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ASSESSMENT OF PETROL FILING STATIONS COMPLIANCE WITH PLANNING STANDARDS IN BENIN CITY, EDO STATE, NIGERIA

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Abstract

Petroleum is a major energy source that propels an economy and the distribution of filling stations is a measurement of its use. The study is on the assessment of filling station's. compliance with planning standards in Benin City, Edo State, Nigeria. 852 respondents were used in the interview survey. The study area was divided into core, intermediate, and sub-urban zones where 287 filling stations are sited. A radius of 100m was circumscribed around each filling station where three respondents were randomly picked at every 5th house in a street around a station. The trained interviewers estimated distances and areas of plots the stations were sited. The global position system readings of co-ordinates and distances between stations were determined. Descriptive analysis of percentages and frequencies were used to analyze data; inferential techniques of paired sample t-test was used to compare observed standards with planning standards; and nearest neighbor analysis was used to establish the pattern in the distribution of filling stations. The results showed non-compliance with the planning standards; the paired sample t-test on standards of plot size, sight distance and set-backs were significant. Also, the patterns of distributions at the core, intermediate and sub-urban were not regular. The study recommends that space standards for plot size, sight distance, and set-backs should be strictly enforced by the Ministry of Physical Planning and Urban Development; environmental monitoring of impacts should be carried out by responsible agencies, and that every filling station should have a fire-hydrant.

Key words: compliance, development control, petrol filling stations, set-backs, standards

Introduction

The place where premium motor spirit is sold is usually referred to in Nigeria as a petrol filling station. Although many different types of fuels are sold and services are rendered, the service stations are commonly known as petrol filling stations because premium motor spirit or petrol is the most common product demanded by consumers. According to Chinambu (2011), petroleum products constitute a critical energy requirement for transportation and industrialization in many countries. This assertion is also supported by Taylor, Sichinsambwe and Chonsa (2016) as constituting a prime moral of the present

movement of persons and goods world-wide. Thus filling stations are a visible part of the urban landscapes where economic and social activities gravitate (Taylor, et al. 2016). Petroleum products are highly volatile and have serious environmental consequences, and their locations require a guided selection to reduce their negative impacts (Ogundahunsi, 2014; Mshelia, Abdullahi and Dawha, 2015). The hazards involved in dispensing petroleum products demand intervention to shield urban residents from their negative environmental impacts. This task has been placed on some bodies such as the physical planning departments and agencies giving the approval of siting of filling station. Tah (2017) emphasized that the existence of regulatory bodies is a necessity, which must be, entrenched in a structure development plans. In Nigeria, the statutory bodies that are vested with the approval and siting of filling stations rest mainly on physical planning ministries and the Department of Petroleum Resources (DPR).

The standards that are used for the location and operations of filling stations involve location, plot size, set-backs requirements which the operators of petrol filling stations must comply with. In Edo State of Nigeria where the study area Benin City.is, the operators of filling station are to comply with the space standard of 33 x 33 square metres, a front set-back of 15 metres of the pump to the edge of the road, a 400m of distance separating two filling stations, a buffer of 50 metres separating filling stations from residential plots, and a filling station should share common boundaries with schools and hospital and so on (Edo State Government, 2014). these standards generally form the basis for the siting of petrol filling stations in urban environment of Edo State of Nigeria. In addition, the operators of the filling stations are expected to show their site plans and environmental impact reports of the operation of their proposal before obtaining approval for siting filling stations (Edo State Government, 2014).

The compliance by the operators of filling stations with planning standards has been observed in the literature. Taylor et al (2016) evaluated public opinion on the location of filling stations in the Zambian City of Kitwe found that 77.39 percent of the filling stations did not meet location standards. Also, Tah (2017) employed Geographic Information System (GIS) and remote sensing techniques in the locational analysis of filling stations in Kaduna metropolis revealed an over-concentration of filling stations on higher hierarchy roads thereby violating the minimum distance of 400 metres between two fillings in a road. Arokoyou, Ogoro and Aman-oritsewo (2015) also used GIS and remote sensing approaches in Obio-Akpo Local Government Area of River States and found that the minimum safe distance requirement of 400 metres between two stations and 15 metres front set-backs of pimps to the roads were grossly violated. Olusola (2017) observed the distribution pattern of petrol filling stations at Ilesha using Nearest Neighbour Analysis (NNA) and he found that the distribution pattern tended towards clustering (i.e. 0.36). The author suggested a more proactive approach by the planning authorities in striving at a better, regular distribution pattern. Olugenga (2017) remarked that there is a general phenomenon of non-compliance with many aspects of development control standards by developer and operators of development control regulations in Nigeria. The author attributed some reasons for these, which are: political influence on the location of filling

stations and corruption on the part of approving officials. Inter-agencies conflicts, especially between planning authorities and Department of Petroleum and Resources can hamper compliance to standards (Okafor, 2011).

The appraisal of PFSs compliance to planning laws and standards in Benin City will be assessed with these research questions:

1. What is the spatial pattern of location of petrol filling stations (PFSs) in Benin City?
2. To what extent do PFSs in the study area comply with planning standards specified by Edo State Urban Physical Planning Ministry?
3. What are the factors that promote PFSs non-compliance with planning standards in the study area?
4. How can the problem of non-compliance be addressed in Benin City?

Study Area

Benin City is located between latitudes 6^{O} 10' 39.161'' and 6^{O} 29' 52.153''N, and longitudes 5^{O} 26' 38.45'' and 5^{O} 49' 39.299''E as shown in Figure 1. City has a land mass of 10,956km^2.

Research Methodology

The approaches adopted include descriptive cross-sectional survey, geographical information systems (GIS), and field measurements. The study employed primary and secondary data. Primary data comprise PFSs geographic coordinates, setbacks to roads and linear distance from one PFS to another. Secondary data were collected from literature review and the standards operationalized in development control by the Edo State Ministry Physical Planning and Urban Development. The population of Benin is 1,634,501 (projected from 1991 to 2018). Using a sample size calculator, the estimated sample size is 384. (David Van Amburg cited in Mitchel and Jolley, 2007). However, 861 respondents were used for the survey because of the 100m, radius around each station in which three respondents were picked.

The sample size of 861 was distributed around 100m radius of a filling station, and the number of filling stations that was investigated is 287.The sampling technique is systematic random technique of every 5^{th} house in a street that falls within 100m around a filling station was chosen. A sampling ratio of 4:3:2 was applied to select the streets in the core, intermediate and sub-urban zones of Benin City in that order respectively. This translates to a total of 861 respondents, but 852 was retrieved. A structured questionnaire with Likert-type format was used for the interview survey. The responses were a five-option type with the lowest value option as 1, 3 as neutral, and the highest anchor value for the scale as 5.

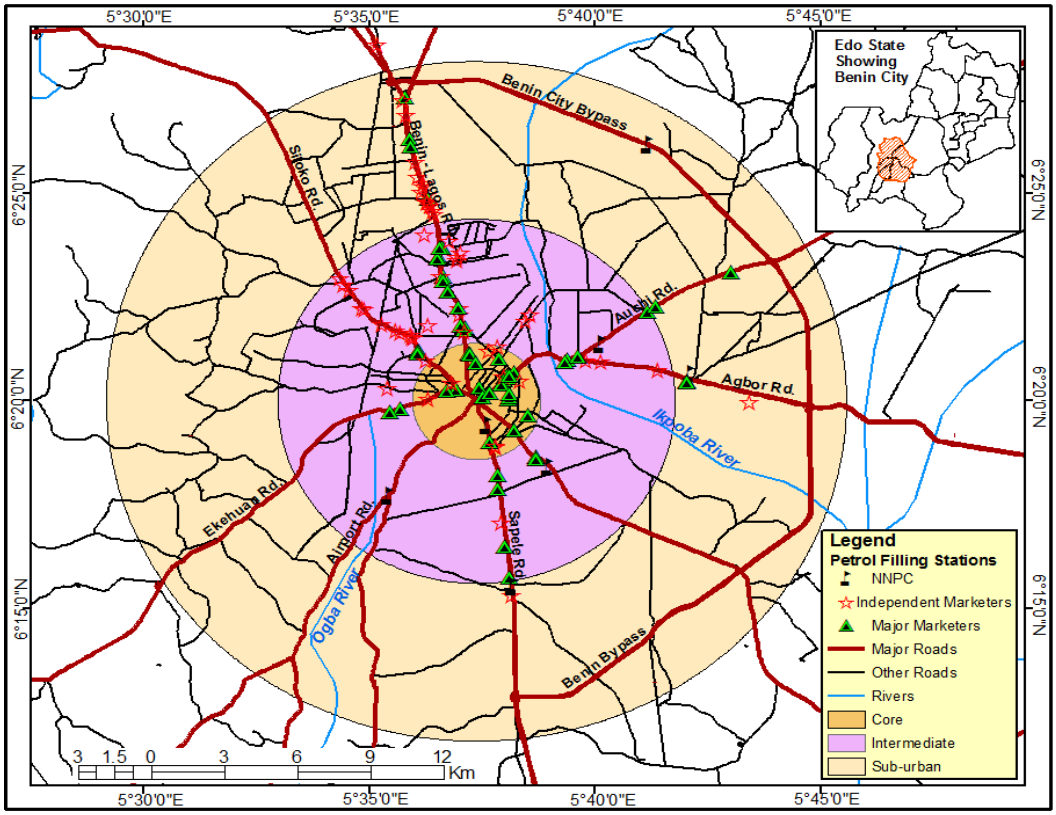

Fig. 1. Benin City Showing Petrol Filling Stations

Source: Compiled from Open Street Map and Google Earth, 2018

The question items bordered on classificatory questions and those relating to operators' non-compliance with planning standards. Six interviewers were trained to administer the survey. Two of them were assigned to a zone. The interviewers were trained on how to estimate the distance of the set-backs, the distance between filling stations, and plot size areas. The core had 379 respondents, the intermediate had 284 respondents, and the suburban had 189 respondents that were interviewed. .

The instrumental determination of the readings on distances between filling stations and their coordinates were read with the aid of Global Positioning System (GPS), using an assistant from Geography and Regional Planning Department, University of Benin, Benin City. The readings provided the basis for the computation of Nearest Neighbour Analysis to test the patterns for the distribution of filling stations in Benin City. Data were analysed both descriptively and inferentially. The descriptive analysis bordered mainly on the presentation of the variables that influenced the non-compliance of filling stations with planning standards.

The inferential analyses employed the Nearest Neighbour Analysis to test the distribution pattern of the filling stations in Benin City; and paired sample *t*-test was used to test the statistical significance of the difference between planning standards and the observed standards in the field survey. Eta squared was used to measure the magnitude of the significance difference of the observed standards with the standards operationalized by Edo State Ministry of Physical Planning and Urban Development.

Results and Discussion

Filling Stations' Compliance with Standards

There are different operators of filling stations found in Benin City and these range from small independent marketers, Nigeria National Petroleum Corporation (NNPC) to major marketers. All these one expected to meet the same standards in terms of siting, size and other standards as operationalized by the various supervisory authorities. The distribution of these filling stations are indicated in Table 1. The distribution among the operators shows that the independent marketers operate about 70.0 percent of the filling stations and NNPC operates 1.2 percent, which is the least.

Table 1. Ownership/Operator of Filling Station

S/N		Frequency	Percent
1.	Independent Marketer	201	70.0
2.	Major Marketer	68	23.7
3.	NNPC Retail Outlet	10	3.5
4.	Don't know	8	2.8
	Total	287	100.0

Source: Author's Field Survey, 2019.

Set-backs from the Road to Dispensing Pumps

The front set-back separates the pump from the road. In planning the minimum set-back is at least 15 metres for the least class of roads. Table 2 shows that 75 percent of the stations fall short of this standard in the study area; Arokoyou et al (2015) also found this. The minimum set back of 15m from the centre of the road to pump is only ideal for roads whose breadth is 15m and grossly inadequate for roads that are above 20m wide. In such situations the planning department uses its discretion in determining the set-back when approving such developments. This distance is needed in order to prevent traffic interference and accident during sales of petroleum products.

Table 2. Observed Set-back from the Road to Dispensing Pump

S/N		Frequency	Percent
1.	0 – 14 metres	213	74.2
2.	$\geq$ 15 metres	74	25.8
	Total	287	100.0

Source: Author's Field Survey, 2019.

Observed Distance Between Two Filling Stations in a Road

The inter-visibility or distance between two filling stations is not expected to be less than 400m. About 62.4 percent of the filling stations in Benin City failed to meet this standard (see Table 3). Most of the non-complying filling stations are found along the major roads within the core and intermediate areas; and in the peripheral areas, the distance separating two filling is generally higher than the minimum of 400m. The breach of their standard was observed in Kano by Tah (2017), and this led to over concentration of filing stations in some areas at the expense of other areas.

Table 3. Observed Distance Between Two Filling Stations

S/N		Frequency	Percent
1.	0 – 99 metres	66	23.0
2.	100 – 199 metres	64	22.3
3.	200 – 299 metres	49	17.1
4.	300 – 393 metres	28	9.8
5.	400 – 499 metres	28	9.8
6.	Above 500 metres	52	18.1
	Total	287	100.0

Source: Author's Field Survey, 2019.

Plot Sizes of Filling Stations in Benin City

A major planning requirement for the approval of filling station by the planning department is the plot size for a filling station. The standard is a plot size of 33m by 33m (i.e. 1089 sq. m). Only 33.1 percent of the filling stations in the study area met this standard. Table 4 indicates the level of compliance of the filling stations to plot size standard. The standard for plot size is meant to organize space in terms of vehicles attempting to refill their tanks such that the traffic does not spill to the roads abutting the stations. A part from some of these stations not meeting this standard, their irregular plot shapes make traffic movement erratic and difficult to control.

Table 4. Plot Size Compliance

S/N	Sq. M	Frequency	Percent
1.	≤ 900 metres	63	22.0
2.	901 – 1089 metres	129	44.9
3.	1090 – 2179 metres	53	18.5
4.	2180 – 3269 metres	16	5.6
5.	≥3270 metres	26	9.1
	Total	287	100.0

Source: Author's Field Survey, 2019.

Adequacy of Sight Distance of the Filling Stations to Approaching Vehicles

The sight distance of a driver who wants to buy fuel will enable him take pre-emptive decision on his driving. This quality of safe driving was assessed by the respondents and indicated in Table 5.

Table 5. Adequacy of Sight Distance of the Filling Station to Approaching Vehicles

S/N		Frequency	Percent
1.	Very Inadequate	276	32.4
2.	Inadequate	172	8.5
3.	Average	125	14.7
4.	Adequate	102	11.9
5.	Very Adequate	172	20.2
6.	Not Indicated	5	0.6
	Total	852	100.0

Source: Author's Field Survey, 2019

Only about 20 percent of the sight distances were adequate for safe driving; similar results was confirmed by Tah (2017) in Kano. The implication of the inadequacy of site distance is that motorists are not adequately prepared on driving decisions to take, but rather, take abrupt decisions to detour which can cause traffic accidents.

Factors Responsible for Non-compliance

Expensive Registration Process

Many have alluded to expensive plan registration process as a causal factor in non-compliance (Okafor, 2011). Some 65.5 percent of the respondents on cumulative basis claimed that expensive process of registration is responsible for non-compliance as operators try to maximize the use of space to advantage which may amount to non-compliance. Only few of them saw the process of registration as of average cost; however, about 15.8 accepted that the process is not expensive. Table 6 shows the responses on the expensive plan registration process of petrol filling stations.

Table 6. Expensive Registration Process

S/N		Frequency	Percent
1.	Very Expensive	296	35.0
2.	Expensive	261	30.6
3.	Average	150	17.6
4.	Not Much	75	8.8
5.	Not Expensive	60	7.0
6.	Not Indicator	7	0.8
	Total	852	100.0

Source: Author's Field Survey, 2019.

Many developers have complained on the due process not followed in plan registration in Edo State (Olugbenga, 2017). Thus this leads one to find out from the respondents: how transparent is the due process for plan assessment in Edo State? The next section makes attempt in answering this.

Due Process in Plan Registration

Due process is a major catalyst for success in planning administration as the processing of development plan must be seen to be transparent in the eye of the public. The respondents were asked to assess this and their responses are shown in Table 7. On cumulative basis, 81.4 percent of the respondents rejected the claim that the operators of filling station get transparent process when applying for approval of their developments. Only 11.9 percent claimed that the process is average; and 5.8 percent remarked that it is transparent. Operators believe that the monetary enticement they give to corrupt officials is a license for them to sideline planning standards especially on site coverage of developments and space standards.

Table 7. Due Process in Registration

S/N	Due Process	Frequency	Percent
1.	Not at All	306	35.9
2.	Little	388	45.5
3.	Average	101	11.9
4.	Much	30	3.5
5.	Very Much	20	2.3
6	Not Indicated	7	.8
	Total	852	100.0

Source: Author's Field Survey, 2019

Location Standard

The location of petrol filling station is not to be haphazardly done. It is often located where sight line is clear, not at a road junction, and two filing stations do not share common boundary. The respondents were asked to use these criteria to assess the suitability of the location of filling stations in Benin City. Table 8 shows the extent of non-compliance of filling stations with location standards.

Table 8 Extent of Non-compliance with the Location Standards

S/N	Non Compliance with Location	Frequency	Percent
1.	Very High	200	7.9
2.	High	241	7.2
3.	Average	287	5.9
4.	Low	80	3.4
5	Very Low	34	3.4
6.	Not Indicated	10	6.0
	Total	852	33.7

Source: Author's Field Survey, 2019.

About 71.4 percent of the filling stations did not comply with the criteria set for locating them; average level of noncompliance was 33.7 percent; low level of non-compliance was 15.6 percent. Thus the rate of non-compliance with location standards is very high (Edo State Government, 2014).

Spatial Pattern of Location

One of the most widely used techniques in evaluating the distributional pattern of phenomena in space is the nearest neighbour analysis (NNA) developed by Clark and Evans (1954). This framework was used to evaluate the locational pattern of PFSs in Benin City. The NNA, although computed using it algorithm in Arc GIS 10.1 is computed using the formula in Equation 1:

$$Rn = 2\bar{d}\sqrt{\frac{n}{A}} \quad \text{(1)}$$

where, R*n* = nearest neighbour index *n*

A = land area of the study area

d = total mean distance between the fuel stations

n = number of fuel stations

The R*n* values ranges from 0 to 2.15 interpreted as follows:

R*n* = 0: the distribution is clustered

R*n* = 1: the distribution is random

R*n* = 2.15: the distribution is regular

Figure 2 shows the spatial pattern of the distribution of filling stations in the study area. This is an omnibus nearest neighbour (R_n) analysis and the pattern shows

R_n = 0.514172, p = value = 0.000001.

The R_n index shows a weak random pattern

Also, see Table 9 which provides further analysis on the pattern of distribution of the filling stations in Benin City.

Table 9 Summary of Nearest Neighbour of PFSs in Benin City

Average Nearest Neighbour Summary	
Observed Mean Distance:	350.279261 metres
Expected Mean Distance:	681.248857 metres
Nearest Neighbour Ratio:	0.514172
z-score:	-15.745416
p-value:	0.000000

Source: Field Survey (2019)

The R_n which is 0.514172 is close to random in terms of the pattern of distribution; and also, this is significant at 0.000001.

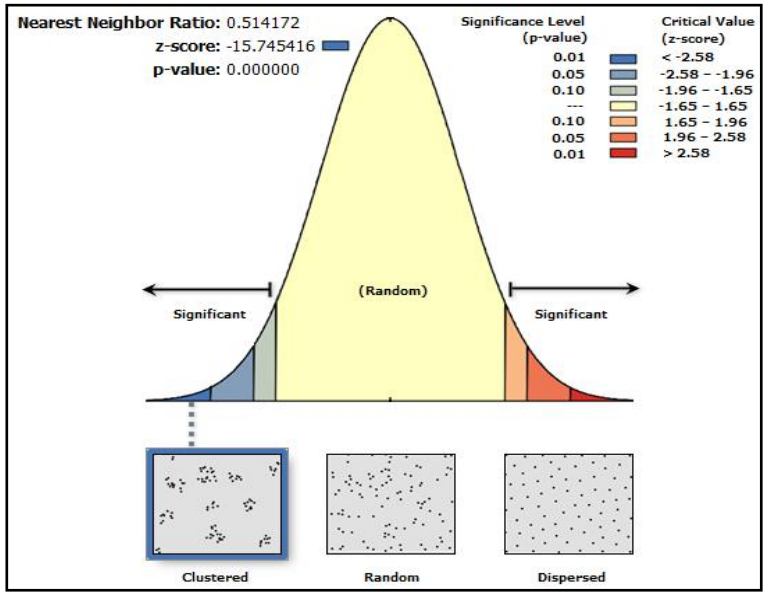

Fig. 2. Average Nearest Neighbour Summary of PFSs in Benin City

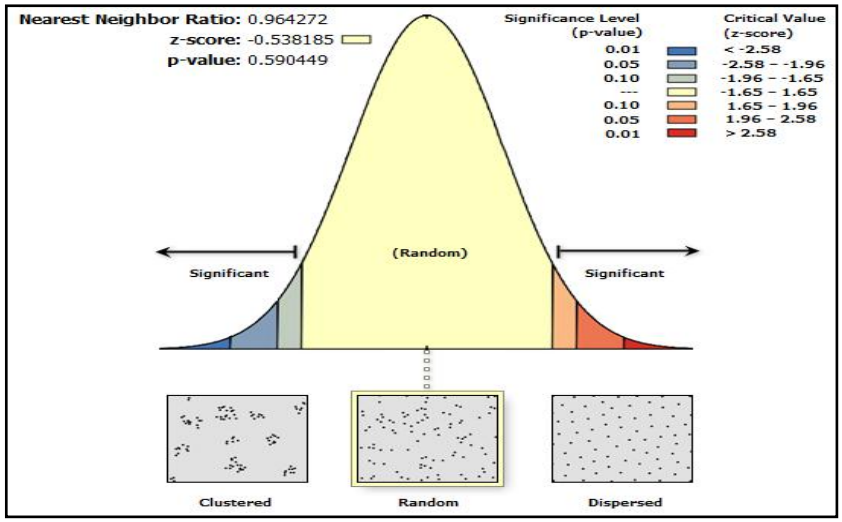

Fig. 3. Summary of Nearest Neighbour of PFSs in Core Zone of Benin City

Source: Field survey, 2019

The analysis is taken further in terms of the spatial units of analysis at the core, intermediate, and sub-urban or peripheral areas. Figure 3 depicts the graphic representation of R_n index and its significance values at the core of Benin City.

The R_n is 0.964272, which is close to 1, a value for random pattern. This is, therefore, a case of random pattern. However, the p-value of 0.590449 is not significant (See Figure 2 and Table 10).

Table 10. Summary of Nearest Neighbour of PFSs in Core Zone of Benin City

Average Nearest Neighbour Summary	
Observed Mean Distance	262.300538 metres
Expected Mean Distance	272.019153 metres
Nearest Neighbour Ratio	0.964272
z-score	-0.538185
p-value	0.590449

Source: Field Survey (2019)

Given the P=0.590449, the Rn = 0.964272 though close to random is not significant.

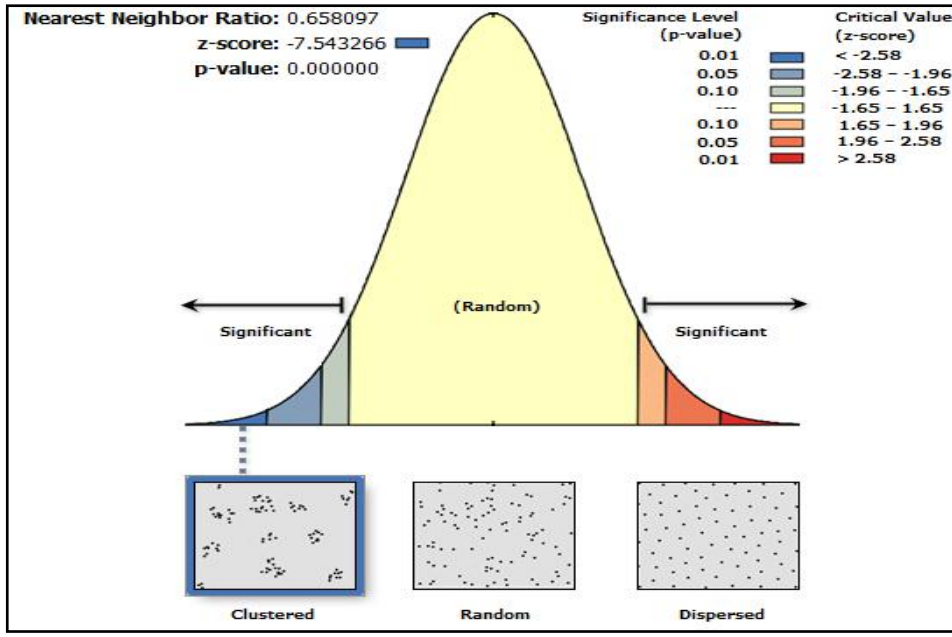

Fig. 4. Summary of Nearest Neighbour of PFSs in Intermediate Zone

The distribution pattern of the filling station at the intermediate zone is R_n index of 0.658097, which is close to 1 (random). This is a fairly weak tendency towards random which is a rarity in human spatial distribution of population and facilities. Its p-value of 0.000001 is significant (see Figure 4 and its complementary Table 11).

