India. With a view to stimulating investments in productive assets, government of India abolished wealth tax on all assets except certain specific assets since 1993. In India, wealth tax is charged at the rate of 1 per cent of the amount by which the net wealth exceeds Rs.15 lakhs. In India, wealth tax on financial assets such as shares, bank deposits, bonds and debentures has been abolished and is levied only in respect of assets such as residential houses, farm houses, urban land, etc.

From these observations, it can be expected that large amounts are being transferred among the families for the generations. In the absence of reliable data on intergenerational transfers, we infer that the savings habit of the households reflects the intergenerational transfers motive. In the absence of reliable data on household intergenerational data, the available data on the substantial household sector savings can be construed as indicating the nature, size and pattern of intergenerational transfers in India. Therefore, an examination of household savings and transfers behaviour involving motivations and determinants of savings and transfers would certainly be worthwhile. The present paper attempts to enquire into certain aspects related to savings and transfers behaviour of households in Chennai. The main objective of this paper is to identify and estimate the effects of factors that influence household savings behaviour and the motives and nature of intergenerational transfers.

A Brief Review of Literature

Household Savings Behaviour

Mikesell and Zinser (1973), Gersovitz (1988) and Deaton (1989) survey the literature on savings behaviour in developing countries. Since consumption and savings are interrelated, analysts take either of this. The main determinants of private savings or consumption considered in the literature fall into some major groups (Corbo and Schmidt-Hebbel, 1991); like income and wealth (Deaton, 1989; Zeldes, 1989), rates of return, interest rateand inflation(Gupta, 1987; Lahiri, 1989), foreign savings (Fry, 1980; Giovannini, 1985; Gupta, 1987), and demographic factors (Mason, 1988; Collins, 1991).

Turning to household savings motives, a number of theoretical and simulation studies have analysed savings for selected motives, such as savings for retirement (Modigiliani and Brumberg, 1954), savings for housing purchase by (Artle and Varaiya, 1978; Slemrad, 1982; Hayashi et al. 1988), savings for precautionary purposes (Leland, 1968; Sandmo, 1970), and savings for health expenditures (Kotlikoff, 1989). A large number of studies, inspired by Kotlikoff and Summers (1981), attempt to estimate the share of a given country's capital stock that is attributable to intergenerational transfers i.e. bequests and inter-vivos measured transfers and the share thereof that is attributable to life-cycle savings as evidence by Kotlikoff (1988), Modigliani (1988), Kessler and Mason (1989) and Horioka (1993). Horioka and Watanable (1997) estimate that net savings for bequest motive accounts for about 3.23 per cent of total net savings for all motives.

In general, several types of motives are attributed to household for savings behaviour. But three main motives the life cycle motive, bequest motive and precautionary motive emerges as the predominant motives for the savings at the household level. It is observed from the studies that many households save for future uncertainty (precautionary motive) and the retirement (life cycle motive). However, since date of death is uncertain, the households are not depleting their entire life time resources during their retirement stage. Naturally, households bequeath their wealth to their children (bequest motive), either with intention or accidentally.

Identification of Operative Bequest Motive

In the intergenerational transfers literature, altruism is observed as a prominent bequest motive for savings of households. Barro (1974) and Becker (1974) observe that children with low earnings enjoy larger bequest from parents. Altonji, Hayashi and Kotlikoff (1997) observe that parents bequeath less to the children whose income level is higher. But, Menchik (1980), disagreeing with them, argues that parents generally bequeath equal amount to their children. Tomes (1988) favours unequal bequest by parents. Wilhelm (1996) tests the equal vs unequal division among 4188 descendants who bequeathed directly to natural born or adopted children. According to Wilhelm, the majority of all wealthy descendants bequeath equally to their children. In other words, over two thirds (68.6 per cent) of the descendants divided their estates exactly equally among their children. Over three quarters (76.6 per cent) divided their estates so that each child received within $\pm$2 per cent of the average among children in the family. In this context, it is compared with Tomes (1988) and 21.1 per cent by Tomes (1988) and Menchik (1980) were 21.1 per cent and 84.3 per cent in Menchik (1988).

According Gokhale and Kotlikoff (2002), the wealth of a family through bequest is influenced by the size of wealth at the time of parent's death, the number of siblings among which the wealth to be shared and the inheritance of parents from their ancestors. Kotlikoff (1988) provides six types of evidence concerning the importance of intergenerational transfers to savings: (1) comparison of total U.S. wealth with life cycle wealth, defined as the amount of U.S wealth there would be in the absence of any net intergenerational

transfers (The difference between total wealth and life cycle wealth is defined as transfer wealth), (2) flow of transfers, (3) zero transfers, (4) rate of asset decumulation of the elderly, (5) evidence from annuity market, and (6) evidence concerning the correlation of savings rates and changes in the length of retirement. An extensive research along these lines are available in Kotlikoff (1989), Kotlikoff and Spivak (1981), Kotlikoff and Summers (1981), Kotlikoff, Shoven and Spivak (1986) and Altonji, Hayashi and Kotlikoff (1997).

One important source of evidence on the bequest motive is the study of the consumption and savings behaviour of the elderly. Even casual observations show that the elderly continue to save and dissave not all savings in retirement. The elderly seems to accumulate wealth as they age (Mirer, 1979; Menchik and David, 1983; Kurz, 1984). Many elderly people also continue working and earning even after the normal retirement age. They do not consume their entire wealth at any particular stage. Hence, a bequest motive certainly exists behind accumulation of wealth, and also that wealth is likely to increase at any age.

This behaviour is in stark contrast to the simple life cycle theory of savings which predicts that people save during their working years and dissave in old age (Modigiliani and Brumberg, 1954), but compatible with a bequest motive for savings. Mirer (1979) and Menchik and David (1983) show that the wealth holdings of elderly households tend to increase with age. Laitner and Juster (1996) show that 38 per cent of respondents had stopped saving at retirement whereas 35 per cent of respondents continued savings even after retirement. The elderly in the US with a bequest motive were found to have accumulated nearly $300,000 - $ 400,000 more than the elderly with no interest for bequest. Alessie, Lusardi and Kapteyn (1999) explain that a large fraction of elderly households continues to accumulate wealth, even if the average household decumulates wealth. The savings behaviour of German households observed by Borsch-Supan (1992; 1994) and Schnabel (2003) shows that the average net worth of elderly German households increases with age, and the average as well as median savings rates are positive i.e. more than half of German households actually continue to save in retirement.

Another test for the bequest motive is whether the savings or consumption behaviour of individuals with children differs from the behaviour of individuals without children. Hurd (1987) finds lower dissaving rates for elderly respondents without children, an observation clearly at odds with a bequest motive for savings. Kuchlwein (1993) analysed consumption data and finds evidence in favour of a bequest motive, which is, however, equally prevalent among households with and without children. Blinder et al. (1990) finds a positive but weak effect of the number of children as an estimate of planned bequests.

Yet another test for an operative bequest motive is to study the bequest intention of households (Mirer; 1980; Alessie et al. 1999). While Mirer reports a fairly strong positive effect of bequest intention on savings levels, Alessie et al. (1999) find insignificant effects with changing signs. Kozarosian (1997) finds no significant influence of a bequest intention

dummy on the ratio of wealth to permanent income. Laitner and Juster (1996) study the bequest intention of retirees and estimate that at age 65 households interested in leaving an estate have accumulated on average at least 40 per cent more net worth than those without such an interest. According to Modigilani (1988) and Alessie et al. (1999), wealthier people were found to be more inclined towards bequeathing. Hurd and Smith (2001) show that changes in the subjective probability of leaving a bequest are significantly related to changes in wealth. Jurges (2001) examining the age-wealth profiles from the German Socio-Economic Panel (GSOEP) in search of an operative bequest finds that though wealth profiles of elderly households with children may decline less or increase more than those of their counterpart with children, the differences are not statistically significant.

In an interesting way, Cox (1987) and Bernheim, Shleifer and Summers (1985) find evidence that children visited and called their parents more frequently when their parents had larger amounts of bequeathable wealth. They interpret these findings as evidence of an exchange theory of transfers in which bequests are made to children in exchange for their earlier attention and care. Parents are able to elicit attention because they can threaten any child not providing attention with the credible promise to disinherit him in favour of his siblings. This theory of transfers means to say that the amount of bequest depends on the amount of love, care and attention shown by the children. In other words, in families with more than one child, children may compete with one another in grabbing a larger bequest from parents. But, in the case of parents with just one child, the question of unequal bequest can never rise. Even if love and care towards parents is not much, bequest comes wholly to the only offspring.