At the sub-urban zone of Benin City, the R_n index is 0.34461, which is showing tendency toward clustering that has a value of 0. The pattern of distribution is significant at p-value = 0.000001 as shown in Figure 4 and Table 11.

Table 11. Summary of Nearest Neighbour of PFSs in Intermediate Zone of Benin City

Average Nearest Neighbour Summary	
Observed Mean Distance	396.428340 metres
Expected Mean Distance	602.385732 metres
Nearest Neighbour Ratio	0.658097
z-score	-7.543266
p-value	0.000000

Source: Field Survey (2019)

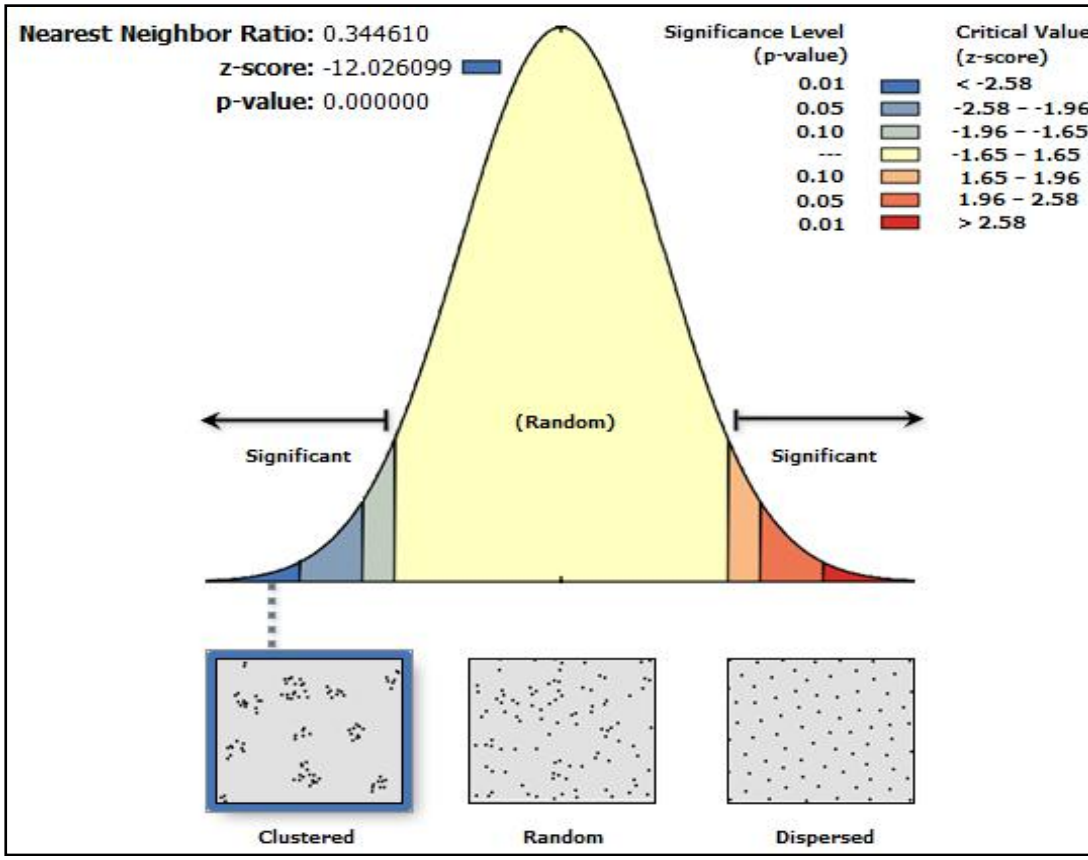

Fig. 5. Summary of Nearest Neighbour of PFSs in Sub-Urban Zone

Decision: Given the z-score of -12.03, there is a less than 1% likelihood that this clustered pattern could be the result of random chance. The quantification of spatial pattern of the distribution of filling stations is however limited by the morphology and areal coverage of the different zones in which the exercises were carried out (Waugh, 1995). This explains why the result is not quite meeting the theoretical expectation because the shapes of the zones the exercise are not contiguous, but that is, rectangular, but rather tapering and circular ring form.

Table 12. Summary of Nearest Neighbour of PFSs in Sub-Urban Zone of Benin City

Average Nearest Neighbour Summary	
Observed Mean Distance:	414.915796 metres
Expected Mean Distance:	1204.016374 metres
Nearest Neighbour Ratio:	0.344610
z-score:	-12.026099
p-value:	0.000000

Source: Field Survey (2019)

Comparison of Observed Standards in the Field with Planning Standards of Physical Planning Ministry

The descriptive analyses have to a considerable extent established the fact that the planning standards set as average conditions of what have been described, for example, front setbacks from middle of roads to pumps, sight distance between stations, plot sizes, have shown that these standards have been violated by many filling stations in Benin City. The inferential statistical tests amounted to a further conclusion on the discrepancies between what are on the field and the physical planning standards. Paired sample *t*-test was used for the comparison (see Table 13).

Table 13. Paired Sample t-Test

S/N			Paired Differences 95% Confidence Interval of the Difference Upper	T	df	Sig(2-tailed)	Eta Squared
1.	Part 1	Observed distance between filling stations – ideal distance by Edo State planning	-496.63726	-4669.593	286	.001	0.999
2.	Pair 2	Plot size of the filling station – ideal plot size by Edo State Planning Standards	-897.51779	-13207.552	286	.001	0.999
3.	Pair 3	Observed setback from the first dispensing pump-distance by Edo State Town Planning	-13.69125	-531.269	286	.001	0.999

The difference in the observed distance between two filling stations and the standard in physical planning is significant, t(286) = -4669.593, $P < 0.005$ (two tailed). The difference in the observed plot size and the one operationalized in planning is significant, $t(286) = -1320.552$, $P < 0.005$. The third variable, observed setback from the dispensing pumps is also different from the ideal distance and significant at $t\ (286) = -531.269$, $P <$

0.005. The analysis of the significance of the i-test was further extended to verify the magnitude, and this was done with eta squared. The computed eta squared for the three variables of violation of standards are in Table 4.27. According to Cohen (1988) a value of 0.99 is a very high effect size. Thus the three variables used for establishing violation have high magnitudes of significance.

Conclusions

Many filling stations in Benin City, Edo State of Nigeria do not comply to planning standards, because of the fac that the regulatory bodies are not strictly enforcing compliance. Thus there is the need to halt nonchalance on the part of the planning office.

The following recommendations have been suggested to address the problems of non-compliance with planning standards by the operators of filling stations in Benin City.

1. The Ministry of Physical Planning and Urban Development must insist that future filling stations that are to be established in the study area to comply with the space standards of 1089 square metres. This space standard is critical to the activities carried out in a filling station which must be accommodated.
2. Future filling stations must observe the mandatory sight distance of 400m. Filling stations should be sited not to face each other or have a common boundary on the same side.
3. All filling stations in Benin City should have water hydrants because water is an essential ingredient in fire- fighting in an event of fire accident.
4. Filling stations should have a buffer of at least 6m separating properties from the left and right sides. This buffer is to be freed of any development, so as to offer empty spaces for the spread of fire and maneuvering space for fire-fighting equipment.
5. The supervisory agencies should do some post-impact assessment monitoring to have a feel on what the operators are doing to mitigate environmental hazards of fire disasters, petrol spillage and air pollution. Any deviations from standard practices set down, should be sanctioned by the supervisory bodies.
6. There is the need to discourage the over-concentration of filling stations in the core area of Benin City by not granting license to would-be-operators to establish filling stations there. This is aimed at minimizing environmental hazards associated with filling stations at the densely populated core zone of Benin City

When these recommendations are enforced by both the Ministry of Physical Planning and Urban Development and Department of Petroleum Resources, operators of filling stations would comply with the standards that guide the operation of the stations in Benin City.

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QUANTITATIVE ANALYSIS OF CROP COMBINATIONS IN CYCLONE PRONE NELLORE DISTRICT, ANDHRA PRADESH

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Abstract

In India, Agriculture plays a vital role in the economy. It is an important sector as it contributes about 17% to the total GDP and provides employment to over 60% of the population. The agricultural sector includes field crops, Horticultural crops, agro-forestry plants, livestock and fisheries. Cyclones in Coastalareas severely affect all these components of agricultural sector through direct damage by high speed winds, torrential rains and extensive flooding. Proper cropping system and cropping pattern promotes Food security in any region especially in the disaster prone areas. India, being a second most populous country, there is a need for the optimum utilization of every piece of land, as land is fixed and limited compared to the population. Though the Green revolution enhanced the food grain production, the sustainability of land quality, its environment and recurring disasters posed a problem to the farmers, Policy makers and Planners. Cropping system comprises all components required for the production of a particular crop and the interrelationships between them and environment. In the cropping systems, sometimes a number of crops are grown together or they are grown separately at short intervals in the same field. To understand the cropping systems the study of Crop Combinations brings out a comprehensive scenario of any area. Hence in the present endeavour an attempt is made to study the Crop Combinations in the Cyclone prone Nellore District of Andhra Pradesh using Doi's Method.

Introduction

Crop Combination is a process of cultivating multiple crops in the same field. This practice helps farmers to harvest more than one crop in different seasons. Crop Combination also nurtures the soil and increases its fertility. The concept is an integral and important part of agricultural geography as it provides a good basis for agricultural regionalization. The crops are generally grown in combinations and it is rarely that a particular crop occupies a position of total isolation with other crops in a given areal unit at a given point of time. The mapping of the integrated assemblage of various crops grown in an aerial unit in the form of crop combinations is more important and comprehensive than the depiction of individual crops in a map . For example, the demarcation of India into the Rice region or Wheat region does not explain the agriculturally significant fact that very often the Wheat region also has a Rice crop and vice versa, or wheat is often grown with gram, barley or some other crops.

For a comprehensive and clear understanding of the agricultural mosaic of an agro-climatic region and for the planning and development of its agriculture, a systematic study of crop combinations is of great significance. In recent years the concept of crop combination has engaged the attention of geographers and agricultural land use planners. Hence, in the present article, an endeavour is made to study the quantitative analysis of crop combinations in Cyclone prone Nellore District. The district being frequently prone to Cyclones, planning of crop land use matters a lot. The study throws a light in this direction.

Study Area

Nellore District the southern most coastal district of Andhra Pradesh lies between $13^0\ 30^1$ and $15^0\ 6^1$ of the Northern latitude and $70^0\ 5^1$ and $15^0\ 6^1$ of the Eastern longitude. It is bounded on the north by Prakasam district, on the east by Bay of Bengal, on the South by Chittor district and Thiruvallur district of Tamil Nadu and on the west by Veligonda hills which separate it from Cuddapah District. The principal rivers which drain the district are the Pennar river and other streams of occasional and torrential in character are Kandleru and Boggeru. The district spreads over an area of 13,07,000 hectares and accounts for 4.75 per cent of the total geographical area of the state. The Net area sown is reported as 3,33,451 hectares in the district. According to 2011 census the total population of the district accounts to 29.64 lakhs and the density of population is 227 Persons/sq.km. The main objective of the present study is to identify the crop combinations in two time periods i.e. between the trienniums 1987-90 and 2012-15 in Nellore District and to bring out the changes in the combinations during 25 years period.

Database and Methodology

In the present study, secondary data pertaining to General cropping pattern for two trienniums i.e., 1987-90 and 2012-15 have been collected from the Government records and reports from Chief planning officer, Hand book of Statistics, Agricultural office of Nellore District taking 'Mandal' as Unit. Simple statistical techniques such as percentages and averages have been used to analyse the data. Doi's method has been employed to find out various crop combinations in the district.

Results and Discussions

Crop Combinations (1987-90)

By employing Doi's method, the crop combinations are identified in the district for the triennium 1987-90. Broadly speaking, the following crops namely, Paddy, Jowar, Bajra, Ragi, Pulses, Groundnut, Spices and condiments, Tobacco, Fruit crops are found at least in one of the crop combinations and hence these crops are considered very significant. The distributional pattern of the combinations revealed seven major combinations in the district. Both in area and number, mono crop combination namely Paddy is more prevalent in the district.

Mono Crop Combination

Monoculture is found in 43 per cent of mandals of the district (Fig.1). Paddy is in monopolistic position in terms of areal extent of monoculture. All the coastal mandals except a few in extreme south are confined to this combination.

Double Crop Combination

This is the second largest combination in this district and account 19 per cent of the mandals. In all the two crop combinations Paddy is cultivated as first crop in combination with groundnut. The two crop combinations are found in Kota, Ozile, Tada, Vakadu, Naidupet, Dakkili, Pellakur, Venkatagiri and Balayapalli mandals which are generally confined to the southern part of the district.

Triple Crop Combination

Only 11 per cent of mandals in the district exhibits three crop combinations. Of the total three crop combinations, Paddy + Jowar + Tobacco combination is found in two mandals such as Kondapuram and Atmakur, Paddy+Jowar +Bajra combination is noticed in Ananthasagaram mandal, Paddy + Fruit crops +Groundnut is observed in Gudur mandal and the last combination of Jowar + Groundnut 4 paddy belongs to varikuntapadu mandal. All the three crop combinations except one are found in north-western part of the district (Fig.1).

Four Crop Combination

This is the third most important combination regarding to areal extent occupying 15 per cent of mandals in the district. Groundnut + Paddy + Bajra + Ragi is observed in 2 mandals such as Seetharampuram and Udayagiri. Jowar + Paddy + Pulses + Fruit crops combination is seen in Chegerla, Jowar + Paddy + Fruit crops + Pulses in Podalkur, Paddy + Groundnut + Spices and condiments + Tobacco combination in A.S.Peta, Jowar + Spices and Condiments + Paddy + Pulses noticed in Kaluvoya and the last sub combination composed of Fruit crops + Paddy + Groundnut + Jowar is found in Sydapuram mandal. Four crop combinations are spatially belongs to western part of the district especially in the southern bank of the river Pennar.

Five Crop Combination

Spatial pattern of this combination is very tiny occupying only one mandal such as Rapur. The crops involved in the combination are Paddy + Groundnut + Fruit crops + Jowar + Pulses.

Six Crop Combination

Nearly about 4 per cent of mandals in the district have this type of combination. The crops involved in this combination are Tobacco, Paddy, Jowar, Groundnut, Bajra, Ragi,

spices and Condiments and Pulses in the two sub group of six crop combination. The combination with Tobacco as first rank crop is found in Marripadu and the other one is with Paddy noticed in Kaligiri mandal. These two mandals are located in north-western corner (Fig.1), as it is stated earlier it Is the driest part of the district where generally diversified cropping pattern is observed.

Seven Crop Combination

Like in the case of six crop combination, the areal extent of this combination is too small which belongs to north-western corner where crop diversification is more. There are two Kinds of 7 crop combinations with crops such as Jowar, Bajra, Ragi, Groundnut, Tobacco, Paddy and spices and condiments. The combination with Jowar as first crop is noticed in Duttalur and the other combination is reported in Vinjamur with Paddy as first rank crop (Figure 1).

The crop combinations of Nellore District showed 7 major combinations during 2012-15. The crops involved in these combinations are Paddy, Jowar, Bajra, Tobacco, Spices and Condiments, cotton, Sugarcane, Fruit crops, Pulses and Grams, Vegetable crops and Groundnut in various combinations with different positions. These 9- crops are found at least in one of the crop combinations during the study period.

Crop Combinations (2012-15)

During 2012-15 about 11 crops such as Paddy, Jowar, Bajra, Tobacco, Cotton, sugarcane, Groundnut, Fruit crops, Vegetable crops, Spices and Condiments and Pulses and Grams which as found in at least one of the crop combinations of the study period. It is analysed that there are 7 major combinations starting from mono crop to 8 crop combinations excluding 6 crop combinations noticed in Nellore District during the triennium 2012-15. Aerially Mono crop combination dominated by Paddy crop is the most significant combination confined to 26 mandals of the district.

Mono Crop Combination

Monocrop or one crop combination is observed in 26 mandals of the district during 2012-15 (Figure 1). In all these one crop combination regions Paddy is having monopoly which shows its dominance. Most of the mandals located in coastal lowlands belong to Paddy crop combination zone.

Double Crop Combination

In about 6 mandals of the district, 2 – crop combinations are been observed during the study period. They are Paddy + Fruit crops combination is noticed in Kavali, Balayapalli, Chillakur and Ojili mandals, whereas Fruit crops + Paddy combination is found in Podalakur and Sydapuram mandals (Figure 1).

Triple Crop Combination

Triple crop combinations is reported in 4 mandals in Nellore District during 2012-15 Paddy + Pulses and Grams + Fruit crops combination is noticed the Chejerla mandal, Fruit crops + Paddy + Pulses and Grams is observed in Rapur mandal, Fruit crops + Pulses and Grams + Paddy combination in Varikuntapadu mandal and Pulses and Grams + Paddy + Tobacco combination is reported in Kondapuram mandal.

Four Crop Combination

About 6 mandals have been reported under 4 - crops combination with various crops in various positions in the study region during 2012-15. They are Kaligiri (Pulses + Grams + Tobacco + Paddy + Fruit crops), Duttalur (Pulses and Grams + Tobacco + Fruit crops +Paddy), Gudur (Fruit crops + Paddy + Pulses and Grams + Sugarcane), Vinjamur (Pulses and Grams + Paddy + Sugarcane + Fruit crops), Kaluvoya (Paddy + Pulses and Grams + Fruit crops + Jowar) and Atmakur (Paddy + Tobacco + Pulses and Grams + Cotton) mandals.

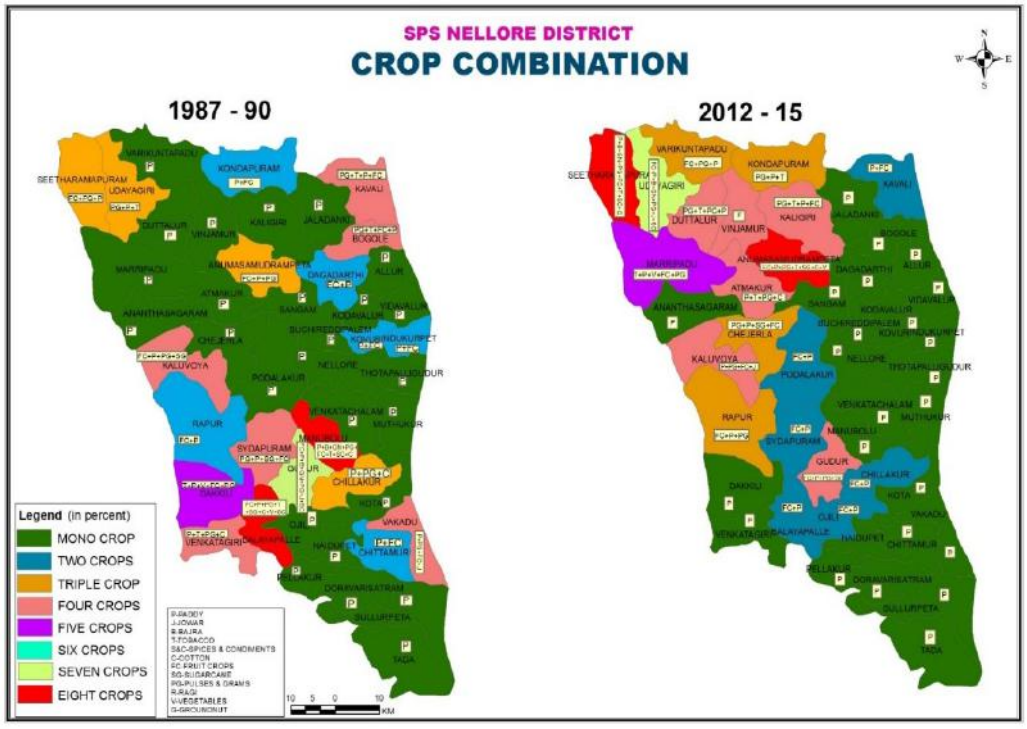

Fig. 1. Crop combination in the Mandals of the Nellore District

Five Crop Combination

Spatially, this combination is confined to only one mandal i.e., Marripadu with a combination of Tobacco + Paddy + Vegetable crops + Fruit crops + Pulses and Grams.

Six Crop Combination

This combination is completely absent in Nellore District during the 2012-15.

Seven Crop Combination

This combination is also restricted to only one mandal such as Udayagiri with the combination (Fruit crops + Paddy + Bajra + Groundnut + Pulses and Grams + Jowar + Sugarcane).

Eight Crop Combination

About 2 mandal have been found under 8 crop combination, such as Sitaramapuram mandal (Paddy + Bajra + Groundnut + Pulses and Grams + Fruit crops + Tobacco + Spices and condiments + Cotton) and Anumasamudrampeta mandal (Fruit crops+ Paddy + Pulsesand Grams + Tobacco + Sugarcane + Cotton + vegetable crops + Spices and Condiments) (Figure 1).

Changes in Crop Combinations (1987-90 to 2012-15)

The advent of Green revolution influenced food grain crops especially, Paddy in the coastal and irrigated districts of Andhra Pradesh. During 25 years of period (1987-90 to 2012-15) the spatial expansion of monoculture or monocrop cultivated area is reported in Nellore district. This expansion is spread over to 26 mandals (2012-15) from 20 mandals (1987-90) in the district. Paddy is the only crop dominated in the entire mono crop combination regions. The spread has been extended to southern mandals of the Nellore District apart from the original coastal mandals of the district. In all the other combinations spatial shrinkage is observed apart from the newly emerged 8- crop combination zone (Table 1). This shows dominance of mono crop combination with Paddy at one end and newly emerged diversified combination (8 – crop combination) the other end during 25 years period. Spatial decrease of 3 mandals has been reported in 2 – crop combination, one mandal in 3- crop combination and 4 crop combination. The number of mandals remained unchanged under 5 crop combination during the study period. Six crop combinations has been completely disappeared in the district. There is a shrinkage from 2 to 1 mandal in 7 – crop combination. The newly emerged 8 – crop combination has been seeing in 2 mandals (2012-15) which was completely absent in 1987-90. Change is also observed in the number of crops involved in the various crop combinations during 1987-90 and 2012-15 in Nellore district. About 9 – crops such as Paddy, Jowar, Bajra, Groundnut, Tobacco, Spices and condiments, Fruit crops, Pulses and Grams and Ragi have been reported in various combinations in different positions during 1987-90. In 2012-15 except Ragi crop the other 8 – crops have been observed in various combinations along with 3 more new crops namely Cotton, Sugarcane and Vegetable crops in Nellore District. Ragi crop, which is considered as an inferior millet crop, lost its ground in the crop combinations in Nellore District (Table 1).

Table-1 Crop Combinations for Nellore District: 1987-1990 and 2012-2015

S No	Crop combination	Number of Mandals		Decrease/Increase in 25 years period
		1987-90	2012-15	
1	Mono crop	20	26	+6
2	Two crop	9	6	-3
3	Triple crop	5	4	-1
4	Four crop	7	6	-1
5	Five crop	1	1	No change
6	Six crop	2	-	-2
7	Seven crop	2	1	-1
8	Eight crop	-	2	+2

Conclusions

The analysis of crop combinations in Nellore District revealed that the crop combination with one or two crops are more significant than multiple crop combinations both in 1987-90 to 2012-15. About 60-70 % of the mandals fall in these two combinations only. Crop combinations with the lesser number of crops are found in Coastal lowlands and Southern part of the district. Paddy dominates in most of the Mono crop combinations. In contrast the combinations with more number of crops are mostly prevalent in the Western and North Western part of the district due to dry climatic conditions.

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A SPATIO-TEMPORAL STUDY OF THE SURFACE WATER-SPREAD IN RURBAN ZONE OF HYDERABAD METROPOLIS

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Abstract

At no other time in the annals of human history, there has been so much of concern for Water Resources as at present, due to gross mismanagement of available surface fresh waterbodies, further impacted by global warming phenomena. Hyderabad, located in a semiarid/ sub humid tract of Indian Subcontinent, is not only witnessing climatic aberrations but also the anthropogenic impact on its waterbodies. This makes it essential to monitor its Water Resources for better prospective Regional Planning. In this paper, an attempt is made to evaluate the Surface Waterbodies in the Rurban Zone of Hyderabad through spatial technological inferences.

Keywords: Surface waterbodies, Spatial Technology, Rurban Zone, Evaluation, Global Warming,

Introduction

Fresh Water, a natural resource, is an elixir of life which is scantily available on the Land surface. Unfortunately, this limited resource is tending to be increasingly being termed as an economic resource, merely due to gross mismanagement and a steady decline in the availability of this resource. It is a well-known fact that this resource is over dependent on natural rainfall for its repletion which is unevenly distributed, making the proper augmentation, a tough task. At no point of time in the history of mankind, there has been such a debate on Water Resources and their management as is evidenced now. There has been a steady increase of the climate change impact on the existing availability of water, adding to these woes is also the deteriorating water quality.

Hyderabad was known as a city of the thousand lakes during Nizam's period. There were thousands of waterbodies which fulfilled the irrigational, domestic and edible water needs at that point of time. As the times progressed, it has been observed that there are only countable numbers of fresh water bodies left over. Many waterbodies all around Hyderabad have disappeared. The foresighted vision, during Nizam's time, was responsible for creating a linked pond chain, so that the excess water would not be wasted, in case of overfilling of one tank and ultimately joining a river system.

Due to warranted built up activity, majority of these ponds have been filled up and the catchment areas of these ponds have become concrete jungles, leading to high intensive overland flows. The recent Chennai floods are a testimony to this fact. The 2000 flood in Hyderabad, is also attributed to the same reason. Urban floods in a way are manmade floods. Reviewing the earlier studies, few notable ones are to be addressed here:

Ritu Singh and Manu Bhatnagar (2012), in a case study of Delhi, have identified because of land alteration and encroachment in the process of urbanization there is a sharp decrease in surface storage of storm water resulting in increasing surface runoff and sediment input to the streamlines and water catchments. Decreased groundwater recharge results in decreasing groundwater flow, which reduces base flow and may eliminate dry season flow. Altering the convexity of slopes and terrain concavity affects water gathering and water disseminating properties.

Siddhartha Koduru and Swati Dutta (2013) in a case study of Hyderabad Urban Development Authority region, have examined the impact of urbanization, over exploitation, encroachment to the lakeshores and altering the catchments for cultural and religious purposes which led in shrinking and even diminish most of the waterbodies during last 50 years. Swati Bansal (2015) studied the very similar phenomena occurring in Shri Nagar, Jammu and Kashmir. As per her study more than 50% waterbodies have disappeared over last century in Kashmir because of human interference and rapid urbanisation which is taking a heavy toll on Kashmir's waterbodies. Lakes in the region get silted due to massive erosion in the catchment area and thereby turn into land masses. Even Dal Lake, a major tourists' attraction has shrunk 37% in last 36 years.

Laloo and Ranjan (2017) in an overall study of Indian urban lakes, found the major loopholes in urban waterbody conservation are Lack of proper information, Lack of systematic strategies and coordination, Lack of Ecosystem approach, Lack of capacity building, Lack of balance of interest in management approaches. He also emphasized the Spatial growth of the cities, Encroachment, Illegal mining, Eutrophication and Socio-cultural misuse have been the catalytic drivers for shrinking or disappearing the urban waterbodies.

Similarly, several other studies have been conducted by many researchers which in fact reveals the truth of negative impact of urbanization on its waterbodies. Keeping these observations in view, an attempt is made in this paper to study surface fresh water bodies in 15 - 50km radius, bounding the Rurban Zone of Hyderabad. This area is exclusive of city water with many waterbodies like Ellamma Lake, Red lake, Devils Pond, Ali Lake, Bhagiratha Patel Lake, Kula Lake and Mondikunta Lake, which already have shrunk to a greater extent. Within the city region, Government is proceeding with reclamation and rejuvenation policy of these waterbodies as waterbodies revival programme. However, a lot more is needed to be done for the waterbodies falling within the peri-urban region of the city. The role of spatio-temporal technology, in this type of study, is highly significant as this can enhance the reliable data generation that further could help for a better decision making.

Study Area

A study area of around 7147.1km2 bounded by 16.971°N-17.874°N and 78.004°E-78.944°E extension is identified for the present study (Figure 1). The region is specifically chosen for the simple reason that, various sprawling studies on Hyderabad have confirmed that this zone has witnessed and is witnessing intensive Land Transformation due to rapid Urban Growth process along with corresponding infrastructural facilities. The study area comprises of mainly 56 Mandals from 4 Districts other than the central Hyderabad District. The region is an elevated plateau region with a height of around 600m. The region broadly can be categorized as a Pedi Plain with numerous hillocks either as continuous stretch or as isolated inselbergs, disintegrated into a number of tors which can be witnessed all aroundthe city region. The general slope is from West to East as all the drainage is east bound. Rivers like Musi and Aler are the major ones, draining the region accompanied by a number of rivulets and tributaries along with a number of waterbodies. The region comprises of Dry Deciduous Forests along with Thorny Scrubs as Vegetal Cover.

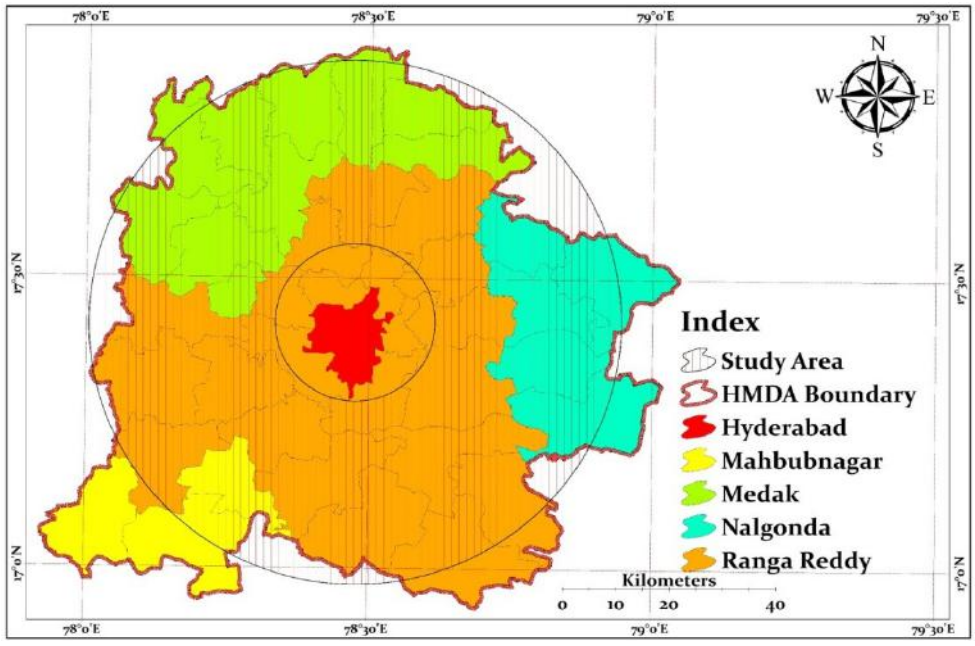

Fig. 1. Location of the Selected Study Area - The Rurban Zone of Hyderabad Metropolis

Source: HMDA, Telangana

The climate is predominantly of semiarid type with hot summers and mild winters. Of late, dryness is on increase with deficit rainfall in monsoon months. The onset and withdrawal of the monsoons are showing variations impacting the growing season of the plants phenology. The soils are red loams, with not so much of fertility component attached to it. However, increasing fertiliser input accompanied by controlled irrigation have made these soils agriculturally practicable.

Being “Rurban (Rural-Urban)”, the region, predominantly, is an agrarian belt. The livelihood of the majority of the people are associated with agriculture, subordinated by service sectors. The demand for water is enormous, not only for irrigational schemes, but also for domestic and industrial needs, which are likely to increase in the near future. The 'Telangana Drinking Water Supply Grid' or ‘Mission Bhagirathi’ is an attempt by the Government to provide 100 litres of safe drinking water per person in rural areas, 135 LPCD for Municipalities and 150 LPCD for municipal corporations. With population projections of 30 lakhs in another couple of years, the total water requirement would be around 43 TMC per annum. Further, the need would be increased to around 63 TMC by 2050. In this context, the need for water resource evaluation becomes more apt and more pertinent.

Database and Methodology

Multi Seasonal and Multi Temporal Scenes of Landsat-5 Thematic Mapper and Landsat-8 Operational Land Imager having 30m of Spatial Resolution (WRS-2, Path-144 & Row-48) along with 70’s & 80’s SOI Toposheets of 56K series on 1:50000 scale, are selected for the Identification and comparison of the area of the Surface Waterbodies populated within the Study Area for the years 1990 and 2015 respectively. Similarly, multiple post monsoon 2016 Satellite Scenes of Sentinel-2 MSI of 10m spatial resolution are taken for the identification of the plenitude of the Surface Waterbodies, which got refilled after an abundant rainfall for the said year. The satellite scenes are classified in a hybrid process (both Supervised and Unsupervised) using ERDAS Imagine 2015 for accurate mapping. Vector maps are extracted from the classified images and are further post processed using Minimum Mapping Unit (MMU) Technique in ArcGIS 10.3 for selecting the major water catchment areas instead of the smaller negligible ones. The Area differentiation is calculated using MS Excel. A standard parameter of 25% interval in the shrinkage of the net catchment area of any waterbodies from 1990 to 2015, is considered for the evaluation of the degree of shrinkage intensity.

Assuming the climate factor to have a greater impact on the water cycle, the historical meteorological data within 0.25^{o} interval *viz. rainfall*, is collected for a period of 36 years (Jan-1980 to Nov-2016), on seasonal and monthly basis, from the Web Server of “Precipitation Measurement Mission” (Global PMM) by NASA. Thus, the database is prepared and the analysis proceeded.

Results and Discussion

The Scenario of Waterbodies in 1990:

The scenario of waterbodies in 1990 clearly reflects the bountifulness of the nature. Dividing the entire Study Area into 8 Zones, one can easily perceive that the West-Central region was dotted with numerous numbers of waterbodies mostly small and few big ones. One can come across a number of tiny dots of waterbodies, along with major rivers draining from West to East. On the other hand, numerous waterbodies were seen dispersed

throughout the North-West, North and North-East Zones along with few rivers and rivulets out there, covering from one hectare to few square kilometres of catchment area. Exactly the East and the South-East region also can't be slurred over, as the regions also were witnessing the major source of surface water flow through the river Musi and many other waterbodies embodied within the agricultural lands and tableland topography of the region. The South and South-West regions were found not to be so rich of water resources as compared to the other 6 zones of the Study Area. These two zones seemed to be more scorched. Mapping the total number of surface waterbodies within the Study Area during 90's counted up to 1147 numbers of waterbodies ranging from 1Ha - 2162.413Ha of catchment area. Out of which 20, major known and other 15 minor unnamed waterbodies are selected for the study of change in areal spread (Table 1). The two major water bodies i.e. Himayat Sagar and Osman Sagar, approximately covering around 1646.70Ha and 2162.41Ha respectively, were in fact the major source of water supply to the twin cities of Hyderabad and Secunderabad. The other major waterbodies *viz.* Shahmirpet Lake, Malkapur Cheruvu, Ibrahimpatnam Lake, Rawiral Cheruvu, Bibinagar Lake, Mahbub Sagar, Maisamma Cheruvu, Cherlaguda Tank and Tangaliapalli Lake etc. covered the area above 100 hectares. Waterbodies *viz.*Isnapuram Tank, Dabilpur Tank, Masab Tank, Bhima Tank, Kalwakol Tank, Pedda Cheruvu, Timmapur Cheruvu, Kachva Tank and Pata Cheruvu were having the area ranging from nearly 50 to 60 hectares. 15 other unnamed waterbodies were also clearly identified for the study which were sum together covering approximately an area of 983.297Ha within the Study Area. Overall, the waterbodies inclusive of major rivers, approximately covered 208.742km^2 of area. Out of these, the major waterbodies covering more than one hectare of catchment area are taken into account for the present study which covered 81.40% (169.927km^2) of the total coverage by the Surface waterbodies. Contrastingly, East of 78^{o}30'E longitude, more open spaces were observed.

The Scenario of Waterbodies in 2015:

During 2015 it was observed that the total area under waterbodies covered only 93.84km^2 which is nearly 1/3rd of the total area as compared to 1990. Most of the smaller unnamed waterbodies, mainly ponds seem to have disappeared. However, the major waterbodies, witnessed earlier, continue to exist but with a shrunken area. Osman Sagar and Himayat Sagar shrunk to 786.307Ha and 1087.377Ha area approximately, reducing by 63.637% and 33.966% when compared to earlier numbers. Waterbodies like Shamirpet Lake, Ibrahimpatnam Lake, Bibinagar Lake, Tangaliapali Lake and Bhima Tank occupied less than 100 hectares, i.e. 52.886, 84.161, 7.571, 14.917 and 12.791 hectares, reducing by approximately 87.067%, 74.096%, 95.66%, 85.95% and 79.897% respectively. This is one of the rapid areal shrinkage in recent times. RawiralCheruvu, Dabilpur Tank, Kalwakol Tank, TimmapurCheruvu and Kachva Tank along with other 15 unnamed waterbodies seemed to be disappeared totally in course of a 25 years of period. MalkapurCheruvu, Mahbub Sagar, MaisammaCheruvu, Cherlaguda Tank, Isnapuram Tank, Masab Tank, PeddaCheruvu and PataCheruvu also witnessed a remarkable shrinkage of area ranging from 7.43% to 53.09% from 90'sto 2015 (Table 2).

Table 1. Major Waterbodies of 1990 within the Rurban Zone of Hyderabad Metropolis.

Sl.	Names of the Waterbodies	Area in Ha.	Latitude (N)	Longitude (E)
1.	Bhima Tank	63.63	17.679	78.184
2.	Bibinagar Lake	174.45	17.480	78.791
3.	Cherlaguda Tank	117.81	17.157	78.121
4.	Dabilpur Tank	68.95	17.666	78.463
5.	Himayat Sagar	1646.70	17.312	78.353
6.	Ibrahimpatnam Lake	324.90	17.192	78.626
7.	Isnapuram Tank	69.86	17.545	78.189
8.	Kachva Tank	49.50	17.558	78.379
9.	Kalwakol Tank	56.45	17.119	78.359
10.	Mahbub Sagar	151.04	17.621	78.097
11.	MaisammaCheruvu	150.94	17.175	78.311
12.	MalkapurCheruvu	358.55	17.572	78.040
13.	Masab Tank	64.80	17.288	78.583
14.	Osman Sagar	2162.41	17.376	78.293
15.	PataCheruvu	49.46	17.590	78.111
16.	PeddaCheruvu	51.80	17.562	78.213
17.	RawiralCheruvu	228.97	17.221	78.502
18.	Shahmirpet lake	408.94	17.611	78.555
19.	Tangaliapalli Lake	106.17	17.224	78.857
20.	TimmapurCheruvu	51.14	17.136	78.553
21.	Unnamed	106.92	17.813	78.400
22.	Unnamed	89.83	17.511	78.872
23.	Unnamed	83.54	17.620	78.479
24.	Unnamed	70.97	17.848	78.471
25.	Unnamed	67.81	17.793	78.500
26.	Unnamed	66.87	17.642	78.357
27.	Unnamed	66.44	17.783	78.612
28.	Unnamed	62.97	17.615	78.405
29.	Unnamed	59.90	17.151	78.259
30.	Unnamed	55.44	17.787	78.359
31.	Unnamed	52.34	17.255	78.688
32.	Unnamed	51.46	17.835	78.332
33.	Unnamed	51.19	17.673	78.224
34.	Unnamed	50.07	17.234	78.836
35.	Unnamed	47.48	17.584	78.187

Source: Landsat-5TM Scenes of 1990

Very likely to 90's, the Western, South-Western and the Southern Zones of the city have been witnessing rapid sprawling activity, thereby encroaching upon all dry lake/pond beds, leaving no scope for inflows, resulting in a complete evanesce of the waterbodies of the Early Times. Contrastingly, in the Eastern side, more revival of the waterbodies is observed. This may be attributed to the increasing agricultural activity on either side of the river Musi, flowing through the region. A comparative study of the concerned waterbodies is reflected in Figure 2.

Table 2. Comparative Status of the Major Waterbodies from 1990 to 2015 within the Rurban Zone of Hyderabad Metropolis

Sl. No.	Name of the Waterbodies	1990		2015		Shrinkage in Ha.	Shrinkage in %age	Degree of Intensity
		Area in Ha	Status	Area in Ha	Status			
1.	Bhima Tank	63.63	Wet	12.79	Wet	50.84	79.90	Very High
2.	Bibinagar Lake	174.45	Wet	7.57	Wet	166.88	95.66	Very High
3.	Cherlaguda Tank	117.81	Wet	109.05	Wet	8.76	7.44	Low
4.	Dabilpur Tank	68.95	Wet	0.00	Dried	68.95	100.00	Very High
5.	Himayat Sagar	1646.70	Wet	1087.38	Wet	559.32	33.97	Moderate
6.	Ibrahimpatnam Lake	324.90	Wet	84.16	Wet	240.74	74.10	High
7.	Isnapuram Tank	69.86	Wet	61.33	Wet	8.53	12.22	Low
8.	Kachva Tank	49.50	Wet	0.00	Dried	49.50	100.00	Very High
9.	Kalwakol Tank	56.45	Wet	0.00	Dried	56.45	100.00	Very High
10	Mahbub Sagar	151.04	Wet	125.65	Wet	25.40	16.81	Low
11	MaisammaCheruvu	150.94	Wet	70.79	Wet	80.15	53.10	High
12	MalkapurCheruvu	358.55	Wet	205.94	Wet	152.61	42.56	Moderate
13	Masab Tank	64.80	Wet	39.00	Wet	25.80	39.81	Moderate
14	Osman Sagar	2162.41	Wet	786.31	Wet	1376.11	63.64	High
15	PataCheruvu	49.47	Wet	30.70	Wet	18.77	37.93	Moderate
16	PeddaCheruvu	51.81	Wet	42.45	Wet	9.35	18.06	Low
17	RawiralCheruvu	228.97	Wet	0.00	Dried	228.97	100.00	Very High
18	Shahmirpet lake	408.95	Wet	52.89	Wet	356.06	87.07	Very High
19	Tangaliapalli Lake	106.18	Wet	14.92	Wet	91.26	85.95	Very High
20	TimmapurCheruvu	51.14	Wet	0.00	Dried	51.14	100.00	Very High
21	Total	6356.53		2730.92		3625.60	57.04	High

Source: Landsat Multi Temporal Scenes of 1990 & 2015

Apart from this, the concretization of the surface makes the soil strata impervious. Regardless of the expansive city growth process, it's unfortunate that status of waterbodies has not been paid due attention. However, with the increasing demand for drinking water, accompanied by irrigational demand for agriculture sector, associated with fresh industrial and infrastructural demand, a thought process of waterbody revival mission has begun. Few of them totally vanished and few reappeared again after 25 years. It has been noticed that although 5 known and 15 unnamed major waterbodies (As mentioned in Table 1) covering an area of 1438.314Ha disappeared but other 20 major fresh waterbodies occupying an area of 966.244Ha are identified as revived in course of time. But, still a dearth of 472.070Ha of catchment area remained un-replenished, suggestive of Enhanced Waterbody Revival Programme by the Government (Table No. 3). This aspect has to be viewed with a serious concern as the revival programme by the Government stands as partially accomplished. Out of the original 35 selected waterbodies for the year 1990 to 2015, 15 unnamed waterbodies and 5 known waterbodies have completely disappeared and the remaining 15 waterbodies have shown a considerable shrinkage in the water spread. A major attempt by the Government could only revive another 15 unnamed and 5 known waterbodies to balance the previous and present water spread, but still there is a major dearth of catchment area to be revived to meet the ever-increasing need.

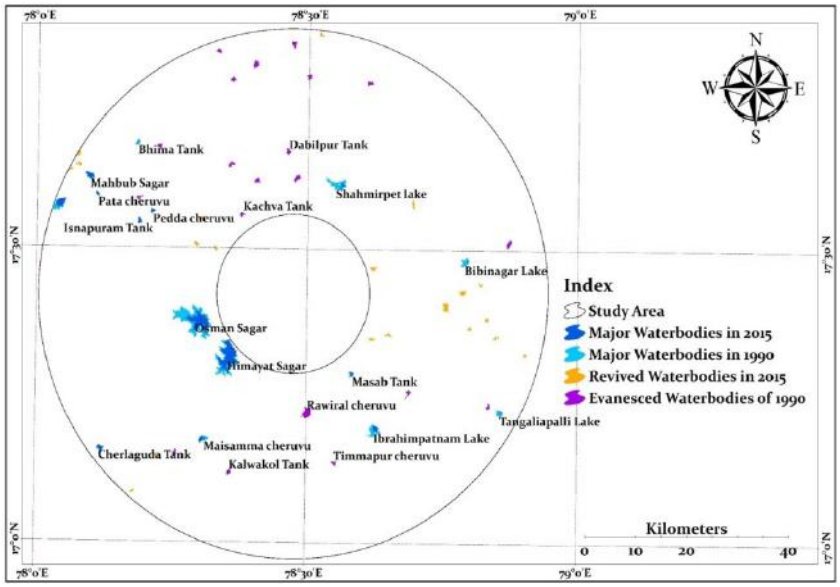

Fig. 2. Change Detection of Major Surface Waterbodies in Rurban Zone of Hyderabad Metropolis from 1990 to 2015

Source: Landsat-5 TM (1990) and Landsat-8 OLI (2015)

Current Scenario (2016)

With the increasing emphasis on renewal of waterbodies by the State Govt., there has been a concerted effort at various levels, to enhance the water resource potential in the region. Though the Dug Pits remained waterless till May 2016, but the copious rainfall in the month of September-2016 has changed the total water-scenario in the state. The water levels of all the waterbodies inclusive of Reservoirs, Tanks, Ponds and Pools have risen considerably giving a new look to the existing waterbodies. The recent satellite scenes of November 2016 (the post monsoon) depicted the total number of waterbodies as more than 3000 out of which 1459 waterbodies are having an area of above one hectare (Figure 3). All this was possible due to continuous downpour of 24cm (approx.) of precipitation within four days (20^{th}-23^{rd} Sep. 2016) in the month of September. From 4 segments of the years i.e. 1. December-January-February (DJF), 2. March-April-May (MAM), 3. June-July-August (JJA) and 4. September-October-November (SON), It can be understood that the Study Area usually receives a better rainfall during the second two seasons, which are usual monsoon months (SW and NE). Comparatively it was observed that in the years 1986, 2000, 2008 and 2016 the rainfall was quite higher than the average rainfall.

From a comparative study between the monthly total rainfall for first 20 years (1980-00, Figure 5) and second 16 years (2000-16, Figure. 6) reveals that both the monsoons have been active showing a similar trend in both the periods. Apart from this, in general, the rainfall was quite adequate as predicted by IMD, due to lack of “Elnino” impact. The following Figure 4 depicts the early seasonal Total Rainfall pattern from the year 80’s to 2016.