In yet another way, Cox and Stark (2005) and Cox, Eser and Jimenez (1998) investigate transfer behaviour of households. They tested downward transfers (from old to young) and reverse transfers (from young to old). The probit results indicate that probability of transfer receipt is inversely related to income. But the effect of income on transfer amount is first positive and then negative. At incomes lower levels increases in income are associated with higher transfer amounts. A one inti increase in income prompts a 0.162 intis increase in transfer amounts. In the case of estimation for the child-to-parent transfer, like downward transfers, the probability of transfer receipt is inversely related to income. Income increases at the first stage of the income spline is associated with increased transfer amounts. These findings contradict pure altruism but are consistent with exchange.

Further search for an operative bequest motive is to go beyond parent-child transfers, into transfers involving more generations of a family. Arrondel and Mason (2001) analyse family transfers involving three generations with motives of altruism and exchange in France. The study shows the importance of retrospective effects on downward (parent-to-child) transfers. In this context, for each transfer, parents are strongly influenced by the corresponding behaviour of their own parents. Moreover, the empirical analysis of upward (child-to-parent) transfer shows evidence of forward-looking indirect reciprocities, in which parents help their own old parents because they expect to receive comparable support in old age from their children.

Park (2003) analyse three types of transfers, from parents to children, from children to parents and between siblings in Indonesia, examining the motives for intra-household transfers. The parent-to-child transfers are estimated to be negatively correlated with children's transitory income but positively correlated with children's permanent income. This indicates that parents transfer to children to release them of liquidity constraints and that parent-to-child transfers are at least partly in exchange for children's filial services. In the case of child-to-parent, transfer amount is estimated to be uncorrelated with parent's income or assets while it increases with parent's age indicating children provide parents with old-age security. In contrast to parent-to-child transfers, children who live far away from parents are likely to make large transfers than those who live closer which is indicates that money transfers from children to parents are substitutes for filial service or time transfers to parents. Park also estimates inter-sibling transfers, which are consistent with the characteristics of altruistic transfers. Inter-sibling earnings are estimated to be negatively correlated with the income are wealth of recipients and targeted toward the younger and female siblings.

Thus, the literature observes that, in general, individuals save during their middle ages and dissave during their retirement stage. People save in order to finance consumption in future when they expect that their income is going to fall on retirement. In other words, over the whole life-cycle, the consumer is trying to organise his uneven flow of cash receipts so that, he makes possibly a much more regular pattern of expenditure even in his end stage of life. However, since, the date of death is uncertain, the households are not completely dissaving their entire life time savings at the time of death. Naturally, households bequeath wealth to their children or legal heirs. Apart from this accidental or unintended inheritance, households may also intentionally save and accumulate wealth and bequeath it to their children (bequest motive). Such intended bequests that pass to the future generations form the intergenerational transfers within the households. Altruistic bequests imply that parents prepared to make transfer to children who are liquidity constrained and inheritance and transfers will compensate for earnings differences between siblings as well as between parents and children. Exchange motive reveals that bequests are made to children in exchange for their earlier care and attention. Strategic bequest predicts that amount of bequest depends on the nature of care and attention and shown by the children. The bequest motive of savings also predicts savings for intergenerational transfers.

Theory of Savings and Transfers

Savings Behaviour

The Life Cycle Savings model as developed by Franco Modigliani and Richard Brumberg (1954) and Albert Ando and Franco Modigliani (1963) is the best-known version of the theory of savings and consumption. Broadly life cycle hypothesis (LCH) explains the way people split their income between savings and spending. It lays a great emphasis on demographic structure, that is, age structure of population in relation to the earnings

capacity. This model assumes that a consumer in his early years spend money without earning income. In other words, he will be provided for by his parents. He then begins to work and earn income. Although there will be certain stages during middle-life when the consumer spends a good deal of expenditure, for example, on his children's education or buying of durable goods like assets and land, etc., his aim will be to accumulate enough assets to allow him to continue at what he sees satisfactory standard of living after he stops working. In this final stage of his life-cycle, after he stops working, he will spend good deal of income. In other words, over the whole life-cycle, the consumer is trying to organise his uneven flow of cash receipts so that he makes possible a much more regular pattern of expenditure.

The life cycle hypothesis is an extension of the simple Keynesian model for multi-period consumption. The consumer's utility function can be stated as:

$$U=U\ (C_0,C_1,C_2,C_3,C_4,\ldots\ldots..C_T) \qquad (1)$$

where U is the utility, T is the life-span (number of years), and C represents the period–specific consumption. The utility is maximised subject to the budget constraint that the present values of lifetime consumption is equal to the present value of life time income:

$$\sum_{t=o}^{T}\frac{C_t}{(1+r)^t}=\sum_{t=0}^{T}\frac{y_t}{(1+r)^t} \qquad (2)$$

Maximisation of utility subject to lifetime resource constraint yields lifetime consumption profile. The life cycle consumption profile can be simply represented as in Figure 1.

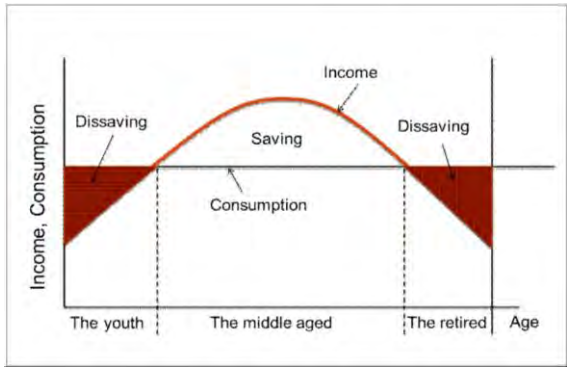

Fig. 1. The Life Cycle Savings Model

The life cycle hypothesis makes an assumption that the income stream is relatively low at the beginning and end of lifespan and relatively high in midlife. Therefore, theconsumer smooths his consumption over the life-cycle by saving during working period and dissaving in later retired life. However, the life cycle hypothesis model assumes absence of a bequest motive in the savings behaviour. Yaari (1965) introduces uncertainty in the life course since the date of death is not known. Kopczuk and Lupton (2007)

develops a life cycle model accommodating the uncertain life on the lines of Yaari (1965), explaining how elderly households that are out of the labour force optimally allocate their wealth over their remaining life cycle. Accordingly, the household maximises the life time utility function:

$$V(W_s) = \underset{C_s, C_{s+1} \ldots C_T}{\text{Max}} \sum_{t=s}^{T-s} \beta^{t-s} \left[\alpha_t u(C_t) + m_t b(W_t) \right] \tag{3}$$

subject to $W_{t+1} = (1 + r) W_t + Y_t - C_t$

where W_t and C_t are the household's wealth and consumption at age t.

The probability of being alive at age t is given by α_t, and probability of dying at age t is given by m_t, the individual die with certainty by age T. Future utility is discounted by the factor of time preference β. Household places value on consuming while alive and leaving some wealth upon death. The period utility function is isoelastic:

$$U(C) = (1 - \gamma)^{-1} C^{1-y} \tag{4}$$

This model further assumes that elderly households are facing the problem of ability to borrow against future income in order to make optimal allocation. Then, the dynamic budget constrain with borrowing constraint is as follows

$$w_{s+N} = (1+r)^N \omega_s + \sum_{t=s}^{s+N-1} (1+r)^{t-s} (Y_t - C_t) \geq 0 \tag{5}$$

at any age N, $N = 1, \ldots, T\text{-}s$

From the isoelastic utility the optimal consumption profile satisfies the following Euler equation (Kopczuk and Lupton, 2007):

$$\left(\frac{C_{1+1}}{C_t} \right)^{-\gamma} \leq \left(\beta (1+r) \left(\frac{\alpha_{1+1}}{\alpha_t} \right) \right)^{-1} - \left(\frac{m_{t+1}}{\alpha_{t+1}} \right) \frac{\alpha}{C_t^{-\gamma}} \tag{6}$$

where α is a constant from the utility of leaving bequest which is linear, $b(w_t)=\alpha w_t$. This implies egoistic motive rather than altruistic or bequest motive. Without mortality risk, the standard relationship between the rate of return on wealth and the degree of impatience defines the scope of the consumption profile until the penultimate period of life.