Table 3. Major Dried and Revived Waterbodies from 1990 to 2015 within the Rurban Zone of Hyderabad Metropolis

Sl. No.	Name of the Waterbodies	Existed in 1990			Revived in 2015		
		Area in Ha.	Latitude	Longitude	Area in Ha.	Latitude	Longitude
1.	Unnamed	106.922	17.813	78.401	151.533	17.403	78.757
2.	Unnamed	89.831	17.512	78.872	74.476	17.428	78.787
3.	Unnamed	83.543	17.621	78.480	61.313	17.468	78.622
4.	Unnamed	70.976	17.848	78.471	60.639	17.658	78.075
5.	Unnamed	67.815	17.793	78.501	54.664	17.578	78.695
6.	Unnamed	66.870	17.643	78.357	54.034	17.506	78.295
7.	Unnamed	66.443	17.783	78.612	50.881	17.551	78.304
8.	Unnamed	62.978	17.615	78.406	49.984	17.640	78.076
9.	Unnamed	59.906	17.151	78.259	41.659	17.355	78.651
10.	Unnamed	55.440	17.787	78.359	41.603	17.348	78.620
11.	Unnamed	52.346	17.256	78.688	38.948	17.865	78.521
12.	Unnamed	51.469	17.836	78.332	38.773	17.382	78.832
13.	Unnamed	51.199	17.673	78.224	36.566	17.352	78.849
14.	Unnamed	50.074	17.235	78.836	31.423	17.367	78.801
15.	Unnamed	47.486	17.584	78.187	31.302	17.632	78.061
16.	Dabilpur Tank	68.951	17.666	78.463	31.146	17.499	78.330
17.	Kachva Tank	49.500	17.558	78.379	30.836	17.147	78.224
18.	Kalwakol Tank	56.453	17.119	78.359	29.901	17.442	78.820
19.	RawiralCheruvu	228.971	17.221	78.502	28.283	17.322	78.903
20.	TimmapurCheruvu	51.143	17.136	78.553	28.283	17.085	78.181
21.	Total	1438.314			966.244		

Source: Landsat Multi Temporal Scenes of 1990 & 2015

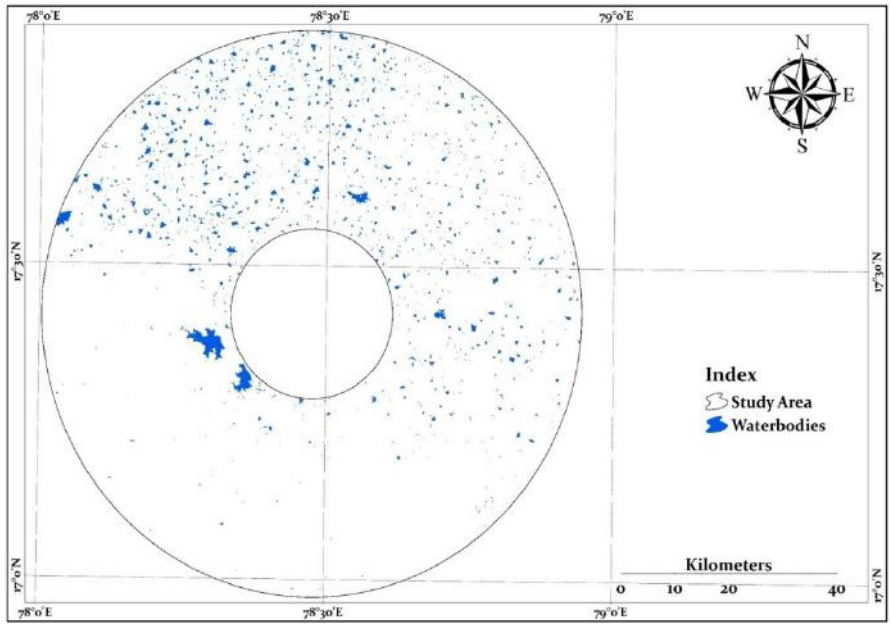

Fig. 3. Major Surface Waterbodies in Rurban Zone of Hyderabad Metropolis in 2016 (Post Mansoon)

Source: Sentinel-2 MSI Scenes

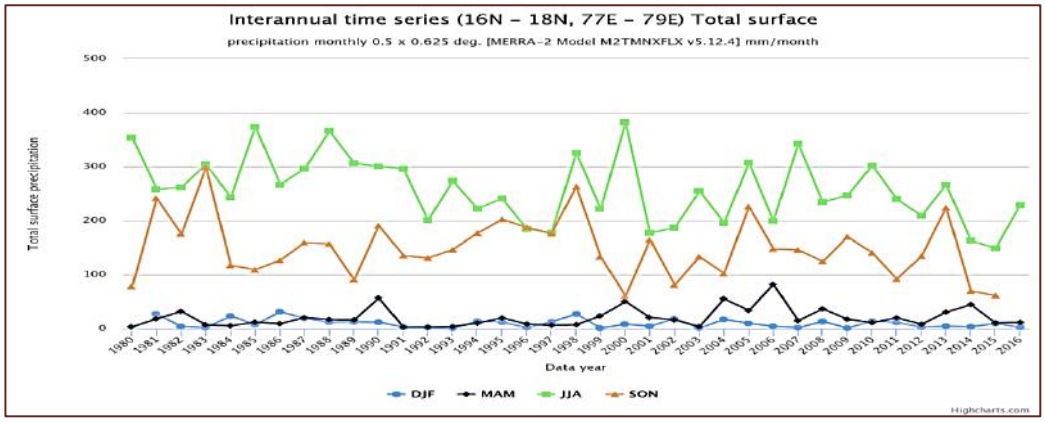

Fig. 4. Quarterly Rainfall from 1980-2016 in 0.5° x 0.625° Interval

Source: PMM Web Server (NASA)

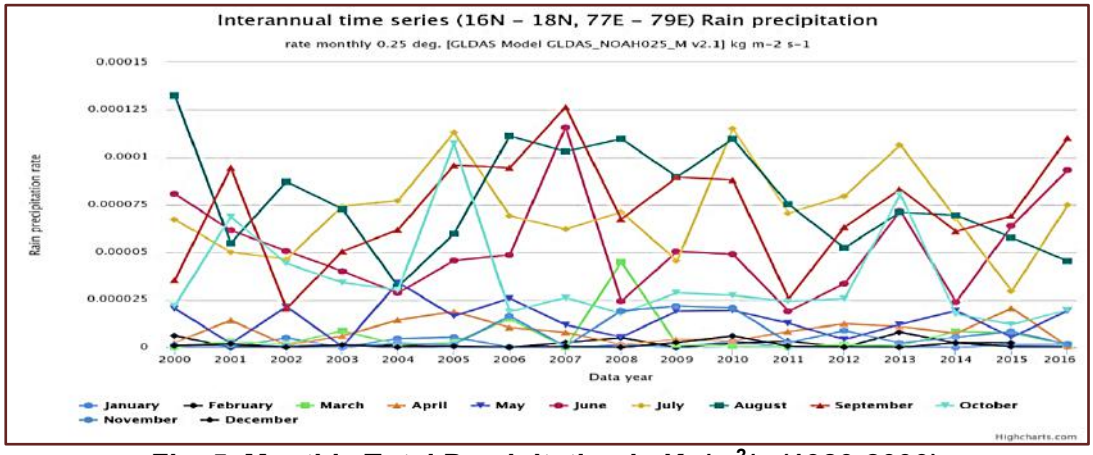

Fig. 5. Monthly Total Precipitation in Kg/m^2/s (1980-2000)

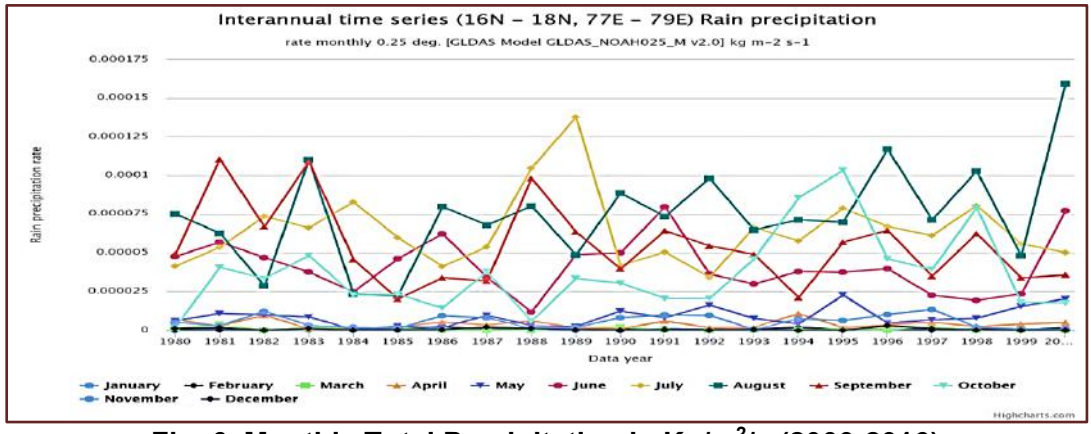

Fig. 6. Monthly Total Precipitation in Kg/m^2/s (2000-2016)

Source: PMM Web Server (NASA)

Conclusion

From the preceding analysis, it can be inferred that the spatio-temporal nature of a water spread in a region is closely linked to not only natural rainfall but also to the manmade activities. The wisdom executed in the historical past of Hyderabad Region have been neglected in the successive times leading to not only the water scarcity but also manmade hazards. Revival of the waterbodies has been a successful venture in the Study Region aided by good rainfall input as has been depicted in the said paper.

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A CRITICAL ANALYSIS ON THE COMMERCIALISATION OF THE FOREST ECOSYSTEM THAT AFFECTS THE EXISTENCE OF TRIBAL CULTURE AND CHALLENGES THE SUSTAINABILITY OF FORESTS OF CHITTERI HILLS, EASTERN GHATS

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Abstract

Commercial opportunities for tribal communities as a result of decentralisation and democratisation have a deeper impact on tribal culture. The present study is based on the Malayali Tribe of the Chitteri Hills of the Eastern Ghats located at the Tamil Nadu state of South India. Research findings indicate that the biological properties of many tropical species face the stage of extinction. The transition of tribal culture from subsistence agriculture to commercial exploitation has higher risk on forest ecosystem sustainability. No longer has the younger tribal population depended on forest for their livelihood but they have experienced opportunities outside the forest. It is difficult to objectively measure the degree of commercialisation on tribal culture and ecosystem sustainability, because of the complex linkage between commercialisation and change in tribal culture and ecosystem sustainability.

***Keywords**:* Tribal Culture, Forest Ecosystem, Commercialisation, Ecosystem, Sustainability

Introduction

The forest dwelling scheduled tribes in India are residing on their ancestral lands from ancient times. They are integral to their very survival and sustainability of the forest ecosystems. The most interesting aspect of tribal economy is that though a majority of the tribal population depends on agriculture, yet they do not depend on it exclusively. Their economy is also based on the collection of forests and it is considered as a significant occupation among the tribal people. Collection the forest products like the fruits and nuts, honey and even dried leaves is a common practice in these areas. These inexpensive materials can be collected almost throughout the year and has become a dependable source of income for the tribal people in this region.

Manufacturing of handmade products and art materials were very much in demand in the past and now becoming obsolete in due course of industrialisation and urbanisation. However, we need to rejuvenate this practice as these materials are very eco-friendly, easy to use, a great piece of art to the urban people and most importantly it can be a critical source of subsistence for the tribal economy. The current research aims to improve our understanding on the issues relevant to the commercialisation influencing the tribal culture and the forest eco-system of the Chitteri Hills. In order to achieve this objective, the paper has the following research questions.

1) What are the interactions between commercialisation and community and household welfare? 2) What are the interactions between commercialisation and forest ecosystem?

Malayali Tribes

The Malayali Tribes inhabit the hill ranges of Salem, North Arcot, South Arcot and Tiruchirapalli districts. They are involved in agricultural activities. Three divisions are recognised among the Malayalis.

- Periya Malayalis who live in Shevaroy Hills of Salem and Kalrayan Hills of Kallakurichi Taluk.
- Kolli Malayalis who live in the Kollimalais of Namakkal and Attur Taluks in Salem.
- Pachai Malayalis who live in Musiri Taluk in Tiruchirapalli.

The Malayali Tribes of the North Arcot District live in the Javadhu Hills of Vellore and Polur Taluks and Chitteri Hills of Dharmapuri District. Thurston does not treat Malayalis as tribes like Thodas of Nilgiris. This is because of the fact that Malayalis are Tamil speaking tribe unlike Thodas and Badugas. Moreover, many of the Tribal qualities were absent in Malayalis. They call themselves as people of hills (Malaivazhum Makkal) and not as original people (Pazhangudi Makkal). The government of India recognised Malayalis as Scheduled Tribes due to their socio-economic backwardness. Prior to Malayalis, hunters were the predominant groups in Jawadhu and Chitteri Hills. The period prior to Malayalis could have been pristine eco-systems in which the hunters were essentially the primitive group of hunter-gatherers.

The Malayali tribe invaded the areas of hunters and settled in Jawadhu and Chitteri Hills, which started changing the eco-systems of the forest. The possession of the forest land by the tribal households differs. It ranges from less than 1 acre to the maximum of 10 acres (one acre = 100 cents). Malayalis regularly travel to Jamunamaruthur and Alangayam in Tiruvannamaai District. The selling of the forest products take place in the market there. They visit the plains for worshipping in the sacred groves and their beliefs help them to protect the tree cover. They conduct rituals periodically to worship the deities like Kali, Murugan and Amman. The food habits of Malayalis reflect the agricultural pattern. (Ehrenfels, 1943). The major grains grown are minor millets, ragi, maize and corn grown by the people of Chitteri Hills.

The consumption of rice and wheat is seen in recent days thereby there is a gradual reduction the production and consumption of traditional foods. People have started cultivating the high yielding varieties. Basically the Malayali tribes have gradually shifted from subsistence agriculture to commercial agriculture. This transition represents the change in ecosystem. This is evident from the fact that there is a reduction of the forest area. The older Malayali household members indicated that a movement outside the forests was more complex in the earlier days and they hardly moved out of the forests. The people go down the hills to sell their produce and to buy the vital items from the market every Monday. Due to the increase in population in the hills, there is a pressure created to procure the food items from the market.

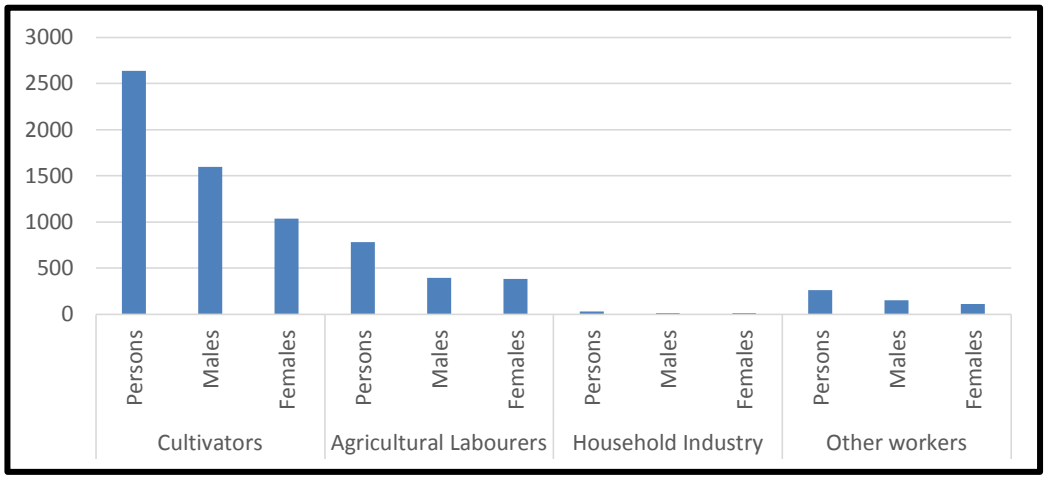

Fig. 1. Industry Category of Main Workers

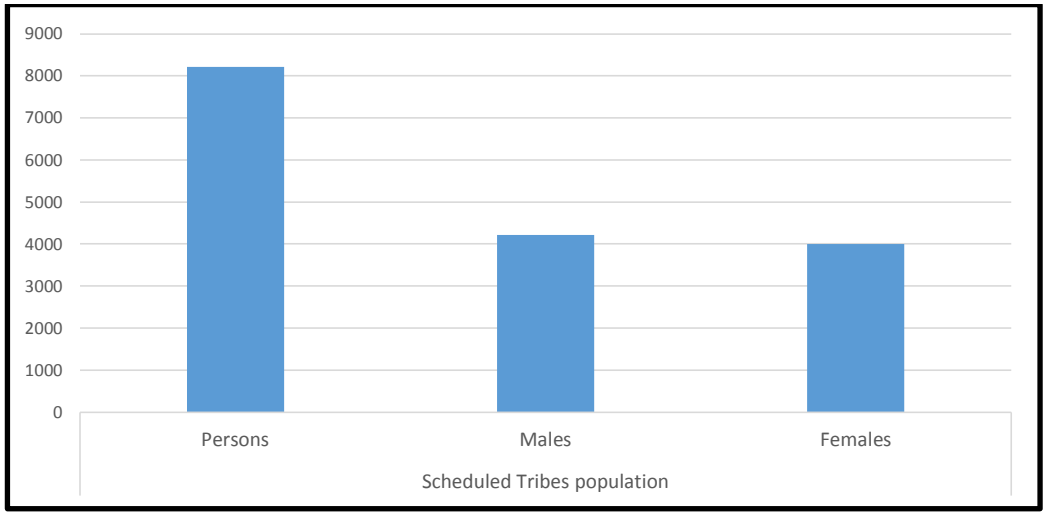

Fig. 2. Scheduled Tribes Population - Chitteri

Source: District Census Handbook 2011

Study Area

The study area Chitteri hills, a part of Southern Eastern Ghats is situated in Harur Taluk, Dharmapuri in Tamil Nadu. It is situated towards North East of Salem district within the geographical limit of 78°51'10" - 78°32'40" E, longitude and 11°55'14" – 12 °4'48" N latitude and occupies an area of about 654 km2.

Database and Methodology

The research was conducted after adopting various analytical techniques, so as to understand the impact of commercialisation of the forest ecosystem in Chitteri Hills. The total population of the Tribes in the Chitteri Hills is 9647 living in around 1604 households (Census of India, 2011). 10 percent of the number of the households were considered for the study. Simple random sampling was adopted and selection was done to accommodate the families in and around the hills. The present study is based on primary data collected from each household to understand the socio-economic status and occupation structure and the change in working population with the help of a well-structured questionnaire and face to face interview. Both qualitative and quantitative aspects has been considered for the study.

The hills form a compact block consisting of several hill ranges and contain tangled ridges and ravines running in the North East and South West directions, enclosing many narrow valleys, rivers viz., Kallar, Varattar, Kambalai and Anaimaduvu (Harur Forest office Report, 2007). In the western region, Thottilmadu rivulet join with Varattar rivulet and reach Varattar dam or Vallimadurai dam located in the foot hills of Chitteri near Vallimadurai village. Kalmaduvu rivulet flows towards southern region and reach Puluthikuttai dam of Salem district. The Kottar rivulet flows towards Eastern region and joins with Kottapatti rivulet and reach Sattnur dam of Tiruvannamalai District.

Non-Timber Forest Products

A NTFP literally means every natural resource from the forest except timber. The hunter gathering tribes and the settled agriculture tribes totally depend on the forest for their livelihood and their way of life is no way harm the sustainability of the forest. However, their property rights, harvesting practices and management strategies largely decide the sustainability of forest eco-system.

Forests feature predominantly in tribal development because they depend on a wide variety of plants, animals for their own use and for sale. Forest products have commercial markets and generate substantial revenues. In the search for development, forests provide a flow of valuable products. If people's life is to be improved in an environment friendly way, it should be without being subject to the destructive way of harvesting. Commercialisation culture of tribal helps to understand the relationship between forest products, poverty reduction and sustainable forests.

The degree of relationship between the contributions of forest products to the household economy measured in terms of the ratio of total cash and in kind income and the degree to which tribal households are integrated into the cash economy. In subsistence oriented tribal households, more than half of the cash income comes from selling forest products. They tend to be located in relatively remote areas with abundant forests and limited transportation infrastructure. The land which they cultivate is licensed land; ensure the rights of sales only to a tribal and access to other forest resources is open. They supplement their agricultural income with gathering or extracting NTFPs. Off-farm activities help make ends meet the return often find insufficient to lift tribal households out of poverty. In the Chitteri Hills range, these tribal households tend to invest very little effort in cultivation and rely on NTFPs which has been declining as a result of overexploitation, inefficient management and loss of habitat.

Malayali tribe generally extract NTFPs in times of the year in which income from cultivation or from other sources is low. The labour requirements for extracting for NTFPs is relatively high when compared to agriculture or off-farm labour. They do the job when labour requirements for agriculture are low. NTFPs are more important to the low income tribal people. But poverty alleviation requires increased trade of NTFPs results in an increase in income. Change in the tribal culture induced by commercialisation cause resource depletion. Tenure security need not necessarily lead to sustainable harvest of NTFPs but it may change the attitude for conservation. Moreover, people do not necessarily prioritise long-term availability of resource for their future economic security.

Table1. Important Non-Timber Forest Product of Chitteri Hills

Local Name	Botanical Name
Tamarind	Tamarindus Indica
Nellikai	Phylinthus emblica
Yettikottai	Strychnos mix-vomica
Avaram bark	Cassia auriculata
Konnai bark	Cassia siamea
Kadukkai	Terminali chebula
Pungan	Pongamia glabra
Tagarai	Cassia siamia
Mani Pungan	Sapindus emarginata
Seekai	Acacia sinuta
Woodapple	Feronia elephantum
Elandai	Zizyphus maurtiana
Kilakkai	Carissa carandas
Setha	Anona squamosa
Thuringimaramn	Alibizzia amara
Alingimaram	Alangium lamarckii
Arasamaram	Ficus religiosa
Veppalaimaram	Wrightia tomentasa
Kattu elumichai	Atalantia monophylla
Sundakai	Solanum trilobatum

The plight of the tribal people to a large extent depends on the historical resources and tenure claims for their survival. The livelihood of the tribal depends in different degrees upon on access to forest resources. Much of their uses are to meet the subsistence needs but the cultural survival of the tribal depends on the production and marketing of NTFPs.

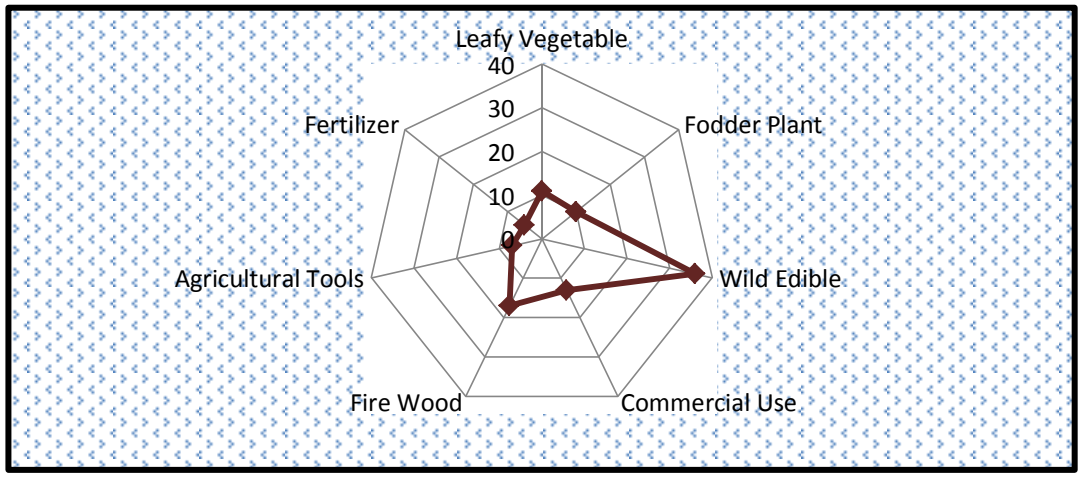

Fig. 4. Usage of NTFP by the Malayali Tribes of Chitteri Hills Tribal Agriculture

The best among the patta land of Malayali Tribe is used for paddy cultivation. The rotten leaves and branches brought from forest areas act as manure. In order to protect the crops from cattle, they made up fence of poles and dried wood. The paddy cultivation lost its significance due to the availability of ration rice from the public distribution system. Earlier paddy cultivation is meant for the domestic requirements. Paddy cultivation is not a good commercial proposition due to the high transportation cost of taking the paddy to the market. The important commercial crops of Malayalis are Ragi, Bajra and Maize. Chitteri Hills receive less amount of rainfall when compared to the Western Ghats hence; these less water intensive items are cultivated. It is also noticed that some of the fields of the tribal are connected to electric pump sets for irrigation. The introduction of tar roads, public transportation system and state sponsored public distribution system has a major impact in the agricultural pattern. It is surprised to note that almost all the tribal households in Chitteri Hills are connected to electricity.