Intergenerational Transfers Behaviour

As such the individual is not consuming the entire life time resources during his final

stage of life. Therefore, a fraction of wealth is left unconsumed. This unconsumed wealth goes to the next generation as inheritance. In general, some individuals may intentionally accumulate their savings for intergenerational transfers and some individuals unintentionally (accidentally) leave a bequest for their offspring. Whether intended or accidental, the positive wealth left by the individual at the time of his death goes to his children as inheritance. Therefore, the parent can effectively use this unconsumed wealth accumulated as bequest to children to extract old age support and other child services. The children have incentive to provide parental care as the bequest to be received from parent depends on the attention they provide to the parent. According to this type of bequest model, the size of inheritance becomes a strategic tool for parents to derive the desired child services. The parent gets his desired level of attention by threatening his children not to leave them any inheritance if they do not comply or support them. The amount of the bequest and a sharing pattern between children are fixed in advance by a non-revocable will, and using the will as a threat, the parent plays the children against each other letting them know he will leave more or all of his wealth to the siblings who best take care of him. In this spirit, Bernheim et al. (1985) formulates a strategic bequest model which suggests that attention or service provided by the children to a parent is motivated by their expectation of an inheritance.

The theoretical approach for modeling intergenerational transfers is the standard economic utility maximisation approach; the utility function of the parent includes his own consumption, the utility of children, the services provided by children to parent, and the size of transfers. The intergenerational transfers include both inter-vivos transfers (gifts) and bequest transfers, both physical and financial in nature. Under the strategic bequest motive, the parent's utility function is as follows:

$$\max_{S_1 \ldots S_n, T} U = U(C_P, S_1 \ldots\ldots S_n)$$
$$\text{Subject to } -C_P = Y_P - T \qquad (7)$$

where C_P is consumption of parent, S services provided by each child S €{1, ...n},Y_p parents wealth, and T bequest (transfers) to the n children. In this model, the parent uses inheritance to influence ex ante decisions of children and hence adopts a manipulative strategy.

The children's problem is to:

$$\max_{s} V_C = V_C(C_K, S)$$
$$\text{Subject to } C_K = Y_K + \beta_K T \qquad (8)$$

This model assumes that the children's income is exogenous and each child provides services and maximises his utility (V_C) with $V_S < 0$, the child receives a fraction β_K

of T in exchange for the attention S devoted to the parent. The sharing rule β_K in this model is expressed as:

$$\beta_K = \beta_K (S_1,\ldots\ldots..,S_n),\ \sum_{i=1}^{n}\beta_K = 1 \qquad (9)$$

There are two conditions in this model. First, the parent chooses his level of consumption C_p and then he leaves for bequest T and the sharing rule β_K. Second, the child chooses his optimal attention S and receives the predetermined transfers at the death of the parent.

Bernheim et al. (1985) expects a positive relationship between parental wealth and the mean level of attention provided by the children. Victorio and Arnott (1993) predict that there may be offsetting effects since a higher expectation of inheritance increases the child's price of services. In this strategic bequest model, the parent compensates unequal services from the children by willing unequal shares to children. It is also important from the child's point that, if he is not likely to involve in this strategic rule, inheritance is shared between his siblings. There is also a possibility of coalition among siblings deciding to share equally the parental inheritance after the death of the parent. In that case, the level of service received from children is not set at its maximum value. Also, this strategy rule does not work for parents with only one child. Moreover, a benevolent parent may find it hard to stick to his threat of disinheritance. Therefore, the parent should only care about total attention from the all the children and not about the care received by the particular child in the family (Cremer and Pestiean, 1991).

Strategic Bequest Motive and Transfers Division

Wilhelm (1996) develops a family bequest model with unequal division based on some observable and unobservable child characteristics which determine differences in family transfers. Under the divisible bequest motive, the parent's utility function can be written as:

$$\mathrm{Up}\,(c_{oj}, y_{1j}, y_{2j}, \ldots\ldots\ldots, y_{N_j j}), \qquad (10)$$

which is defined over his parent's lifetime consumption (c_{oj}) and his children's lifetime resources (y_{ij}). The subscript "0" indicates a parent variable, and i = 1, …,N_j indexes his children, the number (N_j) of which is assumed exogenous. It is assumed in the model, that the parent has symmetric concern over his children and hence the y_{ij} enter the utility function symmetrically. The lifetime resources of children are defined as:

$$y_{ij} \equiv h_{ij} + b_{ij} \qquad (11)$$

where b_{ij} is the bequest from the parent and h_{ij} is the exogenous lifetime earnings (measured by human capital) of the child. The parent then chooses c_{oj} and the b_{ij} to

maximise utility subject to a budget constraint determined by his lifetime resources (y_{oj}) given a fixed intergenerational discount factor ρ. It is convenient to construct the choice problem in terms of y_{ij} instead of b_{ij} (Becker, 1981), yielding the budget constraint:

$$C_{oj} + \rho \sum_{i=1}^{N_j} y_{ij} = Y_{oj} + \rho \sum_{i=1}^{N_j} h_{ij} \quad (12)$$

where the right-hand side is "family income", a family-level variable henceforth denoted Y_j. The first order conditions produce a solution, $f(y_j, \rho)$ for children's lifetime resources which is a function of family income and the discount factor, and which along with child resources yields a prediction concerning bequests:

$$b_{ij}^{*} = -h_{ij} + f(Y_j, \rho) \quad (13)$$

A stochastic bequests specification function is developed when utility is modified to be a function of $(C_{oj}-\gamma_{oj})$ and $(y_{ij} - \gamma_{ij})$, where γ_{oj} and δ_{ij} are minimum demand levels for consumption and children's lifetime resources, respectively. Let the minimum demand levels be:

$$\gamma_{oj} = \mathbf{D}'_{oj}\delta_p + \eta_j \quad (14)$$
$$\gamma_{ij} = \mathbf{D}'_{ij}\delta_c + \varepsilon_{ij} \quad (15)$$

where $\mathbf{D}_{oj}$ is a vector of parent-specific demographic characteristics $\mathbf{D}_{ij}$ is a vector of child-specific demographic characteristics, δ_p and δ_c are the respective parameter vectors, η_j is a parent-specific heterogeneity term, ε_{ij} is a child-specific heterogeneity term, and each error term is independently and identically distributed in the model. Although the demand levels allow bequests to be affected by observable and unobservable characteristics of children, assuming these characteristics influence bequests independent of the identities of the children possessing them implies that utility remains symmetric in the $(y_{ij}-\gamma_{ij})$. Then, the optimal bequests are given by:

$$b_{ij} = -h_{ij}^{*} + \mathbf{D}'_{ij}\delta_c + f(\hat{Y}_j, \rho) + \varepsilon_{ij} \quad (16)$$

where $\hat{Y}_j$ is family income redefined to include γ_{oj} and within-family sums of the γ_{ij}. Family income thus redefined remains a family-level variable; all of its stochastic components are family-specific unobservables. Symmetric concern assumption implies that the scalar $f(\hat{Y}_j, \rho)$ is common to all children within each family. Hence, $f(\hat{Y}_j, \rho)$ can be modeled as a family fixed effect in the estimation of the bequest function. Rewriting the bequest rule in terms of derivations from within-family means:

$$b^{*}_{ij} - \bar{b}^{*}_{ij} = \beta_h (h_{ij} - \bar{h}_{aj}) + (\mathbf{D}_{ij} - \bar{\mathbf{D}}_{aj})'\boldsymbol{\delta}_c + (\varepsilon_{ij} - \bar{\varepsilon}_{aj}) \quad (17)$$

where the overbar denotes within-family averages and β_h is the degree to which the parent uses the bequest to compensate inter-sibling differences in earnings.

It is to be observed that equal division $(b^{*}_{ij} = \bar{b}^{*}_{aj})$ should occur only in the unlikely event that siblings have equivalent lifetime earnings and other characteristics. Because this contradicts the prevalence of equal division, a generalisation of the standard model is required. Therefore, assuming that the parent suffers a psychic cost k_j, resulting from inter-sibling jealousy and family conflict, the parent chooses to divide his estate unequally among his children. The decision process proceeds in the first place the parent determining the optimal unequal bequests and then calculating the optimal equal bequests (b^{**}_{aj}) that maximises his utility subject to his budget constraint and an additional constraint of $b_{ij} = b_{kj}$ for all children i and k in his family. The parent goes for unequal division of bequests only if it gives him higher utility after the psychic cost of unequal division is deducted, that is if $U^{*}_{j} - k_j > U^{**}_{j}$.