Results and Discussion

Commercialisation

Commercialisation of forest flora and fauna is a recent phenomenon. Owing to the market demand many Malayali Tribe in Chitteri Hills harvest non-timber forest products of commercial values. The involvement of middlemen, traders and contractors from plains has further accelerated the commercialisation process of forest resources. This has led to the introduction of cash economics in the life of Malayalis and it is gradually substituting traditional self-sufficient subsistence pattern of the tribal household economy.

The modern tribal people get more than 50 per cent of their cash income from off-farm activities. Owing to modernization and the thirst of consumerism modern tribal people make relatively large trade in mature markets yield higher income. The size of tribal household income depends on property rights, size of land, accessibility to markets and the opportunity costs of labour. Modern tribal enjoy better transportation facilities and other physical infrastructure such as communication and electricity. There is a tendency among them to overexploit forest products. In this situation forestry is generally the default option.

The areas located nearer to the market, definite tenure rights for land, less requirement of labour for cultivation and by using labour readily available at low periods in the agricultural cycle tended to have higher incomes. Trade in many of the NTFPs has developed only recently. It has proportionately increased with the availability of new products in the market. The gathering of the forest products from the wild is associated with subsistence oriented livelihood strategies. Gathering from wild does not always mean gathering from an undisturbed natural forest. Sustainable forests naturally regenerate resources in order to improve the quality of life of the tribal people.

Commercialisation is an effort of tribal households for socio-economic and political empowerment. The question of ownership of land and control of access to NTFPs determine the extent of poverty and wealth distribution among them. The issues of ownership and control of resources form the central to socio-political studies of commercialisation. Women play an important role in the harvesting, processing of the NTFPs, while men do the job of marketing. The examination of land tenure reflects commercialisation. The major challenge of the tribes for the economic empowerment is the difficulty of getting their goods to the market and to receive fair prices for their products. In Chitteri Hills, the Malayali Tribe has two forms of access rights. They enjoy the benefits of both private property resources where they cultivate and being the member of the village forest council they enjoy the benefits of non-timber forest products. Individual tribal households have private rights to specific land surrounding their dwellings. The NTFPs on forest land are common property which are protected and harvested jointly by the tribal households.

Medicinal Plants

The tribal knowledge of medicinal use of plants is still an unexploited area. In the 1780s an employee of the British East India Company convinced botanists in England to establish a network of naturalists in India reporting to the Kew Garden (British Imperial Institute), (Grove 1995). A majority of NTFPs in Chitteri Hills is for medicinal use. The genesis of Indian native medicines of Ayurveda and Sidha can be traced to what called ethno medicines is practiced by the tribal communities. It is observed that the tribal knowledge of medicine is either on the verge of extinction or being destroyed. At present tribal depend more on trained doctors of town which give them immediate relief from pain. It is reported that forest herbs and leaves are the best medicines for immunity, fertility, abortion, asthma etc.

Market

Tribes are considered to be the most economically impoverished community of India. The net income contributed by Malayali Tribe showed an inverse relationship between percentage of income derived from NTFPs and total household income. The poor tribal households of interior forest relatively depend on economic support from NTFPs collection. The poor tribal households engage in NTFPs extraction in the absence of alternative income sources. The poor households with surplus labour and low opportunity cost accept less paid wage employment. Some of the tribal households undertake intensive forest agriculture. The output per unit of land is higher than non-forest agriculture but the income per hectare of land in forest is lower than that in non-forest areas depending on the distance of the land from the market. Some of the tribal households in Chitteri Hills hire ass to transport their agricultural products to the market. The transportation cost accounts for a substantial portion of the revenue from the sales.

Most of the people interviewed highlighted a fixed life based on agriculture. At present in the list of necessities many more items are included. The number of items included in the consumption basket persuades them to find alternative income earning sources. Some of the tribal households sell their labour outside the forest even at a long distance. It indicates that tribal no longer depend forest for improving their livelihood but search for opportunities that give better opportunity cost. It indicates that the dependence of tribal on the forest decreases with the percentage of educated members in the family and income from other vocations. The interviews highlighted the preference of the tribal for vocations rather than the forest dependence. The tribal people who have greater dependence on the forest did not improve their living standards significantly. In a situation of rising commercial values, the tribal people can be subject to exploitation. There are some tribal households complained that some of them were the victims of theft cases even if they are innocent.

In the areas where communication and transportation facilities are poor, the costs of transportation to the market are high. The trading of NTFPs reflects the prevailing social, economic and geographical considerations of tribal people. In some household's producers themselves act as traders and in other cases middlemen visit their dwellings to procure the NTFPs produced by the tribal households. But in majority of the cases, middlemen are accused of exploiting producers and their excessive profit share leaving the producers a paltry sum. Certainly the middleman or traders have the advantage of the weak bargaining power of the producers. The tribal people sell the same NTFPs of the same quality at different prices in different locations of the forest. The tribal households are exploited while selling their forest produces and labour. They sell their agricultural products to the Chitteri market every Friday. The traders come to the market from outside who act uniquely to procure these products at a lesser price. For some of the NTFPs, the price difference between the local forest market and the main market is more than 10 times. The tribal population sell their labour for various construction activities in the forest areas.

The contractors get full wages from the forest department but pay them only a fraction. This results in entering a relationship between money lenders and poor people. This has implications for commercialisation because once the produces consumed by the tribal households sold in the market in order to pay the debts. The role of middleman is blamed an important reason for the poverty of tribal in Chitteri Hills.

It is noted that the profit margins of the middlemen can be over emphasised because of the reasons that they bear high transportation costs, financial risks and unpredictable market. The middlemen therefore try to shift the burden on the tribe who are ignorant about the outward market. The tribal also face uncertain market for their NTFP because local trader come to the market only when the agricultural products of the tribal are very cheap when compared to the other markets. The monopoly control of the traders acting under a cartel makes producers powerless to capture good returns for their producers.

The village forest council is a step towards reducing the control of the middlemen in order to get a greater share of benefit to the tribal households. But it is reported that the tribal people receive a little as 10 to 40 percentages of the sale price as a return to the forest council which will be circulated among the tribal households (village forest council members).

Village Forest Council

In Chitteri Hills, Village Forest council is the popular strategy to harvest NTFPs from State Forest reserves. The very objective of the council is to integrate local tribal community NTFPs. Chitteri Hills witness participatory forest management with focus on NTFPs. The village forest council is an alternative management strategy to solve the problems of degradation of forests and growing conflict between forest dependent tribal communities and the forest staff. Many of the villages of tribal households in Chitteri Hills come under the control of the Panchayat administration. Despite the situation where official management of forest use lay outside village control, they did create the village forest council to manage and protect their legally designated Panchayat forest. Through management in the village forest council, the tribal households participate in forest protection in return for NTFPs, employment and net cash benefits from rotation of sales. It is noted that some tribal households are not members of village forest council, because they don't have time to participate in the council at the cost of their agriculture. Therefore, relatively rich and interior tribal households are found less as members in village forest council.

Tenure system provides the rules and regulations to harvest forest resources, including ownership and corresponding rights. The defining characteristic of extractive reserves is a specialised tenure arrangement between the state and the tribal. Extractive reserves are forest areas inhabited by tribal population granted long term rights to forest resources which they collectively manage (Joint Forest Council). The extractive reserves are state owned where the rights of forest are allocated only to the tribal people.

This arrangement is viewed attractive because it appears socially just form of forest land use for promoting socio-economic development of tribal and environmental conservation. The basic principle of this exercise is the sustained extraction of renewable commercial forest products by traditional resident population or indigenous or tribal population. There is socioeconomic and conservation implications of tenure arrangement.

Tribal Culture

Perceptions of modern lifestyle make forest based activities less attractive. Regional development changes the culture of tribal people. New roads alternative sources of wage income, government policies protecting the interests of tribal make forests less attractive. The Malayali Tribe fast shift from natural resources based activities of forestry to wage employment in the secondary and tertiary sectors. Perceptions of modernity make such possibilities highly attractive especially for younger generations. The introduction of 35 kgs of free rice per tribal household per month, 1 per cent reservation of educational and job opportunities in government sector and the efforts of tribal welfare societies in Chitteri Hills transform agriculture and harvesting of NTFPs less remunerative. Moreover, the younger and educated tribal people consider these productions as backwards. The Malayali Tribe of Chitteri Hills shows mass migration of younger generation to different metropolitan cities such as Bangalore, Chennai and Pune. They look forward new ways to make a living comparable to their brothers in other parts of the country. This change made ageing labour force in tribal agriculture in forests.

The younger generation of the Malayali is in the transitional stage of tribal culture while the old generation feels a mysterious bond between man and other animals and a symbiotic relationship with the cattle. The tribal ethics of forest sprang among the fundamental facts of their existence. The tribal dependent on the fertility of the forest areas are basically to meet their agricultural needs. They use the edibles among the wild fruits, leaves and roots besides honey. Majority of the forest depending tribal in Chitteri Hills build their houses with bamboos, forest leaves and hay. Majority of these are substituted by concrete houses at present. The younger generation of Malayali Tribes of Chiiteri hills has been forced to discard the traditional way of life and they started adapting to the changing situations. The important consequence of the high degree of commercialisation leads to ultimate destruction of tribal life and their culture. With a disappearance of the important tribal culture, practical understanding of ecological relationship between the society and the environment is disturbed.

The loss of ecological knowledge among these ecosystem people of the Chitteri Hills area is one of the serious issues of concern. The tribal superstitions like worshipping trees for happy life could enforce or at least support ecological considerations though they do not fully realise the significance. It is superior to the value system compared to what we see in the present times. The unsustainable harvesting of forest was considered as a taboo for the fear of antagonising the rules of deities represented by various aspects of nature.

The Malayali tribes have started practicing settled agriculture and started intensive cropping by the use chemical fertilizers is an adaptation of the human society to meet the modern amenities of life. The process of cultural change has become complex due to the increase in interaction with the more developed society. Better transportation facilities between forest market and the outer towns change the culture of the younger generation.

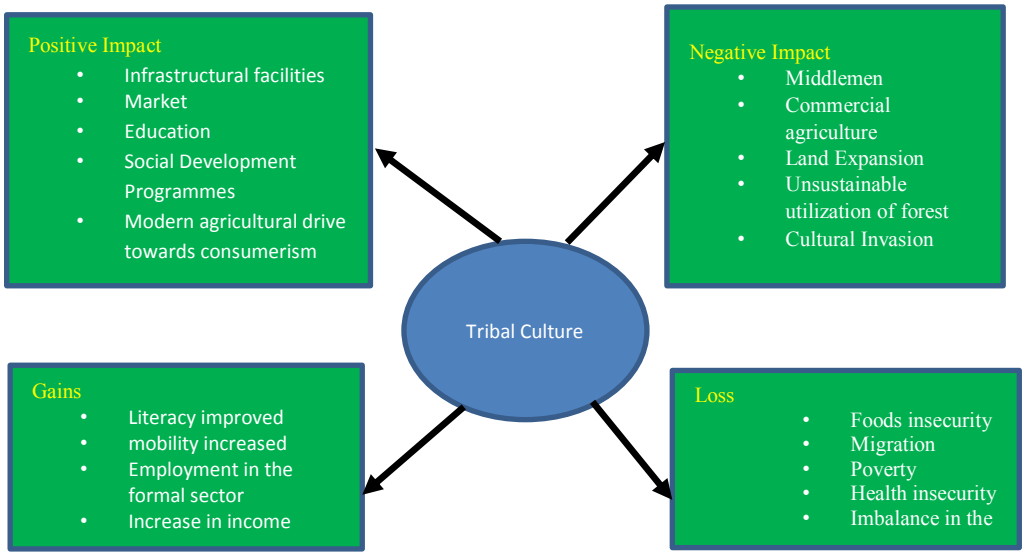

Fig. 5. Impact of Commercialisation on the Tribal Culture

In the traditional tribal culture, the community leader decides the pattern of cropping, time of sowing, hunting and other social and economic activities. With the commercialisation of the tribal culture these largely dictated by the market.

Ecosystem Sustainability

The link between forest ecology and commercialisation can be viewed with special reference to market, institutional and ecological concern was the creation of new markets and expansion of existing market in the forest area. It accelerates over harvesting and resource depletion. These NTFPs are coming to the market and an increasing speed. It is observed that there is a poor overall regeneration while extraction is higher. The NTFPs species face greater deficit because regeneration is affected by collection of seeds and fruits from NTRP species. The problem of overharvesting, especially firewood occurs with rapidly rising commercial value. There is no mechanism to give incentives to the tribes to conserve these resources for long-term use. The weakness of institutions customary or government is another factor causing adverse effects of commercial extraction induce tribal households to lax their customary rules and less concerned with the long run sustainability rather than short-run benefit. Conditions of open access often prevail.

The hunting and trapping often exceeds sustainable forest rates. Hunting is often not meant for domestic consumption but for commercial exploitation. Some senior tribal people accepted a drastic disappearance of many animals in the Chitteri Hills in the past ten years. Development activities instead of assimilating have alienated tribal communities. Development of road facilities in Chitteri Hills accelerated commercialisation and the dependence of Malayalis outside the forest for income generation disrupted the traditional tribal production techniques and they have been deprived of the forest and forest produce. The assimilation and integration of tribal communities with the rest of the society does not take place due to the feelings of insecurity and absence of freedom, quality and mutual respects. In Chitteri Hills the species richness of tropical forest eco-system is in the brink of extinction and the forest eco-system is warned of the perils of deforestation.

Some argued that the extraction of non-timber forest resources by the tribes may lead to biotic impoverishment (Nepstad et al., 1992). It may be due to over harvesting, reduced populations of dispersal agents through hunting, low germination rates, dependence on large openings and burning beneath adult trees. But it is felt that extractors are the beneficiaries of forest resources hence they have in incentive to maintain the resources. The biotic impoverishment will continue within extractive reserves as long as cattle are viewed as the main investment of surplus income. But the extractive model based on village forest council is appreciated because of its economic viability, environmental conservation and social equity.

The Chitteri Hills also face the problem of significant amount of timber and non-timber forest products illegal commercial extraction. The Tribes claim that illegal extraction often coincides with a breakdown of authorities without replacing them with effective authorities. The survivals of effective and honest foresters have to face problems from co-workers and illegal fellers. In India under state ownership, the conditions of the forests deteriorated and tribal communities and other forest dwellers had no interest in conservation without management rights or ownership (Pachauri, 1990).

The growing market demand for certain forest products can lead to an increase in natural resource crime and associated phenomena of violence and corruption. Sandalwood is the costly timber used for the manufacture of medicine, cosmetic products and costly furniture which often subject to the category of natural resource crime leading to negative ecological and economic outcomes. In Chitteri Hills, the high price of super quality sandal wood was the prime reason for the change of the resource base over time.

Rising prices do lead to increase in harvesting through illegal sandalwood harvesting. If the returns from the extraction are lesser than the marginal cost of illegal harvesting, this precludes botanical extinction. Forest management is essential to promote economic development by maintaining and even increasing production while maintaining or improving ecological conditions. The way of life of Malayali Tribe involves the management of forest. The practices are founded on acquiring flora and fauna sustainably for generations living in forest.

Conclusions

The results of the present study reveal the ecological effects of commercialisation of forest products and the constraints of sustainable extraction due to the change in the tribal culture. Research findings indicate that the biological properties of many tropical species face the stage of extinction. The transaction of tribal culture from substance agriculture to commercial exploitation has higher risk on forest ecosystem sustainability. High biodiversity forest inhibits commercial exploitation if tribal culture remains static. The change in tribal culture with limited biodiversity, high population densities and clustered distribution of tribal dwellings make commercial exploitation of forest simple. No longer has the younger tribal population depended on forest for their livelihood but they tasted opportunities outside the forest. It is difficult to objectively measure the degree of commercialisation on tribal culture and ecosystem sustainability, because of the complex linkage between commercialisation and change in tribal culture and ecosystem sustainability.

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SPATIO-TEMPORAL VARIATION OF POPULATION DENSITY IN BAITARANI BASIN IN ODISHA

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Abstract

Population, environment and human health have become the burning issues for social science researchers, planners, policy makers and administrators. The size and structure of population provides a basic idea to planners on the basis of which specific development programmes can be formulated and implemented. Growth indicates the successive positive trend of population increase in an area. Growth of population assumes special importance in the economic and social planning of a state as any planning is for the people. In population geography, the term growth of population is used in its broadest connotation to cover change in population numbers inhabiting a territory during a specific period of time, irrespective of the fact that change is positive or negative. An attempt has been made to identify the factors responsible for this unequal distribution and high growth of population where natural increase and migration induces population growth which has been highlighted by taking into consideration the vital statistics. The paper also deals with the consequences of population growth not only on the demographic characteristics of the region but also the socio-economic and physical environment of the region.

Keywords: Population geography, Population density, Population growth, Demographic characteristics, Environment, Human health, Baitarani basin, Peninsular India

Introduction

Population, environment and human health have become the burning issues for social science researchers, planners, policy makers and administrators. The size and structure of population provides a basic idea to planners on the basis of which specific development programmes can be formulated and implemented. There are various attributes studied within human population. Fertility, mortality and migration are the three demographic processes which affecting population changes in a region or community. Of these three, fertility has become a major concern for demographers. It is a major determinant of high population growth in developing countries. The birth rate (CBR) in developed countries as a whole 11 persons per 1,000 where as it is 26 in developing countries. The death rates in both of the regions are similar. They are 9 per 1000 in each case (PRB, 1998). Thus, high fertility and low mortality are encouraging rapid population growth in developing countries. The same situation exists in the developing community.

Another notable feature of demographic phenomena in developing countries is that the proportion of young population is very high. It is above 40 percent in most of the cases. When this population enters into reproductive process, the population increases fast.

There are various attributes studied within human population. Fertility, mortality and migration are the three demographic processes which affect population changes in a region or community. Of these three, fertility has become a major concern for demographers. It is a major determinant of high population growth in developing countries. Population density and distribution have been discussed at the block and district level. The urban population figure has been taken from 1991-2011 Census data. To show a variation in the density of population within the basin, the estimation is done at the block level.

Study Area

The Baitarani River is one of the important rivers of north Odisha in the peninsular India. It originates from the Gonasika of the Gupta Ganga hill range of the Eastern Ghats located at an elevation of about 981 mt. above the mean sea level. It flows in north to south-easterly direction for about 365 km before meeting the River Brahmani at Bajarpur village of Rajnagar block of Kendrapara district about 8 km from the Dhamra river mouth of the Bay of Bengal near Chandabali. It initially flows in the N-E direction being a boundary line between Odisha and Jharkhand near Champua, and then flows as a boundary line between Kendujhar district and Mayurbhanj district. In the lower reaches it makes boundary lines between Jajpur district and Bhadrak district and Kendrapara district and Bhadrak districts.

The Baitarani is distinguished from its surrounding basins like the Budhabalanga basin on the north and the Brahmani basin on the south-west. The combined river of the Baitarani and the Brahmani drains into the Bay of Bengal as Dhamra River. The Baitarani and Brahmani drain into the Bay of Bengal as Dhamra river. Its main tributaries are Matai, Deo, Indrani, Aradei, Sim-Salandi, Kusei, Sita nadi, Kani, Masala, Kukrakata, Tel, Kanjhari and Remal. The Baitarani basin is a compact elongated shaped basin. It flows through the districts of Kendujhar, Mayurbhanj, Bhadrak, Baleswar, and Jajpur. The basin covers partially nine districts-one district of Jharkhand state i.e. W. Singhbhum and eight district of Odisha. The basin is situated approximately between of 850 10’ and 870 03’ East longitude and between of 200 35’ and 220 15’ North latitudes. The Baitarani river basin has an area of 10, 246 sq km. Out of this about 10,982 sq km. lies in Odisha and about 736 sq km lies in Jharkhand. Total area of the delta is 1713 sq. km and joins with the combined delta the Mahanadi and Brahmani rivers. The river is flashy in nature having a total length of 365 km.

The present effort solely aims to study the density and distribution of population and their variations in study area The main objective of this study is to understand arithmetic density of population in the study region during 1991-2011.The other objective of this paper is to study the block wise decadal population density distribution in Baitarani basin of Odisha.

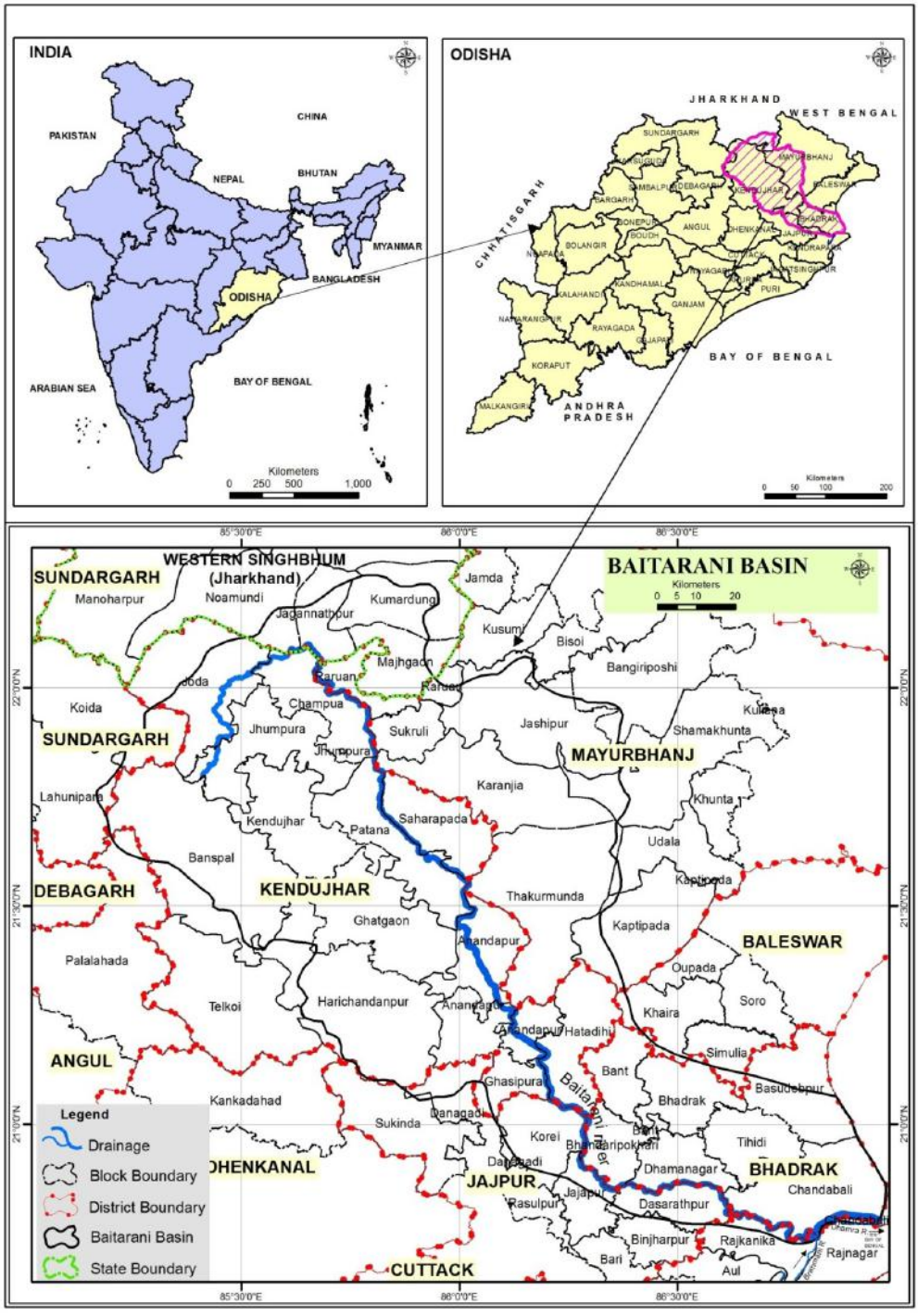

Fig.1. Location of Baitarani Basin

Database and Methodology

The present investigation is based on secondary data. Block wise population data has been collected from census records for the year 1991, 2001, and 2011 from District census Handbook of Odisha have gathered for the basin for 43 blocks. The spatial distribution of population for study region has shown by maps and graphs.

To find out the Very High, High, medium and low population density following formula is adopted.