With the help of a second-order Taylor series expansion of U^{**}_{j} around the optimal unequal bequests b^{*}_{ij} and assuming that parental utility is separable in $y_{ij} - \gamma_{ij}$, the optimal bequest division rule leads to the following approximation of $U^{*}_{j} - U^{**}_{j} > k_j$:

$$b_{ij} = b^{*}_{ij} \quad (18)$$

$$\text{if } N_j^{-1} \sum_{i=1}^{N_j} \left\{ \beta_h (h_{ij} - \bar{h}_{aj}) + (\mathbf{D}_{ij} - \bar{\mathbf{D}}_{aj})'\boldsymbol{\delta}_c + (\varepsilon_{ij} - \bar{\varepsilon}_{aj}) \right\}^2 > k_j$$

$$b_{ij} = b^{**}_{aj} \text{ otherwise (for all i in family } j)$$

This expression is an estate division rule and the intuition of the division rule is straightforward. The likelihood of an unequal division is sizable if siblings differ greatly in their income and other observable and unobservable characteristics, e_{ij}'s, and if parental psychic cost k_j is low.

Econometric Methodology

In the empirical analysis of savings and transfers, the decision on savings and transfers is modeled as a probit equation which estimates the effects of background characteristics on the probability of such decisions. The size of savings and transfers is

estimated by Tobit equation, given that a positive decision on savings and transfers have been taken by the parent.

Probit Method

The assumption underlying probit analysis is that there is a response function of the form:

$$Y^{*}i = \alpha + \beta X_i + u_i, \tag{19}$$

where X_i is observable but Y_i is an unobservable latent variable and u_i has the standard normal distribution. What is observed in practice is a Y_i when $Y_i > 0$ and 0 otherwise:

$$\begin{aligned} Y_i &= 1 \quad \text{if } \alpha + \beta X_i + u_i > 0 \\ Y_i &= 0 \quad \text{if } \alpha + \beta X_i + u_i \leq 0 \end{aligned} \tag{20}$$

If we denote by F(z) the cumulative distribution function of the standard normal distribution, that is, $F(z) = P(Z \leq z)$, then:

$$\begin{aligned} P(Y_i = 1) &= P(u_i > -\alpha - \beta X_i) = 1 - F\left(\frac{-\alpha - \beta X_i}{\sigma}\right) \\ P(Y_i = 0) &= P(u_i \leq -\alpha - \beta X_i) = F\left(\frac{-\alpha - \beta X_i}{\sigma}\right) \end{aligned} \tag{21}$$

The joint probability density of the sample of observations (called the likelihood function) is therefore given by:

$$L = \prod_{Y_i=0} F\left(\frac{-\alpha - \beta X_i}{\sigma}\right) \prod_{Y_i=1} \left[1 - F\left(\frac{-\alpha - \beta X_i}{\sigma}\right)\right] \tag{22}$$

where $\prod$ denotes the product of terms. The parameters α and β are estimated by maximising the likelihood function, which is nonlinear in parameters and estimated by the method of maximum likelihood.

Tobit Method

The Tobit model as developed by James Tobin is applicable to a censored sample in which information on regressand is available only for some observations. The Tobit model arises when the Y variable is limited (or censored) from above or below. For example, if we want to measure the amount of savings we might use data on the savings

decision and amount saved by the household in a year. However, if the savings amount is below a certain level then the Y variable would be limited by the amount not saved or spend out. Then:

$$Y_i^* = \beta_1 + \beta_2 X_{2i} + ... + \beta_k X_{ki} + u_i \tag{23}$$

$$y_i^* \text{ is unobservable but } y_i = \begin{cases} 0 \text{ if } y_i^* < 0 \\ y_i^* \text{if } y_i^* \geq 0 \end{cases} \tag{24}$$

The likelihood function for the Tobit model takes the form:

$$\log L = \sum_{\gamma_i > 0} -\frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{(Y_i - \beta X_i)^2}{\sigma^2} \right] + \sum_{\gamma_i = 0} \log\left[1 - F\left(\frac{\beta X_i}{\sigma} \right) \right] \tag{25}$$

The likelihood function is maximised to obtain the parameter estimates.

Data and Empirical Analysis

The study is based on a primary data. The primary data were collected through questionnaire method during the period between September 2006 and September 2007. The area chosen for the present study is Chennai, the capital city of Tamil Nadu State in India. Sample households are drawn from the two wards (ward nos.85 and 86) in Chepauk division of the Chennai city. Through a random sampling method, the sample size has been decided as 328 households. There are 1610 households in No.85 ward and 1676 households in No.86 ward. 158 households were selected in ward No.85 and 167 household in ward No.86 considering 10 per cent of the samples. As some households in the sample did not respond to the required information, data has been collected from 315 households. Through a structured questionnaire detailed information have been collected on the demographic profiles of households, income, expenditure, savings, dissavings, work and earnings, assets and liabilities, physical (movable and immovable property)and financial (money, financial instruments) transfers in the form of bequest, gifts and inter-vivos, children related characteristics, child services (expected and satisfaction) and other relevant information.

From the descriptive statistics of the sample households, it is observed that on average the household income is Rs.22,200 per month, household expenditure is Rs.14,000 per month and the household saves Rs.5380 per month. For nearly 49 per cent of households, the dominant motive for savings is the life-cycle motive and old-age concerns. About 55.45 per cent households prefer savings in physical form and 44.50 per cent save in the financial form. A majority of elderly persons continue to save in their old age and their dissavings is also comparatively less to the non-elderly households. About 72

per cent of households received gifts from parents in physical form and 28 per cent received gifts in financial form, while 77 per cent of households have given gifts in physical form and 23 per cent in financial form. In the sample, 217 households received bequest transfers, while 250 households have given bequest transfer.

With respect to the intergenerational transfers, the average size of transfers is about is Rs.2,15,500 in Indian households, out of which bequests from substantial part. The physical form has the dominance (92.62 per cent for receivers and 73.20 per cent for givers) compared to financial transfers. The average size of gifts received is Rs.20,430 and the gifts given is Rs.9600. The mean of bequests received is Rs.1,52,640 and the mean bequests given is Rs.3,03,150. The elderly persons transferred Rs.3,87,750 while the non-elderly households transferred Rs.93,050 to children. The first child in the family has received a transfer of 1,35,240, the second child has received Rs.1,21,600 while the third child has received a transfer of Rs. 32,140. With respect to the sex of children, the first male child received a bequest of Rs.1,80,320 while the first female child received a transfer of Rs.87,443 only. These statistics reveal that the bequest transfers is substantial and the intergenerational transfers are not equal among children in the Indian households.

Savings and Transfers Decisions Behaviour

The Probit and Tobit models are used to estimate the savings and transfers decisions of the households and the amount of savings and transfers respectively. The Table1 presents the probit estimates, the probability of decisions in favour of savings and transfers as against not to save and no transfers. The marginal effects show that the probability of savings decision for a unit increase in the independent variables. The coefficient estimates show that savings decision is negatively influenced by age of the household head, household expenditure, family loan, parent's college education and number of children, and the probability to save is positively related with household income, nuclear family type, parent's professional education and occupation, married parent and community. The coefficient estimates imply that as the aged household heads and professionally employed parents prefer to save, more in the physical form of savings, while household expenditure and more number of children allows less opportunity for savings.

In the case of intergenerational transfers, the probability of transfers decisions increases with age, parent income, parent's occupation, community, nuclear family, business and self-employed parents and number of children, and household expenditure, family loan and clerical employment of parents reduces the probability of transfers decision. As the marginal effects show the probability of transfers increases by 20 per cent with aging of the parents, 30 per cent with number of children, 25 per cent with professional occupation of parents, 19 per cent with BC and MBC community and 23 per cent with business parents. The negative effect of household expenditure on the probability of transfers decisions is about 5 per cent and clerical occupation of parent is 6 per cent. The negative effect on the transfer probability of parent's marital status and family loan are only marginal.