Very High Population Density	-	(> 600)
High Population Density	-	(400-600)
Medium Population Density	-	(200-400)
Low Population Density	-	(< 200)

Results and Discussion

The concept of growth of population is often used to connote the change in the number of inhabitants of a territory during a specific period of time, irrespective of the fact whether change is negative or positive (Chandna 2008). It is controlled by the relative balance of fertility, mortality and migration which are generally influenced by six groups of factors: biological, environmental, economic, social, political and technological (Sauvy, 1969). Population growth rate calculated with the help of actual population counts is known as natural increase of population growth.

This Natural rate of growth of population is obtained by dividing the difference between the birth and deaths of population at the beginning of the period and multiplying it with hundred it implies that while in case natural growth rate only the births and deaths are taken into account ,in case of actual growth rate, the factor of migration is also taken into consideration both actual and natural rates of population growth have been subjected to spatial portrayal and interpretation. The factors which are responsible for population growth consists of progressive character of population , greater transport and communication facilities urbanization development in agriculture and infrastructure as well as deterioration in death rate. These factors transform the traditional rural settlement i.e. village into a town/city.

Population growth of Baitarani basin can be analysed with the help of census data available from 1991 onwards. As it is well known that India's population remained stationary around 100-200 million through most part of its demographic history as both fertility and mortality remained high and cancelled out each other leaving very little scope for its population grow in numbers. The density of population is very uneven of the basin; due to unfavorable relief features, human activities and natural resources. Density of population has been changes because of natural birth rate, death rate and migration.

Population Density

Geographers have devised various types of population densities having a varying degree of utility in different situations. The objective, of course, has been to arrive at a better understanding of the population–resource relationship. These ratios have been called as arithmetic density, physiological density, agricultural density, economic density etc. (Chandan, 2008). However each of these suffer from one or the other types of handicaps like availability at specific areal unit and their comparatively. Clark (1972) observes that despite all these handicaps, the concept of density of population is a useful tool in analysing the distribution of humans over the space. The present paper dealing with population aspects Baitarani basin has taken into account to depict the spatial pattern of city for the year 1991, 2001, and 2011. Arithmetic density is expressed in terms of persons per square unit of land area. The density of population affects the socio-economic conditions, urban environment as well as the facilities like health, education, employment, recreation etc. it is considered as an important factor in understanding how cities function. In addition, high urban density has potential costs in the form of congestion, noise and localized pollution, but at the same time low density of population can also be costly, the higher economic and environmental cost of mobility. Density of population has changed from time to time with increasing population density of the basin. The density of population in the basin increased from 303 persons/km^2 in 1991 to 379 persons/km^2 in 2011 (Fig.2). At every census (since 1991) the density of population in Baitarani basin has remained higher than the average of Odisha (Fig.2). It was quite natural as the basin is situated in the zone of reliable rainfall and mining and industrial zone. Density of population in coastal blocks is higher than the basin figure. The density too is rising constantly over the census periods in all coastal blocks.

There is block wise variations in density of population. According to 2011 census, the density of population of the basin is 379 (Fig.2). The highest density of population is recorded at Dasarathapur (789) and the lowest density of population is recorded at Koira (121). According to 2001 census, the density of population of the basin is 357. The Highest density of population is recorded at Binjharpur (805) and the lowest Population density is recorded at Koira (104). According to 1991 census, the density of population of the basin is 303. The Highest the density of population is recorded at Binjharpur (712) and the lowest population density is recorded at Koira (96) (Fig.3).

In 2011, out of 43 CD Blocks, at 17 CD Blocks, the population density is greater than the basin average, at 30 CD Blocks the population density is greater the state average and at 16 CD Blocks the population density is greater than the national average. In 2001out of 43 C.D. Blocks, at 16 C.D. Blocks, the population density is greater than the basin average, at 28 C.D. Blocks, population density is greater than the state average and at 17 C.D. Blocks, the population density is greater than the national average. In 1991, out of 43 CD Blocks, at 15 CD Blocks the population density is greater than the basin average, at 27 CD Blocks, population density is greater than the state average and at 18 CD Blocks, population density is greater than the national average.

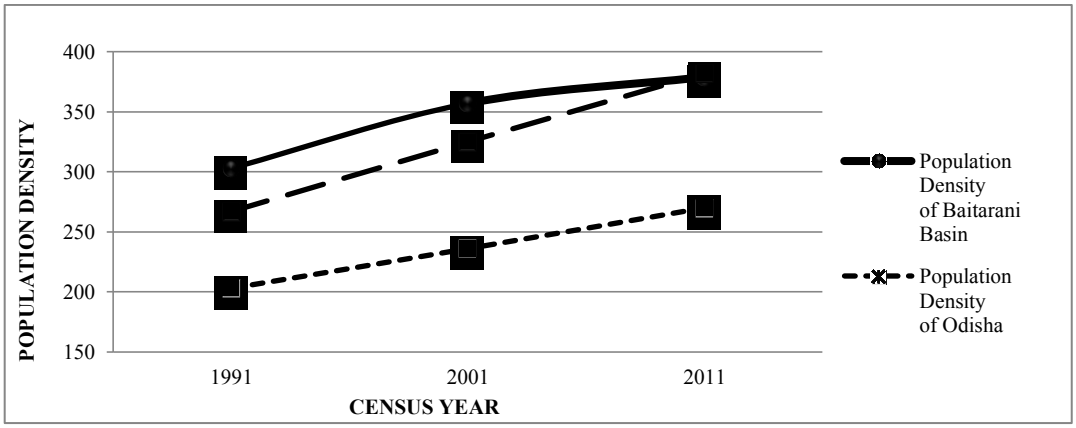

Fig. 2. Population Density of Baitarani Basin, Odisha and India (1991-2011)

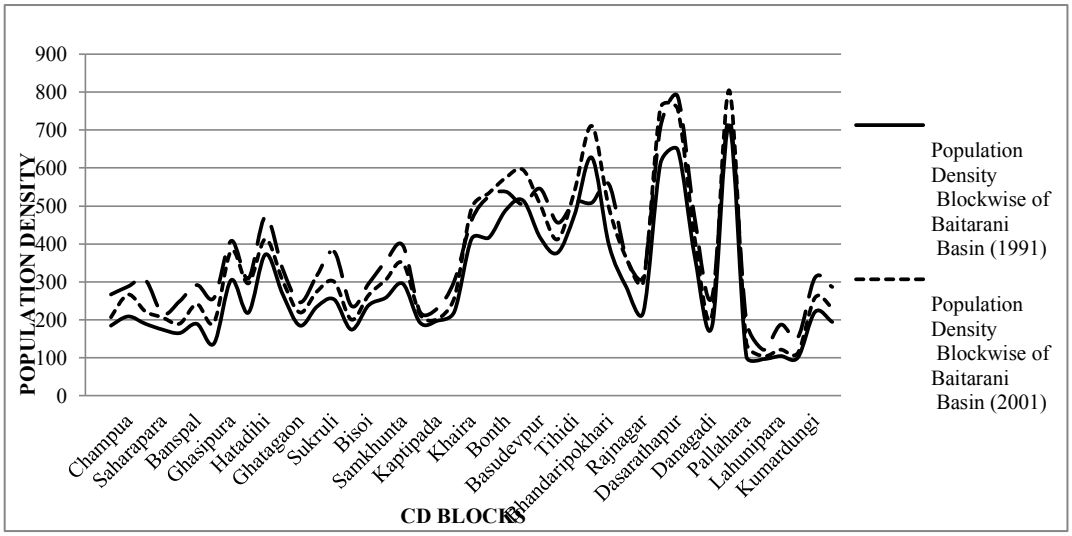

Fig. 3. Population Density of the Baitarani Basin (1991-2011)

In 2011, 3 C.D. Blocks are in very high density, of 12 C.D. Blocks are in high density, of 24 C.D. Blocks are in moderate density and of 4 C.D. Block are in low density (Fig.4). In 2001, 4 C.D. Blocks are in very high density, of 10 C.D. Blocks are in high density, and 23 C.D. Blocks are in moderate density and 6 C.D. Blocks are in low density (Fig.5). In 1991, 4 C.D. Blocks are in very high density, of 6 C.D. Blocks are in high density, and 17 C.D. Blocks are in moderate density and 16 C.D. Blocks are in low density (Fig.6). In 2011, due to out migration for proposal of industries, results population of Dhamnagar decreased and Dhamnagar became in High Population Density category. Density of population is higher at the coastal region than the interior mountainous region. Fertile coastal plain supports high density of population, and barren, usar land at the mountainous region have very little level land to support high population density.

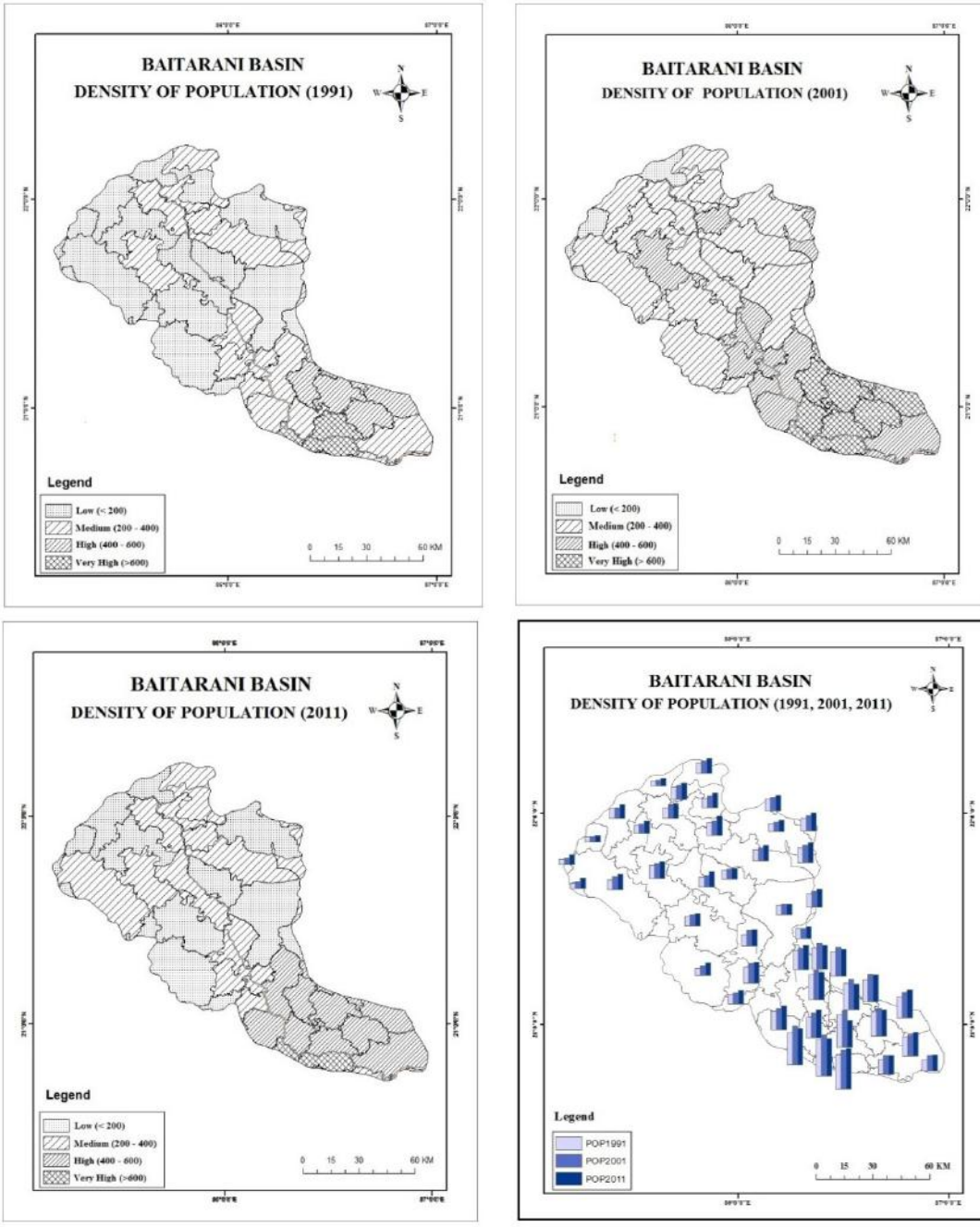

Fig.4 to Fig.7 Comparison of Density of Population Year Wise from 1991-2011

Fig. 2, 3, 4, 5, 6 has been shown here to explain the spatial-temporal variation of arithmetic density and the Fig. 3 and 7 has been shown the block wise decadal variation of population density between 1991-2011.

Conclusion

The present paper aims to highlight some of the realities related to demography of Baitarani basin in Odisha and an attempt has been made to examine, analyze and interpret the demographic characteristics in spatio-temporal perspective. The basin has witnessed a fluctuating growth of population and there is spatial biases population concentration in favour of physical and socio-cultural and economic factors both. The density of population of the basin is 379 in 2011 census, 357 in 2001 census, and 303 in 1991 census. In 2011, 3 C.D. Blocks, in 2001, 4 C.D. Blocks and in 1991, 4 C.D. Blocks are in very high density category. The density of population is unevenly distributed through the district. The concentration of population is depended of the region. In 2011, due to out migration for proposal of industries, results population of Dhamnagar decreased and Dhamnagar became in High Population Density category. Density of population is higher at the coastal region than the interior mountainous region. Fertile coastal plain supports high density of population, and barren, usar land at the mountainous region have very little level land to support high population density. Such study has potential to attract experts from the field of planning, agriculture, economics and administration in order to propose a strategy for around development of the city.

Acknowledgment

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IMPACT OF URBANIZATION IN GRADUAL INCREASE IN LAND SURFACE TEMPERATURE OF PATNA MUNICIPAL CORPORATION IN NEW MILLENNIUM (2000-2018) USING SATELLITE DATA

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Abstract

The increase in urbanization negatively affects the natural environment resulting in change in the micro climate of the urban centers and related municipal area. The variations in Land Surface Temperature (LST) with in a Municipal area are of highest concern to study the urban climate and human-environment interactions. For this purpose the increase (change) in level of urbanization is calculated using Normalized Difference Built up Area Index (NDBI). The present study investigates the interrelation between the increase in built up area and simultaneously temporal change in land surface temperature of Patna Municipal Corporation (PMC) using Remote sensing data. The estimation of surface temperature was done using the required Band math for different Satellite sensors and finally spatiotemporal model and statistical techniques were used to determine the variations in Urban Heat Island (UHI) effect in Patna Municipal Corporation (PMC). The results were proportional to the assumptions, with the increase in built up area over the years, the land surface temperature has increased considerably and the dense built up and commercial / Residential areas show higher surface temperature in comparison with adjoining areas while the Urban Greens (vegetations) were the cooler part of the Municipal area.

Keywords – Urbanization, Micro Climate, Land Surface Temperature (LST), Normalized Difference Built up Index (NDBI), Urban Heat Island (UHI)

Introduction

The Municipal areas are dynamic in nature and because of anthropogenic activities, population growth and urbanization they change time to time altering the Land use Land cover (LULC). Zhanq and Wang (2008) studied the inter relationship between these issues and found that there is a correlation between the formation of the heat island, population density and concentration of built (Zhang, and Wang, 2008). With the increase in urbanization the vegetated surface of an area is converted into impervious surface resulting in change pattern in absorption of solar radiation, storage of heat, surface temperature, evaporation rate, and wind turbulence thus negatively affecting the micro climate of the area (Mallik et al., 2008).

Land surface temperature can provide important information about the surface physical properties and climate which plays important role in many environmental processes (Dousset and Gourmelon, 2003) (Weng, et al., 2004). Many studies have estimated the relative warmth of cities by measuring the air temperature, using land based observation stations. The land observation based method can be both expensive and time consuming and lead to problems in spatial interpolation. Remote sensing might be an alternative to the aforesaid methods. The advantages of using remotely sensed data are the availability of high resolution, consistent and repetitive coverage and capability of measurements of earth surface conditions (Owen, et al., 1998). A large number of researches have been done using remotely sensed data to detect thermal characteristics of urban surfaces. Voogt and Oke (2003) reviewed the use of thermal remote sensing for the study of urban climates with respect to the heat islands and described the distinction between the atmospheric and the surface UHIs

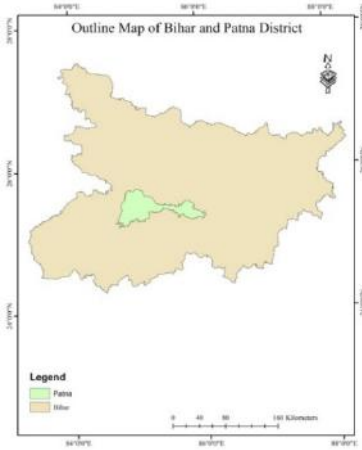
However both the methods including ground based meteorological observation and satellite observation (Remote Sensing data) for Land Surface Temperature estimation have their own positive and negatives. The former has the advantage of analysing directly the differences in temperatures between urban and suburban areas, but because of the discrete distribution and limited numbers of observation stations, it has shortcomings in large-scale studies. Remote sensing, on the other hand, is useful for analysis of regional-scale characteristic because of the continuity of observations, and it is widely used in every scale of research. When remote sensing is used, land-surface temperature is usually retrieved through a mono-window algorithm, a thermal radiance transfer equation, and an image-based inversion algorithm based on thermal infrared data. The latter algorithm is relatively simple, and it can be used to study the dynamic changes of the thermal fields. However, the best method for delimiting UHIs is still uncertain (ISRSE35, 2014).

Study Area

Patna is one of the oldest continuously inhabited places in the world and Patna Municipal Corporation (PMC) is located between Latitude: 25°33'10"- 25°39'03" North and Longitude: 85°03'16"- 85°16'10" East, it lies on the south bank of the River Ganges. PMC is approximately 21.5 km long (east to west) and 11 km wide (north to south). The corporation area is important commercial centre. The commercial establishments within the city are mainly lined along the arterial and major roads and there is extensive mixed land use of commercial and residential use throughout the city.

The natural growth of PMC has been towards the west till date, with the older part of it being in the east side of the city (M. Ashraf, 2014). This core area of PMC faces problems of overcrowding, which has lead to enormous pressure on the physical infrastructure and traffic congestion. The newer developed areas lying in the central and western part of PMC comprises of both plotted developments and apartment houses.

The apartments in the newly developed area are again straining on the existing infrastructure, as the up gradation of the physical infrastructure has not been done in proportion to the increase in population being accommodated in the apartments.



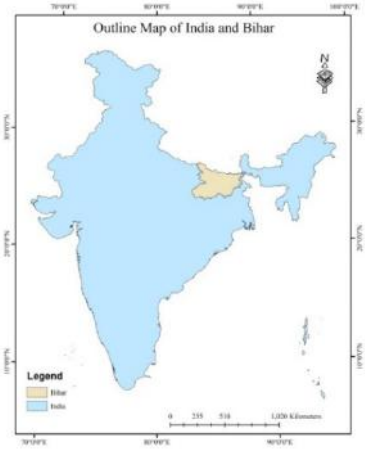


Fig. 1 (a) Outline of India and Bihar Fig. 1(b) Outline of Bihar and Patna District

The Patna Municipal Corporation (PMC) covers an area of nearly 108.164 km2 according to our Remote Sensing and georeferencing results. It is further divided into 72 wards. According to the 2011 census it had a total population of 16, 83,200. The density of population of the PMC is 15562 persons per km2. The trends of population growth have been uneven in the period 1951-2011. The growth registered an increasing trend in the period 1961 to 1981 - from 28.52% to 64.14%. It reduced to 18.14% during 1981 to 1991, rising again in 1991 to 2001 to 48.97% and dropping again during 2001 to 2011 to 32.53% (Census, 2011).

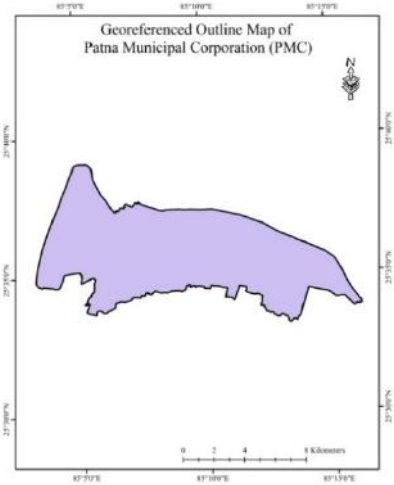


Fig. 1(c) Patna District and PMC Fig. 1(d) Outline of Patna Municipal Corporation

The main objective of this study is to study the temporal change of maximum Land Surface Temperature (LST) of Patna Municipal Corporation in last two decades with the help of Thermal Infrared Satellite data. Establish a correlation between the urban built up increase and land surface temperature. Assess the Urban Heat Island (UHI) effect in Patna Municipal Corporation.

Database and Methodology

Google Earth data for the present year (2019) and Survey of India latest Toposheet G45N2 and G45N6 are used. PMC map* with 72 wards is used. (*Base MAP of PMC is as per 2001 Administrative command, the same base map and boundary is used by Department for International Development (DFID) UK for its developmental plans for Bihar with collaboration with the provincial government). A discrete georeferenced map of Patna Municipal Corporation is prepared from scratch with all the required parameters. KML file was created in Google Earth Pro with the help of Polygon tool according to reference base map of PMC with 72 wards. For georeferencing and shapefile conversion GRgarmin along with ISRO's Bhuvan were used and required ground truthing was done.

Table-1: Details of Satellite data

Satellite	Sensors	Date	Resolution	Band	P/R
Landsat - 5	TM	19/03/2000	Re sampled at 30.0 m	3,4,5, 6	141/42
Landsat - 5	TM	23/03/2007	Re sampled at 30.0 m	3,4,5, 6	141/42
Landsat - 8	TIRS	26/03/2013	Re sampled at 30.0 m	4,5,6, 10	141/42
Landsat - 8	TIRS	21/03/2018	Re sampled at 30.0 m	4,5,6, 10	141/42

This study is mainly based on satellite data. The Thermal Infrared band of Landsat – 5 TM and Landsat – 8 TIRS have been used. Some precautions were taken in selecting the Satellite image. Cloud free images of same week (time window of + - 7 days) were used for minimum impact of isolation related issue. All the satellite images were acquired from United States Geological Surveys (USGS) website. Landsat - 5 TM acquired images for Land Surface Temperature is in DNs (0-255), which can be converted into Celsius after processing. The first step is to convert the Digital Numbers (DNs) to radiance value. For this purpose we need to get the bias and gain values. For getting this value Band 6 of Landsat - 5 TM and Band 10 of Landsat – 8 TIRS were used.

The following formulas were used to calculate the bias and gain for each Landsat scene for Landsat - 5 TM data. For this purpose ENVI 5.1 was used.

$$\text{Bias} = L_{MIN} \quad (1)$$

$$\text{Gain} = (L_{MAX} - L_{MIN}) / (Q_{CALMAX} - Q_{CALMIN}) \quad (2)$$

The formula for converting the DN to radiance is:

$$P_{R} = G\,(P_{DN}) + B \quad (3)$$

Where,

PR = Pixel radiance value
PDN = Pixel digital number
B = Bias (Offset)
G = Gain

After getting the radiance value it should be converted to the Kelvin with the help of following formula

$$Tk = K2 / \ln[K1 / PR + 1] \quad (4)$$

Table 2. Details of K1, K2 for Satellite Sensors that were used

Constant	Landsat - 5 TM
K1	607.76
K2	1260.56

And finally after getting the values in Kelvin, subtracting the value of 273.15 by simple band math the final value can be obtained in Degree Celsius.

$$BTc = Tk - 273.15 \quad (5)$$

where,

BTc = Temperature in Celsius

The methodology and formulas changed for the Landsat – 8 TIRS. Images are processed in units of absolute radiance using 32-bit floating-point calculations. These values are converted to 16-bit integer values in the finished Level 1 data. They can then be converted to spectral radiance using the radiance scaling factors provided in the metadata file:

$$L\lambda = ML * Qcal + AL \quad (6)$$

where,

Lʌ = TOA Spectral radiance (W / (m2 * srad * mm))
ML = Radiance multiplicative rescaling factor for the band (From Metadata it is 0.0003342)
AL = Radiance additive rescaling factor for the band (0.1 from the metadata)
Qcal = Quantized and calibrated standard product pixel values (DN)
TOA =0.0003342* Band_10 + 0.1

Similar to the conversion to radiance, the 16-bit integer values in the Level 1 product can also be converted to TOA reflectance. The following equation is used to convert Level 1 DN values to TOA reflectance:

$$\rho_\lambda = M_\rho * Q_{cal} + A_\rho \quad (7)$$

Where:

ρ_λ = TOA Planetary Spectral Reflectance, without correction for solar angle. (Unit less)

M_ρ = Reflectance multiplicative scaling factor for the band (REFLECTANCEW_MULT_BAND_n from the metadata).