Table 1. Probit Estimates of Household Savings and Transfers Decisions

Variable	Savings decision		Transfers decisions	
	Coefficient estimate	Marginal effect	Coefficient estimate	Marginal effect
Age	-0.198* (0.069) [-2.879]	-0.063	0.193* (0.073) [2.648]	0.208
Age squared	0.002* (0.0006) 2.926]	0.0005	-0.002* (0.0007) [-3.048]	-0.0002
Nuclear family	0.200 (0.183) [1.094]	0.001	0.048 (0.214) [0.225]	0.019
Log (Parent income)	0.113 0.194) [0.581]	0.071	0.282 (0.232) [1.216]	0.035
Log (Household expenditure)	-0.294 (0.229) [-1.285]	-0.216	-0.311 (0.276) [-1.129]	-0.055
Parent college education	-0.094 (0.184 [-0.512]	-0.119	0.632* (0.209) [3.015]	0.097
Parent professional education	0.314 (0.256) [1.220]	0.175	0.339 (0.309) [1.098]	0.254
Number of children	-0.064 (0.130) [-0.493])	-0.0068	0.273*** (0.154) (1.771)	0.298
Parent married	2.773* (0.744) [3.729]	0.158	-0.480 (0.520) [0.923]	-0.0210
Household loan	-4.734 (3.895) [-1.215]	-0.006	-9.101** (4.216) [-2.159]	-0.003
BC/MBC community	0.060 (0.218) [0.274]	0.015	0.698** (0.312) [2.235]	0.188
General community	0.042 (0.258) [0.166]	0.026	0.243 (0362) [0.673]	0.132
Parent clerical occupation	0.448** (0.221) [2.026]	0.060	-0.151 (0.260) [-0.582]	-0.069
Parent business/self-employed	0.091 (0.249) [0.364]	0.210	0.183 (0.305) [0.599]	0.228
Log-likelihood	-202.534		-135.612	
N	315		250	

Note: Figures in parentheses are standard errors and in square brackets are z-statistics.
* significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

The empirical estimates of the determinants of the amount of savings presented in Table 2 reveals that households being as nuclear family, parental income, education and marital status of the head, number of children in the household, transfers received and child income have positive influence on the amount of savings in households that report savings, while household expenditure and family loan negatively affect the savings amount. The households being nuclear family save more than joint family. Naturally, households with few members in the nuclear family contribute more to savings compared to joint family. The marginal effect for nuclear family is about 26 per cent. More importantly, household that have inherited wealth or received transfers from their parents save more and households with earning children also save more. Child earnings contributes to about 33 per cent of household savings and transfers received increases savings by 10 per cent. Earnings of both parents influence household savings; the marginal effect for father's income on savings is 56 per cent while that of the mother's income is 2 per cent showing the dominance of male earnings in household savings. The effect of household expenditure on savings is only a negative 5 per cent. Irrespective of community and occupation, all households save positive amounts and business and self-employed parents save sizably more than the parents with other occupations.

Table 2. Tobit Estimates of Household Savings

Dependent variable: Amount of savings

Variable	Coefficient	Standard error	z-statistic	Marginal effect
Age	0.114	0.148	0.769	0.218
Age squared	-0.001	0.001	-0.902	-0.002
Nuclear family	0.484*	0.167	2.900	0.267
Log (Father income)	0.821*	0.215	3.811	0.568
Log (Mother income)	0.057**	0.026	2.183	0.026
Log (Child income)	0.236	0.175	1.355	0.333
Log (Household expenditure)	-0.519**	0.224	-2.317	-0.419
Log (Transfers received)	0.017	0.022	0.764	0.011
Parent college education	0.486**	0.218	2.226	0.286
Parent professional education	0.055	0.324	0.171	0.119
Number of children	0.374**	0.169	2.209	0.022
Parent married	0.6405**	0.290	2.203	0.042
Household loan	-1.101	3.379	-0.326	-0.020
BC/MBC community	0.474*	0.174	2.724	0.097
General community	0.250	0.212	1.181	0.240
Parent professional occupation	0.222	0.246	0.901	1.0007
Parent business/self-employed	0.215	0.259	0.828	0.474
Constant	5.335	4.489	1.188	-
Log likelihood				-119.586
R^2				0.387
N				315

Note: * significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

Intergenerational Transfers Behaviour

The Tobit estimates of the determinants of household transfers to children among the households that decide to transfer are presented in Table 3. The variables considered are the parent, first child and household characteristics. The factors that significantly influence household transfers from parent to child are age, education, occupation and income of both father and child, expected care by the parent, marital status and sex of child, household wealth and savings, joint family and family loan. The high income coefficient is statistically significant at 1 per cent level and shows that parent with high income transfer more to children. Further, low level of child income increases the probability of transfers by 29 per cent while the parent's transfers decrease by 5 per cent for slightly better earning child. This kind of relationship between parent's income and child income indicates that parent's transfers are targeted to low-income child as compensating principle implies. The age of the donor and receiver play an important role in the transfers pattern. As the parent gets older, the transfer amount significantly increases, while the child is young the transfers is not high.

The significant and positive coefficients of education of both giver and receiver indicate that child with collegiate education is more likely to receive large amount from his parent than their counterparts (school educated). As for the effects of occupational characteristics, parents whose occupation is professional positively make transfers and receivers whose occupation is clerical appear to receive a significantly larger amount of transfers than professional occupation child. It is further observed that retired parent transfers significant amount to his child and the effect of being retired is to increase the transfers by 2.71 per cent.

The estimated effect of expectation of care from child by the parent on transfers is high and statistically significant. In the case of parent's expectations like food support, medical help and old age support, the marginal effects are 76 per cent for food, 62 per cent for medicine and almost nil old age support. The poor old age expectation from child may be due to the presence of alternative supports and insurance facilities as implied by the annuities model of Kotlikoff. These findings are further corroborated by the response of transfers to liquidity constraint (family loan is a liquidity constraint which the child is liable to repay). The estimated coefficient for family loan is 0.638 and the marginal effect is .064. The marginal effect of family loan on the probability of transfers is to decrease transfers by 6.4 per cent.

The estimated results further reveal a powerful impact of the demographic makeup of the household upon transfers. Household savings strongly and significantly influence the transfers. Conditional on the number of people and earning persons in the household, household savings generally increase transfers. The effect of savings on size of transfer is a strong 39 per cent. At the same time, household expenditure reduces transfers, while an increase in the non-labour income, a measure of wealth of the household increases transfers by 3 per cent. The receiver being male as well as being married only marginally increases the size of transfers implying no sex distinction in family transfers. The joint family and BC/MBC community variables negatively influence the transfers. Though, backward

community households are sizable in the sample, the transfers amount is smaller than that of general community households.

Table 3. Tobit Estimates of Intergenerational Transfers

Dependent variable: Amount of transfers

Variable	Coefficient estimate	Standard error	z-statistic	Marginal effect
Parent characteristics				
Age	0.059*	0.021	2.812	1.051
College and professional education	0.701*	0.197	3.560	0.036
Retired	0.446**	0.216	2.071	0.027
Professional	0.830*	0.246	3.353	0.022
Father medium income	0.261	0.209	1.246	0.169
Father high income	0.771*	0.218	3.540	0.036
Mother income	0.003	0.032	0.098	0.011
Food care expecting care	0.361**	0.188	1.915	0.760
Medical care expectation	0.410**	0.183	2.245	0.623
Old age support expectation	0.895**	0.434	2.064	0.0001
First child characteristics				
Age	0.073**	0.030	2.428	0.023
Married	11.374*	2.323	4.895	0.044
Male	1.396*	0.411	3.398	0.005
College//professional education	1.276*	0.262	4.880	0.015
School education	0.216	0.179	1.202	0.026
Professional occupation	0.030	0.369	0.080	0.0002
Clerical occupation	1.409*	0.470	3.198	0.002
Low income	1.135*	0.362	2.767	0.291
Medium income	-0.698	0.450	-1.553	-0.054
Household characteristics				
Wealth (non-labour income)	0.042**	0.021	2.085	0.032
Log (Household savings)	0.480**	0.230	2.255	0.391
Log (Household expenditure)	-0.034	0.198	-0.170	-1.950
Joint family	0.395**	0.170	-2.320	0.063
Log (Family loan)	-0.638*	0.187	-3.406	-0.064
General community	0.461*	0.179	2.577	0.039
BC/MBC community	-0.578	0.313	-1.844	-0.019
Log-likelihood				-305.643
N				250

Note: Figures in parentheses are standard errors. * significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

In order to ascertain motives for household transfers, especially the exchange or strategic motive, the care provided by the child to the parent is considered as the dependent variable in single child and more than one child households. The Table4 reports the estimates of child services in single child family and the Table5 reports the estimates of services provided by children as well as the estimates of equal attention by all children as the dependent variable as another test of strategic behaviour. Child services refers to the nature and size of services rendered by children to parents in the form of medical assistance, food support, time spend with them, monetary support and old age care like periodical visits, taking parents to temples and relative home, etc. The variable child services is measured by the satisfaction realised by the parents from the care provided by their children. Therefore, the dependent variable in the empirical analysis is taken as binary variable representing parental satisfaction with the child services. If they are satisfied, child services takes the value 1, otherwise zero. In the sample, there are 307 households with one child only, 226 households with two children and 35 households with more than two children.

Table 4. Probit Estimates of Parental Care in Single Child Family
Dependent Variable: Child services to parent

Variable	Coefficient estimate	z-statistic	Marginal effect
Age	0.5960 (0.388)	1.53	0.152
Age squared	0.006*** (0.004)	1.67	0.002
Joint family	0.126 (0.472)	0.27	0.033
BC/MBC community	0.076** (0.508)	2.12	0.244
Parent retired	0.414 (0.652)	0.64	0.120
Household wealth	0.910* (0.224)	4.06	0.232
Log-likelihood			24.400
Observed probability			0.731
Predicted probability			0.828
Pseudo R-square			0.374
N			307

Note: Figures in parentheses are standard errors. * significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

Table 5. Probit Estimates of Parental Care in More Than One Child Family

Variable	Child services provided			Equal child services		
	Coefficient estimate	z-statistic	Marginal effect	Coefficient estimate	z-statistic	Marginal effect
Age	0.049 (0.1721)	0.28	0.019 (0.068)	0.018 (0.178)	0.10	0.007 (0.071)
Age squared	0.0 0 1.0 (.002)	0.03	0.000 (0.0006)	0.0006 (0.002)	0.37	0.0002 (0.0006)
Parent good health	0.91** (0.432)	2.12	0.343 (0.139)	0.817** (0.437)	2.32	0.372 (0.131)
Joint family	0.473** (0.225)	2.11	0.190 (0.0873)	0.520** (0.226)	2.30	0.205 (0.087)
BC/MBC community	0.634* (0.227)	2.79	0.249 (0.086)	0.608* (0.229)	2.66	0.239 (0.087)
Parent retired	0.539*** (0.282)	1.91	0.206 (0.101)	0.584** (.285)	2.05	0.224 (0.102)
Household wealth	0.365* (0.103)	3.56	0.145 (0.041)	0.415* (0.104)	3.97	0.165 (0.042)
Log-likelihood	103.684			102.034		
Observed probability	0.464			0.475		
Predicted probability	0.458			0.469		
Pseudo R-square	0.161			0.170		
N	226					

Note: Figures in parentheses are standard errors. * significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

The results of both models are very similar by nature. The results of the empirical model for the strategic behaviour of the household head in the case of single child family and more than one children reveal (in Tables 4 and 5) that age, health status, joint family (children living with parents) transfers given, backward community, retired status and wealth of the household significantly influence the strategic behaviour of the head. The probit analysis shows that as age of the parent increases the probability of getting child services from children increases in both single child and more than one child families. The marginal effect of parental ageing on child services is about 15 per cent in single child families, while the marginal effect is somewhat lower, around 1 per cent only in more than one child families. The probability of receiving care and attention from children by the wealthy parents (non-labour income) is also high. The marginal effect in this regard is about 14-16 per cent

respectively. In this context, it is said that parents with higher wealth may simply pay for their own needs like medical expenses, traveling expenses and temple visits etc. In other words, wealth effects may be less direct in many cases. On the other hand, wealthy children may be more capable of defraying the costs of parental needs. The positive and significant effect of non-labour wealth on care given by both one child and more than one child families shows the importance of strategic motive in pursuit of sizable transfer, children are giving care to the parents and parents are using wealth holdings as an incentive to children to provide the care.

The probability of receiving care and attention from children by the parent in backward (BC/MBC) community households is also high. The marginal effect in this regard is about 24 per cent. The coefficient estimate in this regard is 0.473and 0.520 in care and equal care by all children respectively. The marginal effect is about 19 per cent and 20 per cent respectively. Retired parents receive the care and attention from their children (coefficient value for single child family is 0.414 and in more than one child families, it is 0.540 in one model and 0.584 in another model (Table 5). The marginal effect of the retired parent status on child services is 21 per cent in households. The result of such nature is consistence with the general observation that retired parent may have greater desire for and in fact require children's care and attention, prominent among child services. The probit estimates in Table 5 shows that the health of parents and care given by children are highly correlated. Parents with good health are getting best care and equal attention from their children. Parents in joint family with more than one child receive higher child care and attention from their children (Table 5).A reasonable explanation is that children who live with to their parents may substitute filial services for cash transfers and those who live far away from the parents may do the opposite. In this study there is no geographical distance between parents and children which suggest that parent to child transfers are considered as exchange for children's filial services. The empirical results thus largely support the exchange motive of transfer by parents.

Transfers from Grand-Parent to Grand-Children

In the context of more than two generational relationships, grand-parents may transfer directly to the grand-children. This paper also attempts to understand the transfers behaviour of grandparents to grand-children. There are 23 households in the sample where grand-parents live with grand-children. The dependent variable constructed for the multi-generational transfers analysis is care and services provided by grand-children to grand-parents. The independent variables are age, health status and transfers given by grand-parents to grand-children. The probit estimates presented in Table6 shows that all the variables are statistically significant. The poor health of the grand-parent and transfers induce a higher probability of grand-child services. The estimated marginal effect of poor health of grand-parent is 26 per cent and transfers amount is about 14 per cent. Thus, sick or poor health grand-parents and grand-parents who transfer more receive more attention from the grand-children. In other words, illness increases the probability of care, thereby making a potential bequest to the grand-child.

Table 6. Probit Estimates of Child Services to Grand Parents

Dependent Variable: Child services to Grand-parent

Variable	Coefficient	z-statistic	Marginal effect
Age of grand-parent	0.042* (0.097)	0.43	0.009
Grand-parent poor health	0.654*** (1.422)	0.95	0.263
Transfersamount	0.641*** (0.428)	1.50	0.143
Log-likelihood			-9.080
Observed probability			.826
Predicted probability			.860
Pseudo R-square			0.146
N			23

Note: Figures in parentheses are standard errors. * significant at 1 per cent level. ** significant at 5 per cent level. *** significant at 10 per cent level.

Conclusion

Indian households save significant amounts of their earnings and accumulate substantial wealth over their life. Such accumulation in either the financial or physical forms passes to their children either as inheritance after the death of the parent or as transfers during the parental lifetime itself. Therefore, savings and transfers arise among household members as accidental or as intended for bequest motive. In the presence of an operative bequest motive, intergenerational transfers are motivated either as an altruistic gesture or in exchange for child services. When parents expect child support and care, then the transfers can effectively be used as a manipulative strategy or as a bargaining device to extract maximum services from children by executing a will. An attempt has been made in this paper to analyse the motives and determinants of household savings and transfers of such savings as intergenerational transfers to children in Indian households using a primary survey data and the econometric methods of probit and Tobit models.

Different motives are likely and may coexist in the course of household savings behaviour, like life cycle, precautionary, old age security, wealth accumulation and bequest motives. The life cycle model predicts that households save in their working age in order to dissave in the retired life. However, the phenomenon of saving even after retirement or failure to dissave in old age is a puzzle that even the other motives for savings could not offer satisfactory answers. However, the existence of an operative bequest motive and sizable intergenerational transfers of households offer satisfactory explanation for the

planned and intended savings and wealth accumulation. Such transfers within the household generations are either motivated by altruism or exchange motives and also explain the nature and amount child services expected and provided by parents and children respectively and the behaviour of households with single child, only male child and more than one child families.

The data reveals that nearly 24 per cent of income is saved by households in various forms; the savings in physical form dominates (55.45 per cent) over the financial form. Planned savings or intentional savings for bequests dominates (51 per cent) relative to children's education marriage (33 per cent). Elderly households continue to save in their old age also and some households dissave for age related problems like health care and food expenditure. The probit estimates of the effects of factors that influence the household savings decision and the Tobit estimates of the amount of savings show that savings is influenced by community status, age and education of the household members, occupational characteristics, income, expenditure and the outstanding family loan. The estimates for intergenerational transfers show that bequests are used as payments for child's services and care. The transfer amount is directly related to child income, education and occupation of children and the expected child services by parents. Further, the empirical analysis of the strategic bequest motive shows no significant difference in single-child family and more than one child families in child services and care and attention provided. This shows that there exists still moral and cultural values in the social system in India, wherein children are expected to provide parents with care and support and parents pass on their saved wealth to their offsprings.