A_ρ = Reflectance additive scaling factor for the band (REFLECTANCE_ADD_BAND_N from the metadata)

Q_{cal} = Level 1 pixel value in DN

Note that ρ_λ is not true TOA Reflectance, because it does not contain a correction for the solar elevation angle. Once a solar elevation angle is chosen, the conversion to true TOA Reflectance is as follows:

$$\rho_\lambda = \rho_\lambda / \cos(\theta_{SZ}) = \rho_\lambda / \sin(\theta_{SE}) \quad (8)$$

where,

ρ_λ = TOA planetary reflectance

θ_{SZ} = Local solar zenith angle; $\theta SZ = 90° - \theta_{SE}$

θ_{SE} = Local sun elevation angle; the scene center sun elevation angle in degrees is provided in the metadata

TIRS data can also be converted from spectral radiance (as described above) to brightness temperature, which is the effective temperature viewed by the satellite under an assumption of unity emissivity. The conversion formula is as follows

$$BT = K_2 / \ln[K_1 / L_\lambda + 1] - 273.15 \quad (9)$$

where,

BT = Top of atmosphere brightness temperature (°C) where:

L_λ = TOA spectral radiance (Watts/(m2 * srad * μm))

K_1 = Band-specific thermal conversion constant from the metadata

(K_1_CONSTANT_BAND_x, where x is the thermal band number)

K_2 = Band-specific thermal conversion constant from the metadata

(K_2_CONSTANT_BAND_x, where x is the thermal band number)

Table 3. Details of K_1, K_2 for Satellite Sensors that were used from the Metadata

Constant	Landsat - 8 TIRS
K_1	774.89
K_2	1321.08

BT = (1321.08 / Ln((774.89 / "TOA") +1)) – 273.15 (10)

Now from this stage the similar calculations were done for both Landsat 5 and Landsat 8. After getting the brightness temperature for both satellites the NDVI was calculated using the following formula.

NDVI = Near Infrared (NIR) – Red / Near Infrared (NIR) + Red (11)

Table 4. Details of Satellite and Sensors

Satellite	Bands	NDVI Formula
Landsat 5 TM	Band 3 (Red), Band 4 (NIR)	Band (4) – Band (3) / Band (4) + Band (3)
Landsat 8 TIRS	Band 4 (Red), Band 5 (NIR)	Band (5) – Band (4) / Band (5) + Band (4)

The importance of estimating the NDVI is essential since the amount of vegetation present is an important factor and NDVI can be used to infer general vegetation condition (Q. H. Weng, D. S. Lu, and J. Schubring, 2004). The calculation of the NDVI is important because, afterward, the proportion of the vegetation (P_V) should be calculated, and they are highly related with the NDVI, and emissivity (ε) should be calculated, which is related to the P_v:

Calculating the Proportion of Vegetation (Pv): Pv is calculated according to the following equation. A method for calculating P_v suggests using the NDVI values for vegetation and soil ($NDVI_{max}$ = 0.5 and $NDVI_{min}$ = 0.2) to apply in global conditions (J.A. Sobrino, J. C. Jimenez-Munoz, and L. Paolini, 2004). However here in the present condition the maximum and minimum NDVI value has been taken as input and the following equation was applied in raster calculator.

$$P_v = (NDVI – NDVI_{min} / NDVI_{max} – NDVI_{min})^2 \quad (12)$$

However, since the NDVI values differ for every area, the value for vegetated surfaces, 0.5, may be too low. Global values from NDVI can be calculated from at – surface reflectivities, but it would not be possible to establish global values in the case of an NDVI computed from TOA reflectivities, since $NDVI_V$ and $NDVI_s$ will depend on the atmospheric conditions (J. C. Jimenez-Munoz, J. A. Sobrino, A. Plaza, L. Guanter, J. Moreno, and P. Martinez, 2009).

Calculating Land Surface Emissivity: The land surface emissivity [LSE (ε)] must be known in order to estimate LST, since the LSE is a proportionality factor that scales blackbody radiance (Planck's law) to predict emitted radiance, and it is the efficiency of transmitting thermal energy across the surface into the atmosphere (J. C. Jimenez-Munoz, J. A. Sobrino, A. Gillespie, D. Sabol and W. T. Gustafson, 2006). The determination of the ground emissivity is calculated conditionally as suggested in (J.A. Sobrino, J. C. Jimenez-Munoz, and L. Paolini, 2004).

$$\varepsilon_\lambda = \varepsilon_{v\lambda} P_v + \varepsilon_{s\lambda} (1 - P_v) + C_\lambda \quad (13)$$

The error correction equation for emissivity (ε_λ) is = 0.004* P_v + 0.986

The last step of retrieving the LST or the emissivity corrected land surface temperature T_s is computed as follows (M. Stathopoulou and C. Cartalis, 2007):

$$Ts = BT / [1 + (\lambda BT / \rho) * \ln (e\lambda)] \quad (14)$$

where,

Ts is the LST in Celsius, BT is at sensor Brightness Temperature (°C), λ is the wavelength of emitted radiance (for which the peak response and the average of the limiting wavelength (λ=10.895, Band 10 of Landsat 8 will be used), ε_λ is the emissivity calculated and

$$\rho = h * C / s = 1.438 * 10^{-2} \text{ m K} \quad (15)$$

where,

s = Boltzmann constant (1.38×10^{-23} J/K)
h = Planck's constant (6.626×10^{-34} Js)
c = velocity of light (2.998×10^{8} m/s)

After finishing the above mentioned calculation in raster calculator of ArcMap and getting the final result in degree Celsius the Landsat tile for each base year was clipped as per the area of interest (AOI). The AOI (PMC) was classified into five classes according to the manual breaks in different thermal regions of the area. And lastly Maximum Likelihood Classification was done for all the base years for getting the required LST data for the statistical analysis.

The next step was to calculate change (increase) in Built up area over the years using Normalized Difference Built up Area (NDBI) formula under the raster calculator in ArcMap.

NDBI formula for Landsat 5 TM = Band 5 – Band 4 / Band 5 + Band 4 (16)

NDBI formula for Landsat 8 TIRS = Band 6 – Band 5 / Band 6 + Band 5 (17)

The built up and none built up area were classified using maximum likelihood classifier under ArcMap. None built areas come under the urban greens. Urban greens are the temporary or permanent green (vegetative) spaces under a urban locality which includes urban farming, gardens, parks, open spaces, avenue trees, institutional fields, golf course, cemeteries, green corridors along road, rail, rivers or canals (M. Ashraf, 2015). The famous French urban architect, Le Corbusier rightly considered parks and gardens as the lungs of cities. It is now strongly believed that the quality of life of a city, to a great extent, depends on the share of urban greens.

The present paper investigates the declining 'green infrastructure' and the expansion of 'grey infrastructure' or urban built up and its correlation on the land surface temperature that corresponds to urban heat island effect of a city or municipal area.

Table 5. Details of Software used in Study

Software Used	Functions
Google Earth Professional 7.1.1	For overlaying RAW map and creating Polygon generated outline KML file
DNR Garmin 5.04	Converting KML file to Shape file , Ground Truthing and Georeferencing
ISRO Bhuvan	Evaluation of shapefile and georeferenced data
ENVI 5.1	Processing of Landsat 5 TM Thermal band to degree Celsius
ArcMap 10.1	AOI clipping, Thermal band processing using Raster calculator, ML Classification and LST/UHI Model Creation, NDBI Calculation
MS Excel 2007	Correlation calculation, Graphs and Charts

Results and Discussions

The main objective of this study was to determine the impact of increase in Built up area and its correlation with Land Surface Temperature (LST) after year 2000 A.D. in Patna Municipal Corporation. Four base years were selected depending on the availability of Satellite data with minimum cloud coverage for the maximum accuracy. All the data were of the same period (plus minus one weak) for minimizing the effect of seasonal change on Land Surface. The processed satellite data showed some considerable results regarding increase in maximum land surface temperature and built up area. The results of increase in maximum Land Surface Temperature and Built up area are shown below in table and graph

Table 6. Growth in Built up area and LST from 2000 – 2018

Year	Maximum Land Surface Temperature (LST) in ° C	Built Up (in sq. km)
2000	35.11	62.14
2007	36.80	64.18
2013	39.05	70.05
2018	40.00	76.44

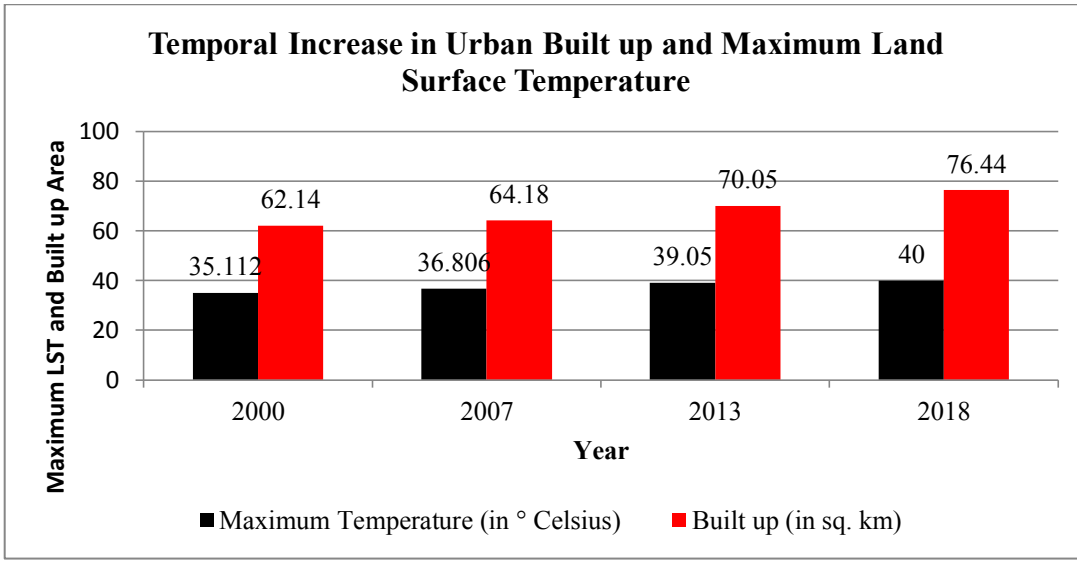


Fig. 2. Temporal Increase in Urban Built up and LST

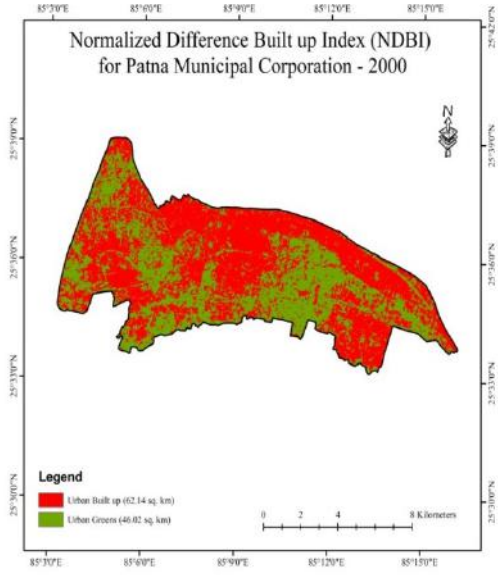


Fig. 3 (a) NDBI Model of PMC for 2000

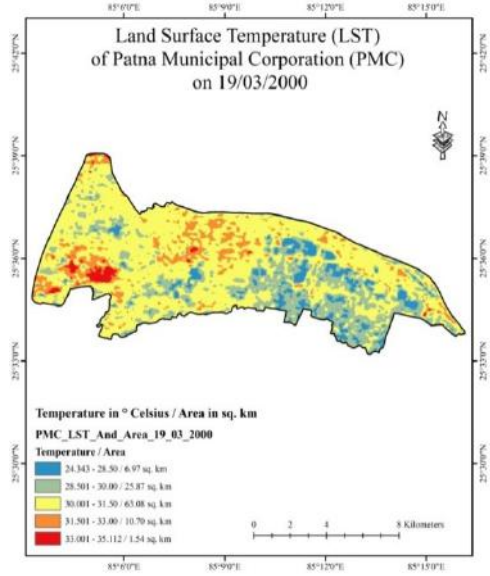


Fig. 3 (b) LST Model of PMC on 2000

The maximum land surface temperature (LST) that was 35.11 °C in 2000 increased gradually from 2000 – 2007. The gain in maximum LST was just 1.694 °C in this seven year period. Similarly the built up area was 62.14 km^2 in 2000 which increased just 2.04 km^2 in seven years to 64.18 km. The rate of increase was slow in both of these parameters from 2000 – 2007. The growth of urban built up and maximum LST are depicted below.

However this scenario changed after 2007. The maximum LST and built up area increased with higher rate in later years. The Maximum LST increased from 36.806 °C to 39.05 °C in the period of 2007 – 2013. The increase in LST was 2.244 °C in this six year period. The rate of growth in urban built up was also on higher side in this six year period. The built up area increased 5.87 km^2 to cover 70.05 km^2 of the 108 .16 km^2 which is the total area of Patna Municipal Corporation. The urban growth further increased which resulted in the total urban built up area covering of 76.44 km^2 in 2018. The urban built up area increased 6.39 km^2 in just five year period from 2013 – 2018. Similarly the increase in maximum LST also recorded at the highest level at 40.00 °C in 2018, the increase was nearly 1 °C in last five years.

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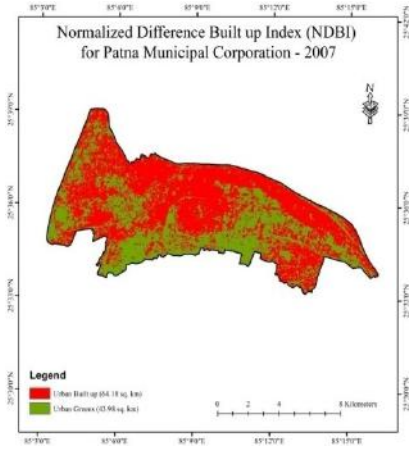
It was also observed by the current LST and NDBI model that those places which are Urban Green areas falls under relatively cooler places comparing to their neighboring concrete structure. For example in every base year the runway of Patna airport and adjoining concrete area which is situated in south – west part of the Patna Municipal Corporation is under Very high LST part which is visible in nearly linear red stripe in figures 3(b), (d), (f), (h). Similarly Patna Zoological and Botanical Garden which is situated on the north east corner of the airport is always found to be cooler place shown in figures in sky blue.



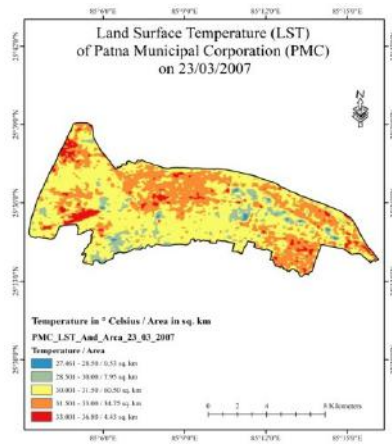


Fig. 3 (e) NDBI Model of PMC for 2007 **Fig. 3 (f) LST Model of PMC on 2007**

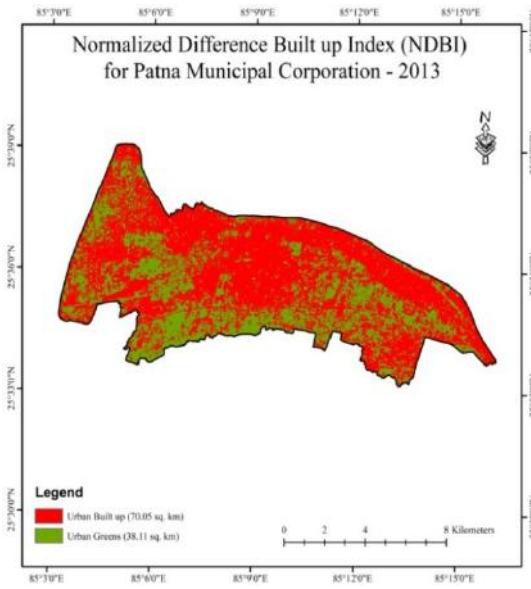


Fig. 3 (e) NDBI Model of PMC for/2013

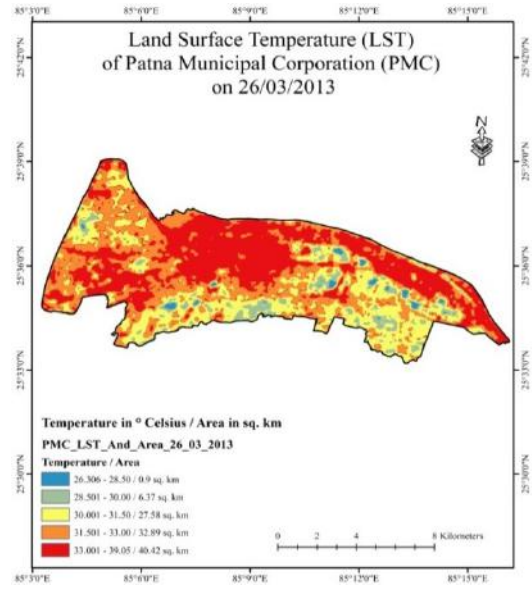


Fig. 3 (f) LST Model of PMC on 2013

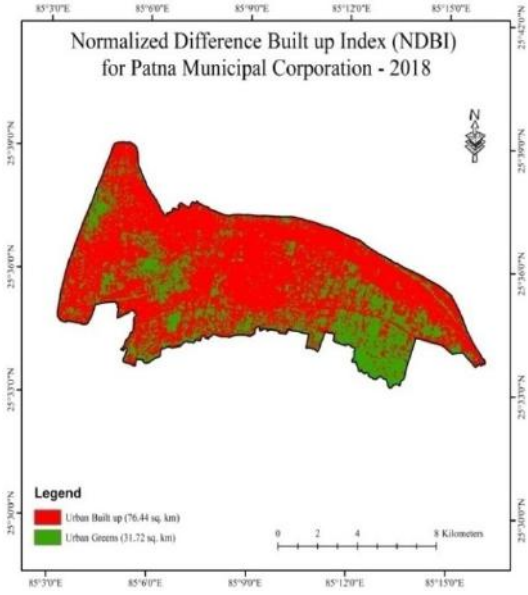


Fig. 3 (g) NDBI Model of PMC for 2018

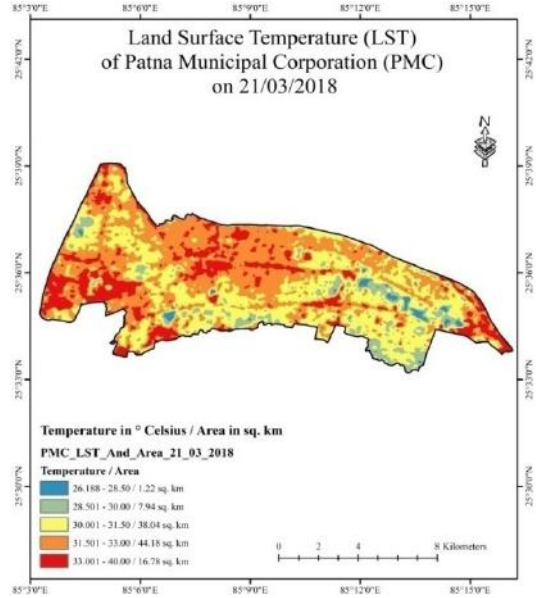


Fig. 3 (h) LST Model of PMC on 2018

The relationship with growth in built up area and increase in maximum LST is shown below in Figure 4.

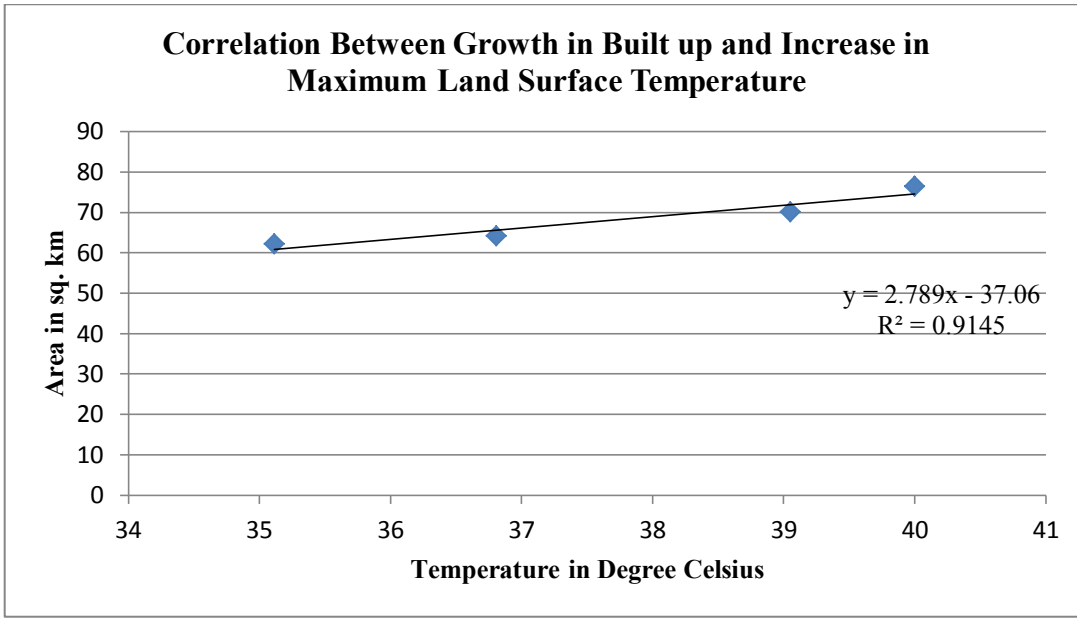


Fig. 4. Correlation of Land Surface Temperature increase with growth in Built up area

Conclusion

The primary objective of this paper was to obtain maximum Land Surface Temperature (LST) from 2000 to 2018. A very clear incremental increase in LST has been found. In 18 years of time span the maximum LST of the same period increased to 4.89 °C. The increase in LST is shown in Table – 6 and Figure – 2. Similarly the second objective was also achieved and a very strong correlation (R^2 = 0.914) between Built up area growth and LST increase has been established. This correlation is shown in Figure – 4. The last objective of satellite data based model of Built up area and LST model are also created successfully using required algorithm accepted globally for this purpose fig 3 (a) to fig 3 (h). It was also found that Urban Greens have the minimum impact of Urban Heat Island effect while the concrete, asphalt, built up area had the maximum impact of UHI. For the planners the understanding of the mechanism of Land Surface Temperature's effect is very important for urban planning to enable greater control over surrounding environment. And in future the results from this study could be used for identifying warmer Municipal areas that could be transformed into sustainable environmental regions.

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FUZZY LOGIC BASED SITE SUITABILITY ASSESSMENT FOR COLD STORAGE CONSTRUCTION AT WESTERN VILLAGES OF LOKTAK LAKE, MANIPUR

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Abstract

Agriculture in India is plagued by a multitude of problems at every stages of the practice. Absence of cold storage limits farmer's ability to solve post harvest problems. This study attempts to find suitable sites for cold storage location in western lakeshore villages of Loktak Lake, Manipur by using fuzzy logic overlay and linear membership analysis in GIS environment. Four suitability zones were obtained, of which, the western part Toubul Village was found to be the most suitable zone.

Keywords: Cold storage, Suitability assessment, GIS, Fuzzy logic, Western Loktak villages

Introduction

Agriculture in India is plagued by a multitude of problems at every stages of the practice. While some farmers lack appropriate inputs in pre harvest phase, others face the vagaries of weather events during sowing seasons (Kannan, 2014). Even in situations where a farmer is able to overcome all such hardships and have a bumper crop, post-harvest problem awaits a typical farmer in India (Maheshwar et al, 2006). Lack of access to market, production of the same crop at the same time having dampening effects on the prices, large gap in crop price between farm and market among others areas some of the important post-harvest problems. For commercial farmers, storing their produce to sell in lean season could make them fetch remunerative price but due to absence of cold storage in suitable numbers and places preclude them from using this option. Manipur, one of the seven sister states of north eastern India, has an agrarian economy with employment structure characterized by dominance of people employed in agriculture sector (S.S Roy et al, 2018). Agriculture in the state has varying level of technological adoptions. While hill areas of the state continue to practice predominantly primitive subsistence agriculture, agriculture in the Imphal valley is of intensive nature with higher levels of technological inputs. There are areas in the valley where commercial agriculture is practice year round with more emphasis on horticulture crops. Toubul, Ngaikhong, Khoijuman and Kwasiphai villages of Manipur and also the case study areas for this research, situated in western lakeshore of Loktak represent one of the most agriculturally advanced regions of Manipur.