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UTILISATION OF LAND RESOURCES IN CITY SYSTEMS: A CASE OF MUMBAI AND DELHI

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Abstract

The rapid growth of the population and the process of urbanisation have resulted in an increasing demand for land in urban areas. Today cities grow not only by population but also by changes in spatial dimensions. The prime factors of the increasing spatial dimension of the cities are also the population growth and related requirements of urban life, such as the development of transport and communication and others infrastructure facilities. This mismatch between the supply and demand of land leads to the degradation of environmentally fragile land, occupation of hazard-prone areas, and loss of cultural resources, open space and prime agricultural land. Mumbai Metropolitan Region (MMR), Delhi, National capital Territory (NCT) are one of the fastest-growing regions of India. Their population increased from 14 million in 1991 to 22.3 million in 2011 for Mumbai and 90 lakh in 1991 to 16.7 million in 2011for Delhi. With the saturation of land in the city followed by suburbs, another part of the Mumbai metropolitan region and Delhi NCT now experiencing fast growth. Due to growing population pressure and related urban life these cities consume 33 to 50% total area for residential purposes and others for various transportation, commercial, and institutional uses. As a result, a built-up area in Mumbai Metropolitan Region and Delhi NCT has increased from 10% in 1991 to 33% in 2011in Mumbai and in Delhi, it reached 12 % in 1991 to 51% in 2011.On the other hand, the area under forest cover and agriculture land has significantly declined. Using various demographic and spatial analysis techniques, this paper attempts to shows the utilization of land resources in the cities of Delhi and Mumbai in various sectors. The study evaluates the effect of population growth on land-uses and subsequently on the regional environment.

Keywords: Resources, Delhi, Mumbai, Population, LU/LC

Introduction

The land is the most important natural resources upon which all human activities are based upon since time immemorial. It is an essential natural resources, both for the survival and prosperity of humanity and for the maintenance of all terrestrial ecosystems. But recently Urbanisation emerges as the most dramatic form of highly irreversible land transformation. While urbanisation is a worldwide phenomenon but it is exceptionally dynamic in countries like India where unprecedented urban growth rates have occurred over the last 30 years. Taubenböck et al., 2005 in their study detailed how urbanization is

arguably the most dramatic form of highly irreversible land transformation. In 1970 India had only 20.2 % urban population which increased to 25.7 %in 1991 and In 2001, about 286 million persons 28.7 % were living in urban areas of India and was the second-largest urban population in the world but in 2011 urban population cross 30% having 3 cities having population greater than 10 million and 53 cities with population one million. This Unprecedented urban growth rate coupled with unplanned development has resulted to rapid increasing additional demand on natural resources thereby causing land-use changes especially in megacities that ultimately leads to exploitation of natural resources. Ravindra., 1996 explained how the metropolitan cities in India have experienced rapid growth of population, particularly in the post-independence era. The rapid conversion of rural areas into urban areas through development is currently occurring at an unprecedented rate in recent human history and is having a marked effect on the natural functioning of ecosystems. Landuse / land cover (LU/LC) is highly focused due to its vulnerability to rapid urbanization and many other anthropogenic activities. Land use is the way in which, and the purpose for which, human beings employ land and its resources (Briassoulis, 2000).Such studies are particularly important because the spatial characteristics of LU/LC are useful for understanding the various impacts of human activity on the overall ecological condition of the urban environment. Thus, an attempt is made through this study to analysethe utilization of land resources in metropolitan cities (i.e residential, transportation, industrial, and commercial) and correlated how rapid urbanization in Indian cities negatively affects urban land resources.

The main objectives of the study are to study the utilisation of land resources in various sectors of cities (i.e. residential, transportional, industrial, and commercial) and to analysis changing urban land use patterns in the metropolitan city of Delhi and Mumbai from 1991 to 2011. How rapid urbanisation effects urban landuse? What are the major problems caused by changing land-use patterns or overuse of the land resources?

The land is the most important natural resources upon which all human activities are based upon since time immemorial.It is an essential natural resources, both for the survival and prosperity of humanity and for the maintenance of all terrestrial ecosystems. The land is scarce in India, even though the country has a land area of about 328 million hectares which is the seventh-largest land area among the countries of the world. India is burdened with a population of 1210 million as per the 2011 census, which grew from 345 million in 1947 with a growth rate of 1.76 in the last decade. In spite of rank 7^{th} in the world in terms of land area, 2nd in terms of population .the land-man ratio is not favorable unlike Canada, Australia, USA, Denmark, and Mexico. Thus, this Increasing concentration of urban population in large cities is one of the characteristics of urban India (Table 1).

In general the land-man ratio in India is not favorable, In 2001 India had about 28.61% population living in urban areas and per urbanite availability of urban land was just 0.03 ha, but in 2011 the urban population of India reached 31% and per urbanite availability of urban land comes down to 0.02 ha, As a result, today most of the urban areas in India faces problem of land deficiency irrespective to their increasing population. At the global

level, cities consume about 3% of the total landmass but produce 75% of all waste. Although figures can vary considerably depending on the city land use is the most common, occupying between 65 and 75% of the surface of a city. Initially, cities grow to benefit the increasing urban agglomerating economy, but after some time due to congestion and crowding leads to urban sprawl / spatial expansion of land into the adjoining area. The cities and its suburbs spill over to the rural areas along their boundaries as a result of approximately, 1.5 million hectares of agricultural land were lost due to this process. Thus unprecedented growth rate coupled with unplanned development in cities leads to urban land transformation.

Table 1. Indian Current Scenario of Availability of Land in 2001 and 2011

Availability of Land	2001	2011
Per Capita Availability of Land in India	0.30 ha	0.27 ha
The total area of under urban settlements	2.52%	3.01%
Urban population	28.61 %	31%
Per urbanite Availability of urban land	0.03 ha	0.02 ha

(Source: Reports of Town and Country Planning Organisation, Ministry of Urban Development, Government of India.)

Database and Methodology

The data for this study has been obtained from the following secondary sources-

- Draft Regional Plan of Mumbai Metropolitan Region (Part I and II), 1991-2011,
- Report of Ministry of Urban Development and Poverty Alleviation, Government of India2011.
- Census of India, General Population Table 2011.

After collecting the data, the information is streamlined. Tabulated and processed manually and electronically. Graphs and maps are made to compare the data changes over time. In this way, data are analysed both qualitatively and quantitatively and help to achieve the major objectives of the study.

Results and Discussion

Utilisation of Land Resources in Mumbai

Mumbai is India's largest metropolitan city covering an area of 4,355 sq.km and with a population of 20,998,395 and population density 27,100 persons/ sq.km in 2011. it is one of the fastest-growing metropolitan cities of India with an overall population size of MMR (Mumbai metropolitan region) has increased from 7.7 million in 1971 to 14.4 million in 1991, almost doubled in a short span of 20 years. Then it finally reached 21.2 million by 2011. Thane, Kalyan, Uran, Bhiwandi and Bassain are growing fast and the share of population in this region has increased from 4.1 per cent, 6.5 per cent, 7.7 per cent, 9.5 per cent, 2.7 per cent, 4.3 per cent, and 2.9 per cent, respectively in1991, and is finally reached to 10 per cent, 11.4 per cent, 7.3 per cent, 5 per cent and 4.5 per cent,

respectively in 2011 This increasing growth rate coupled with rapid in-migration accelerated the demand for land to provide house such large population, the city expanded in a very uncontrolled manner.

In 2011, about 33% or one-fourth area of the MMR used for residential purposes, 18% for transportation and recreational purposes,7% for industrial and 3% for commercial activities respectively (Figure 1).

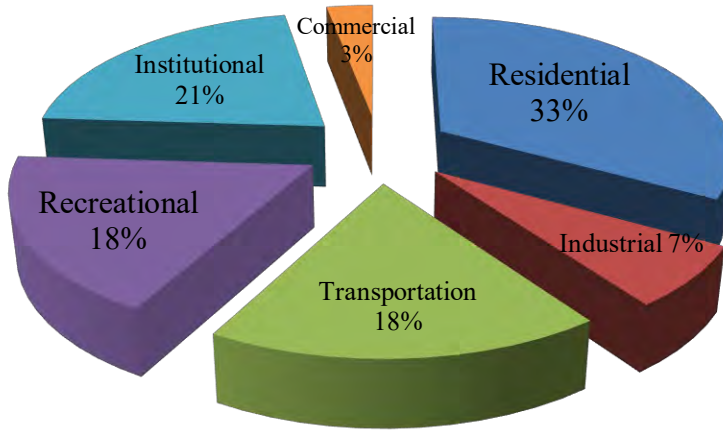

Fig. 1.Urban Landuse Pattern in Mumbai (2011)

(Figure is made by author based on the secondary data obtained)

Source: Ministry of Urban Development and Poverty Alleviation, Government of India, 2011

Mumbai metropolitan region has witnessed the rapid growth of built-up areas during the past decades due to the rapidly growing population and related requirements of urban life, such as the development of transport and communication and other infrastructure facilities (Table 2).

Table 2.Mumbai's Population and Landuse Pattern, 1991 and 2011

Population (in numbers) and Landuse (in sq.km)	1991	2011
Population	1,44,26,553	2,22,52,912
Built -up	351	1,074.04
Industry	101.7	140.02
Agriculture	1,445.9	1,381.3
Forest	1,471.6	879.23
Wetland	362.0	61.9
Water Body	67.6	68.06
Other	54.7	252.64
Total area	**3855**	**3855**

(Source: Draft Regional Plan for MMR, 1991-2011, MMRD (BMRDA, 1968))

In his study Nangia P. and Acharya K., 2004 outlined that the rapid population growth and the process of urbanization are major causes of rapidly changing land-uses pattern. The landuse pattern for 1991 shows that nearly one-tenth of the area or 10% of MMR was used as a built-up area and less than 3 per cent as an industrial area. Two-fifths of the land or 43% was used for agricultural purposes and more than one-third (44%) was under the forest cover. But in 2011 the land use pattern has dramatically change .area under built-up area reached to 33%, forest cover decline to 25%, and agriculture area decline to 40 %. The increase in a built-up area is at the cost of agricultural land, forest land, and wetland. With the saturation of land in the city followed by suburbs, another part of the metropolitan region now experiencing the fast growth and rapid land use transformation.

To see the relationship between population growth and landuse change than it is clear that there is a strong relationship between population growth and land-use change in the Mumbai metropolitan region. As the population increase, the spatial dimension of the city significantly increases within the limited area.

Remote Sensing and GIS were used to detect the changes in the land use pattern over a period of time. The result of the change detection shows Mumbai has witnessed the rapid growth of the built-up area from 1991 to 2011. The built-up area of Mumbai witnessed an overall increment of 33% of the total area i.e. from 351 sq.km to1,074 .6 sq.km during the study period 1991to 2011 whereas there has been a significant decline in forest area/ agricultural land and wetlands (Figure 2). Itis also noticed that with an increase in the level of urbanisationthe mainurban growth city is relocated towards the edge ofthe city. The peninsular of Mumbai shows a spatially polycentric structure, with an urban core and dispersed rural-urban fringe.

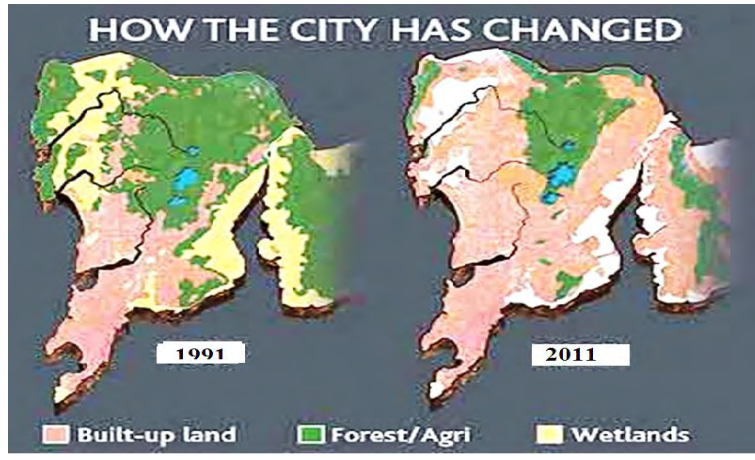

Fig. 2. Landuse and Land Cover Change in Mumbai from 1991 to 2011
Source: Adopted from the Draft Regional Plan for MMR, 1991, 2011, MMRD (BMRDA, 1968)

Delhi NCT is world's second-largest urban agglomeration by population and the largest by area. Covering an area of 33,578 sq.km with a total population of 16,753,265and corresponding population density is 11,297 persons/ sq.km in 2011. it is one of the fastest-growing metropolitan cities of India with an overall population size of Delhi (NCT) has continuously increased from 40 lakhs in 1971 to in 13.2 million in 1991, almost doubled in a short span of 20 years. Then it finally reached 16.7 by 2011. This increasing growth rate coupled with rapid in-migration accelerated the demand for land and to provide house such a large population, the city expanded in a much uncontrolled manner.

In 2011, about 20% or one-fourth area of Delhi is used for residential purposes, 11% for transportation, 20% for recreational purposes and 10% for industrial and 4% for commercial activities respectively (Figure 3). Like Mumbai, Delhi has also observed the rapid growth of population and therefore haphazard growth in different categories of urban land use pattern. Conversion of peripheral region of Delhi into urban area is very well discussed by Mohan M. et.al, 2011 and broad description is provided on the dynamic relationship between urbanisation and its impact on land use land cover.

The increasing spatial dimension of the city is also the population growth and related requirements of urban life, such as the development of transport and communication and other infrastructure facilities lead to removing vegetation cover that ultimately reduces interception and infiltration rates. This has caused a large reduction in the groundwater level. Paved or metalled surfaces not only make the ground impervious but also man-madestructures obstruct the flow of underground water.

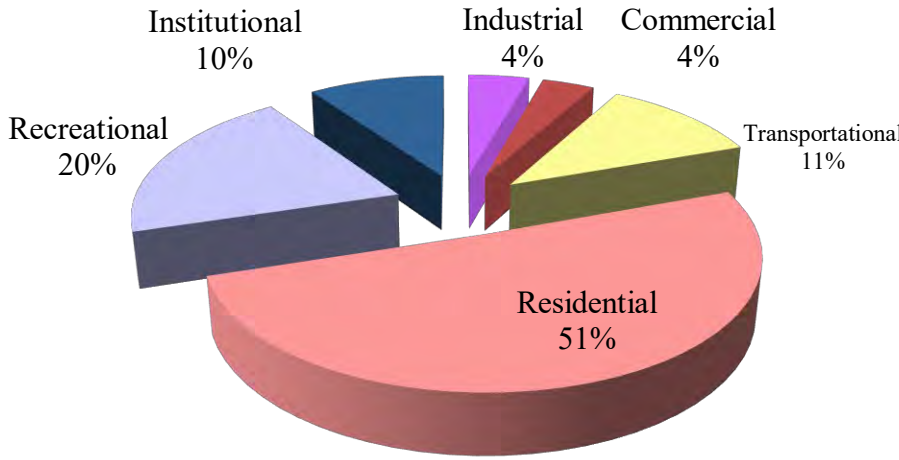

Fig. 3. Urban Landuse Pattern in Delhi (2011)
(Figure is made by author based on the secondary data obtained)
Source: Ministry of Urban Development and Poverty Alleviation, Government of India, 2011

Centre of the cities are often referred to as urban heat islands, having annual temperatures higher than those in suburbs, parks, and ex-urban areas. This is primarily due to the number of central cities covered by buildings and concrete rather than vegetation.Thus, this modification of the land surface by urban development uses materials that effectively retain heat. Waste heat generated by energy equipment. Increase in its average temperature is some of the cause of urban heat island.

Conclusions

The present study has assessed the consumption of land resources by various sectors in cities and evaluated the impact of population growth and urbanization in land use land pattern of 2 major metropolitan cities of India. The results showed that the LU/LC (landuse land cover change) classes of Delhi and Mumbai have experienced rapid changes particularly in the built-up category and decline in crop and fallow land and forest areas. The rapid growth of population, the process of urbanization related requirements of urban life, such as the development of transport and communication and other infrastructure are the prime causes that resulted in increasing demand for land in urban areas. Poorly managed development also causes excessive urban sprawl and negative impact on air quality, energy consumption, and aesthetic quality. The conversion of prime agricultural land to urban use increase costs for locating, storing and purchasing food.

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY

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

Conduct of 3rd Talent Test - 2013 for Geography Students on 7th February, 2013

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The Indian Geographical Society is organising the state wide **Third Talent Test - 2013** for final year UG and PG students of the Geography Departments in Tamil Nadu on **7th February, 2013**. 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,
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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 ***88th IGS Annual Conference*** to be held at Department of Geography, Bharathidasan University, Tiruchirappalli on 02.03.2013 (Saturday). All other participants will be given Certificate of Participation. Please visit IGS website for registration forms and further information: http://www.igschennai.org/

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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