For such villages, cold storage for storing excess produces which would allow withholding of crops to be sold later in lean season in order to get higher price is a necessity. With lack of investment in agriculture in the current economic climate, it is not expected that such facilities will be available in every villages or farms. Therefore, it is imperative that cold storage so established be located at suitable site for maximum benefits to the farmers. However, finding suitable location of cold storage may be influenced by many considerations such as Land use and land cover (LULC) of the area, agricultural production, distance from the village and road, road density etc. of the area, thereby, making it a complex multi criteria decision making process. Remote sensing and GIS based techniques have emerged as the most viable method over conventional methods for resolving such problems provided that there is appropriate availability of quality data as it breaks down the numerous time period and multi-criteria analysis, making more comprehensible (Rosli et al, 2011). Most importantly, GIS offers an elastic environment for gathering, storing, displaying and analyzing advanced data essential (Chang, 2016). Fuzzy Logic approach within the GIS environment, because of its strength to accommodate variables with some uncertainties i.e. having multiple potential cold storage sites, is adopted for this study. This paper seeks to find a suitable site for locating cold storage in a scenario where there is a number of favorable sites by using fuzzy logic on GIS based platform

Study Area

The study area i.e. the 4 villages Ngaikhong, Toubul , Khoijuman and Kwashiphai lies on the western part of the Loktak lake, the largest freshwater lake of northeast India.. It covers an area of 21.46 km^2 lying between 24°37'29"N to 24°37'31"N and 93°47'29"E to 93°47'31"E. The area (Figure 1) is characterised by loss of agricultural produce in large amount in part due to dampness and damage by ants, pets and rodent after harvest. Such losses due to improper storage are an important feature of the area despite having high productivity. This situation leads to the widening gap between the prices of the agricultural products of the local with respect to non-local which in turn reduces their capacity to compete in agricultural market in price terms. Above all, there is also no proper market channel of the marketable surplus of agricultural products. As there is also a larger gap between the physical and financial achievement in this sectors, it leads to the decrease in farmers' income resulting in changing livelihood system. The slow action of the government only worsens the situation. (Singh, 2012).

Database and Methodology

The study encompassed collection of household primary data acquired on purposive sampling basis to ascertain the problems and prospects of agriculture of the villages and acquisition of satellite imageries from USGS of the study area. Moreover, other available secondary sources of data including research articles, governmental reports, and books were also consulted.

1. Data Used and Image Processing

LANDSAT 8 OLI/TIRS image was downloaded from the USGS site with the base year of 2019 to understand the LULC. To ensure cloudless images, data acquired in winter was chosen for the study. Since the image consisted of many bands (band 2, 3, 4, 5, 6, 7), stacking process was done in proprietary image processing software (Erdas 9.1). Prior to performing actual analysis, image enhancement techniques such as histogram equalization, and principal component analysis were applied to the image in order to improve the visibility and interpretability of the image.

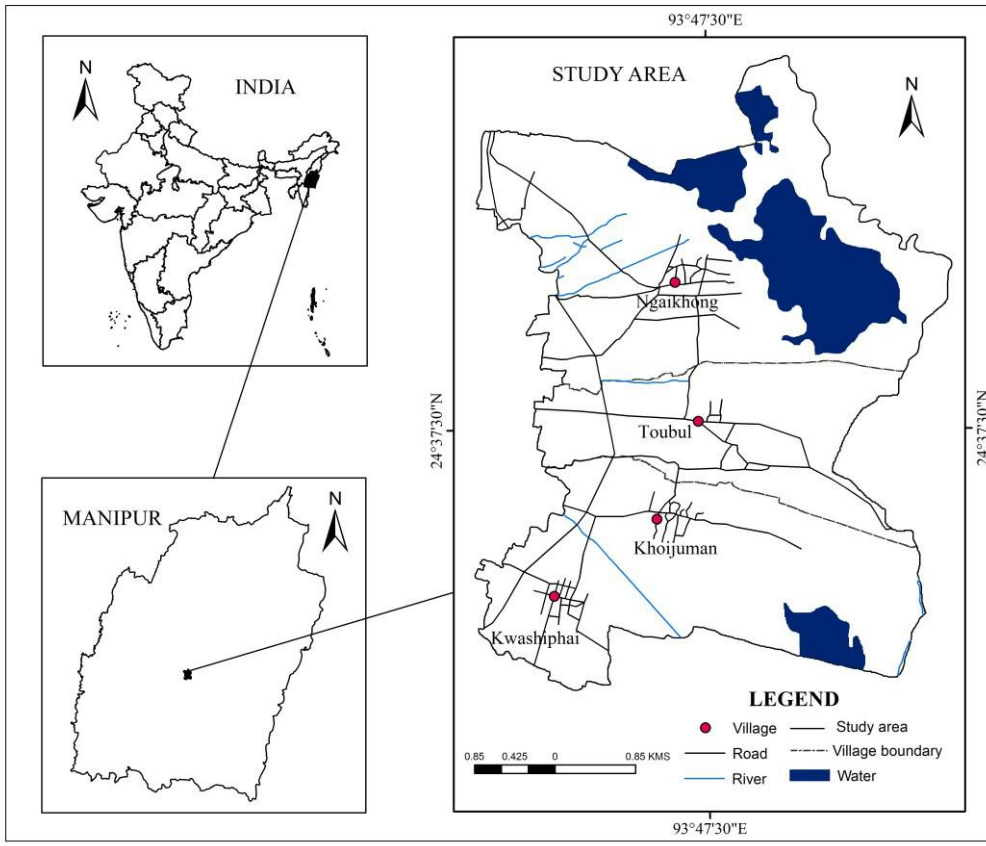

Fig. 1. Western part of Loktak Lake

2. Image Classification and Techniques

Supervised classification technique was used to determine LULC of the area for which each distinctive feature from each band was identified using the spectral response pattern. Eight classes were identified and classified viz. Agricultural land, Built-up land, Fish farm, Inundate areas, Rangeland, Temporary *phumdies*, thin *phumdies* and Water bodies. Here, *phumdies* are floating mat of dead and living vegetation perhaps unique to the lake.

For finding suitable site for cold storage location different factors such as agricultural production, distance from the village, road buffers, river buffer and road density were generated on Arc GIS 10.22. The factors were then reclassified and a suitability map was generated using Fuzzy logic overlay method. A flowchart detailing the methodology is given in Figure 2.

Site Suitability Assessment

GIS based site suitability assessment was used in this study because of the various advantages it offers over conventional method including its ability to handle large number of datasets at a time, modeling at faster rate, ability to answer 'what if' scenarios etc. Fuzzy model, which is one of the stochastic models, was employed as it removes vagueness and handles uncertainly better as compared to weighted overlay technique. As Fuzzy logic is based on the concept of partial truth it produces no sharp boundaries but probabilities of suitability called fuzzy sets. Fuzzy sets were derived from fuzzy membership function which takes value from 1 to 0 with 1 representing complete certain of membership and 0 representing non membership (Burrough et al, 1998). Among many membership functions, linear membership was used in this study.

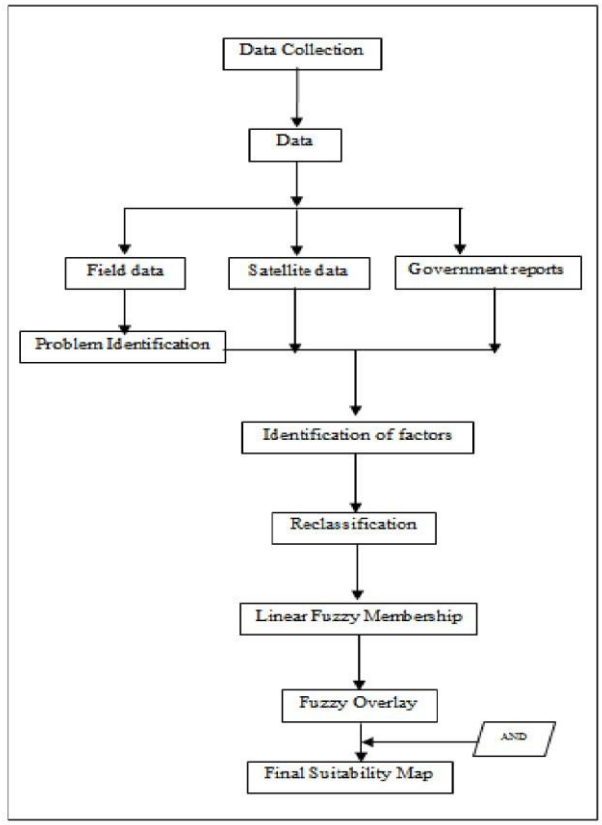

Fig. 2. Methodology Flowchart

Results and Discussion

1. Land use and Land cover

LULC can have significant influence on the location of cold storage sites; therefore the study area was classified into eight LULC categories viz. agricultural land, built-up land, fish farms, inundated areas, rangeland, temporary *phumdies*, thin *phumdies* and water bodies (Figure 4A).The classification scheme proposed by Anderson (1977) was modified to suit the local context and additional classes were added appropriate for the scale of the study. Agricultural class constitutes 32 per cent of the entire investigation region and inundated areas the least, 0.65%.. Here it is important to note that fish farms, inundated areas, *phumdies* and water bodies' classes, including built up areas are unavailable for siting cold storage. This implies that almost 63.22% of the study is unsuitable for location of cold storage.

Table 1. Spatial Extent of LULC

LULC types	Area in km^2	Percentage
Agricultural land	7.04	32.81
Built-up land	2.54	11.84
Fish farm	3.41	15.89
Inundated areas	0.14	0.65
Rangeland	0.89	4.15
Temporary *phumdies*	0.92	4.29
Thick *phumdies*	3.9	18.17
Water bodies	2.62	12.21
Total	21.46	100

Of the 4 villages, Ngaikhong village not only has the largest agricultural land coverage but also most built up area in percentage terms. Kwashiphai village on the other hand has the least area under built up and more under rangeland.

2. Agricultural Production Profile

Understanding agricultural profile of the villages in terms of types of crops grown, production and productivity of the crops and amount of produce loss due to improper storage will add in the identification of suitable sites for cold storage. It is evident that the four villages under study grows crops covering all agricultural seasons i.e. khraif, rabi and zaid (Figure 3). However, in terms of crop productivity there exist marked variations among the villages with Toubul village registering highest productivity in almost all crops while other villages witness consistently low yield in all crops relatively (Figure 4B). Inter village variation in crop productivity reflects the different level of quality and quantity of inputs used for agriculture production in these villages. It was found through our field work that Toubul farmers have greater access to irrigation facilities, uses newer inputs like fertilizer, pesticide and overall agriculture in Toubul is intensively pursuit. (Luckychand, 2016).

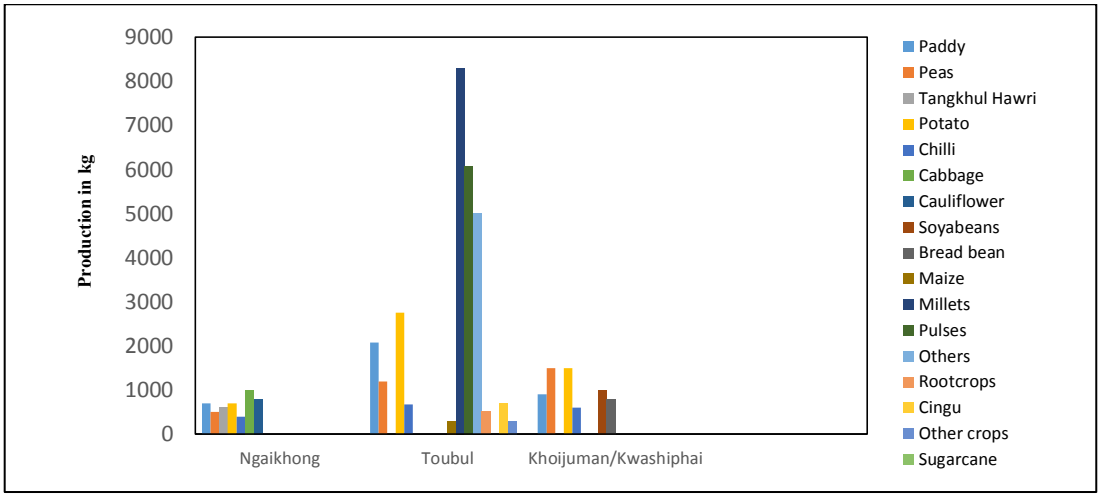

Fig. 3. Agricultural Production (DRDA, 2010-2011)

3. Buffer Analysis

Buffer analysis involves creation of zones at specified intervals (Jian, G. L.and P. J. Mason, 2009). Buffer zones were created to determine the suitable distance of the storage site from the village, distance from roads and distance from rivers.

A suitable site for cold storage should also account for future expansion in population and spatial extent of the villages. Location of cold storage in close proximity to a village may interfere with subsequent growth of the settlement which might in turn affect the future viability of storage. To address this, buffer analysis was performed in all the villages at intervals of 500, 1000 and 1500 meters resulting in creation of three buffer zones for each village in order to account for the future spatial expansion of villages (Figure 4C).

With the progressive improvement and increase in populace, roads are being exposed to development so as to meet the expansion of traffic volume. As the site for cold storage construction requires a high capital investment, it would be prudent to consider the possibility of future expansion of roads because such developments may adversely affect the suitability of the storage site. In this regard, the road buffers of 100 m, 200 m and 300 m are created (Figure 4D).

A suitable cold storage site should also be located in areas where natural hazards like floods do not occur frequently. Floods in Imphal valley are mostly associated with overflow of waters from rivers during monsoon season. Therefore, to exclude areas with potential flooding risk, while searching site for cold storage, river buffer zones at 100,200 and 300 meters intervals were also generated for streams draining the study area (Figure 4E).

4. Road Density

One of the important factors that can have significant influence on location of suitable cold storage is road accessibility. Road density, measured as length of road per unit area, is a simple measure of road accessibility. Here, a delicate balance needs to be achieved between locating in high road density and low density areas.

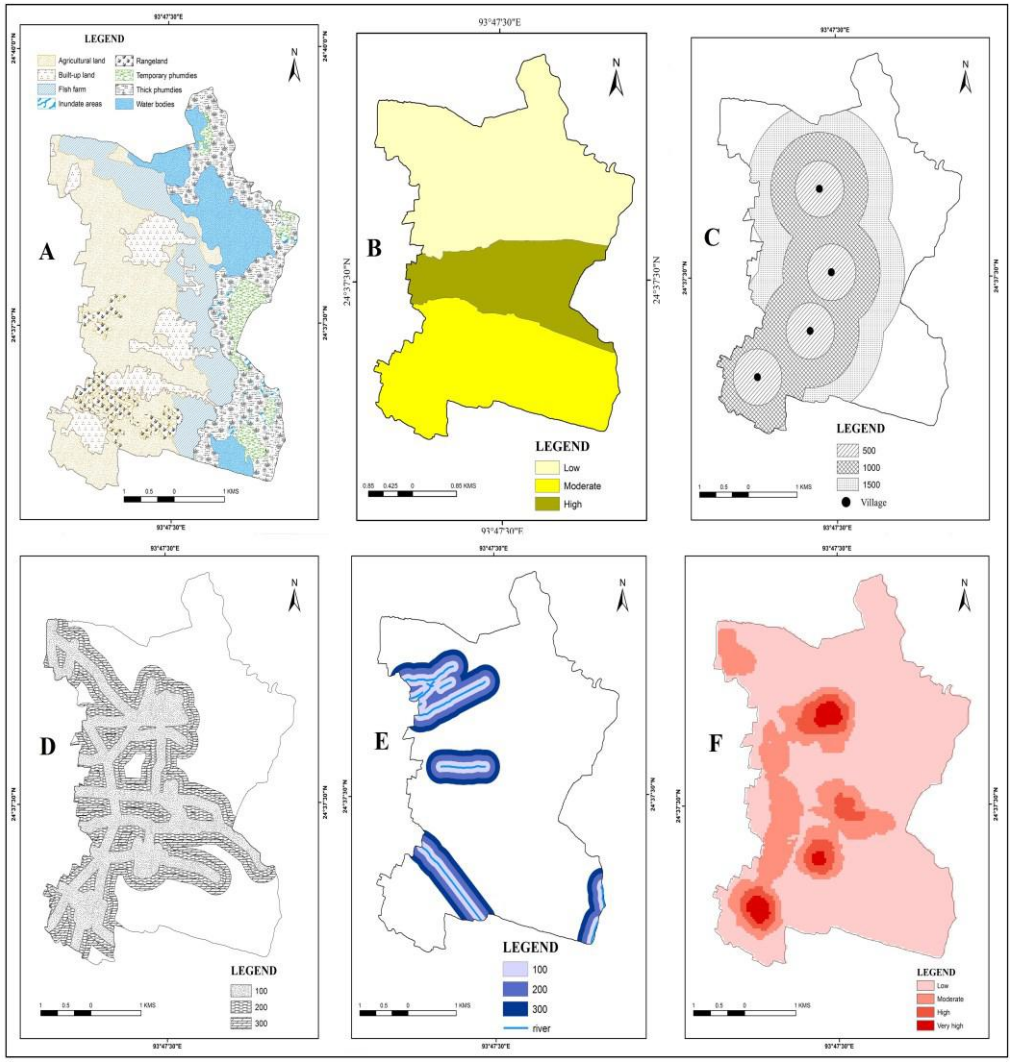

Fig. 4. A. LULC types B. Agricultural Production (DRDA, 2010-2011) C. Distance from the village D. Road buffer E. River buffer F. Road density

The study area has been divided into four road density zones (Figure 4F); Low, Moderate, High and Very High with spatial extent of about 15.96 km2, 4.09 km2, 1.02 km2 and 0.4 km^2 respectively (Table 2). A high road density area may be seemingly more

attractive for locating cold storage in the short run but such areas also have high propensity for population growth thus congestion in future. A low road density on the other hand is marked by low accessibility hence will render the facility with lower capacity to cater to the requirements of farmers.Therefore, moderate zones would ideally be more suitable for siting cold storage. In the study area, very high density zone is seen in Ngaikhong, Khoijuman, Kwashiphai regions. The village Toubul is mostly of High and moderate type.

Table 2. Spatial Extent of Road Density

Types	Area in km^2
Low	15.96
Moderate	4.09
High	1.02
Very High	0.4
Total	21.46

Four Suitable Zones

1. Low Suitability Zone

It encompasses an expanse of about 2.07 km^2 which account for 77.63 percent which is the largest of the whole suitability zone (Table 3). This zone is widely distributed in the 3 villages i.e. Ngaikhong, Toubul and Khoijuman areas. Kwashiphai is devoid of this suitability zone. Among the 3 villages, Ngaikhong holds the largest, followed by Khoijuman and Toubul the least. The low suitability of this zone is on account of lying within road buffers and river buffers areas and having high and very high types of road density, which all disfavor the location of cold storage. Moreover, it is also characterized by the large area of agricultural lands and the existence of all the 3 types of agricultural production and also situating near the villages. Thus, this zone is less suitable for the siting cold storage.

Table 3 Spatial coverage of suitability zones

Types	Area in km^2	Percentage
Low	2.07	77.63
Moderate	0.01	0.38
High	0.48	18.05
Very high	0.52	19.47
Total	2.66	100

2. Moderate Suitability Zone

This type covers an area of about 0.01 km^2, which entails for about 0.38 percent, which is the least among the suitability zones. It extends only in Ngaikhong areas. The other 3 village areas are devoid of this zone. It is mainly characterized by concentration on agricultural land, low agricultural production, etc. It is also marked by moderate density of road, 200 m from the river and 100 m from the road and 500 m from the village.

As this zone falls in all the places that will affect the expansion of built-up and prone to flooding, it is not suitable for the construction of cold storage.

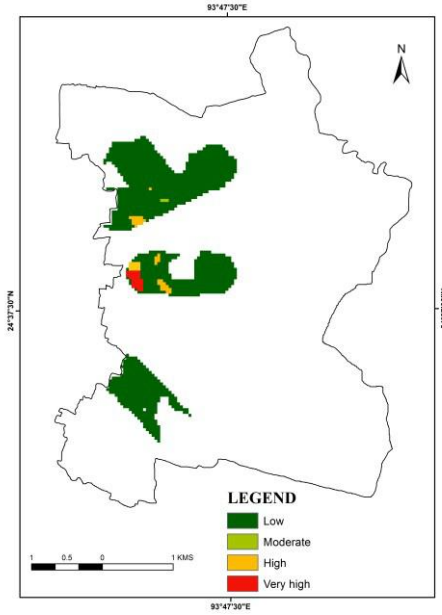

Fig. 5. Suitability Zones

3. High Suitability Zone

Among the suitability types, this type holds a third position in terms of spatial extent. It covers an area of about 0.48 km^2, which accounts for 18.05 percent of the whole suitability zone. When analyzed, it is mainly concentrated at the western part of the Toubul village trailed by Ngaikhong village on southwestern part. The villages of Kwashiphai and Khoijuman is devoid of this category. High Suitability Zone falls in the region of high agricultural and low agricultural production and it covers less agricultural land and contains 100 m and 200 m type of road buffer and 300 m and 400 m type of river buffers. It is also characterized by moderate type of road density. This zone is also suitable and can be considered for locating cold storage in contingency situations.

4. High Suitability Zone

This zone covers an area of about 0.56 km^2 accounting for 19.47 percent of the whole suitability zone. Lower coverage of agricultural land when compared with other suitability zones is its main feature. High Suitability Zone is found only in the western side of the Toubul village. Being farthermost from the village (1500 m) and situating near high agricultural production, i.e. Toubul, makes this zone very suitable for the future cold storage construction. It also fulfills the criterion of not being affected by the future built-up expansions (300 m from the road) and flood risk (300 m from the river) and also characterized by moderate density of connectivity.

Conclusion

Post-harvest problem in Indian agriculture is a real and serious issue compounded by absence of cold storages. This study of villages surrounding western sides of Loktak Lake showed that there can be four levels of suitability zones for cold storage locations but only Toubul village area emerged as the most suitable site. The study also points to the urgent need for cold storage construction in the area. The continuing absence of cold storage in one of the most agriculturally forward regions of Manipur may not only have local effects, but in fact, deter other farmers of the state from pursuing commercial oriented advanced agriculture.

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TRENDS OF URBANIZATION IN RAJASTHAN: APPLICABILITY OF RANK SIZE DISTRIBUTION AND PRIMATE CITY

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Abstract

Urbanization is a process of transformation in a society, transformation from rural lifestyle and stagnant economy to urban lifestyle and dynamic economy. Urbanization is not a very recent process but it started even before industrialization and the process of urbanization in Rajasthan starts from since ancient period of history. The level of urbanization in India is comparatively lower than the developed countries and Rajasthan is also comparatively less urbanized than other states of India. The present study is focused on analyzing the trends and patterns of urbanization in Rajasthan from 1901 to 2011 and to study how far the rank rule in Rajasthan is followed. Urbanization in Rajasthan has increased and the rate of increase is fastest in the last decades. But the process of urbanization in Rajasthan has disparity among the districts. The paper also deals with the concept of primate city in Rajasthan.

Keywords: Urbanization, Primate city, Rank size rule, Disparity

Introduction

Urbanization is the new reality of modern world. Urban areas have been considered as engines of inclusive economic growth. Tremendous urban growth in terms of urban population, density of urban population and number of towns has been registered after the post- Independence period in India. About 32% population of the India from 121 crore of total population lives in urban areas. Census of India characterize urban settlement as, all the places which have municipality, corporation, and cantonment board or notified town area committee. Many historians have been debating on urbanization in the early medieval India. Mark Jefferson, a renowned geographer, put forward the concept of primate cities. According to his definition, a primate city has to be twice as large in size as the next biggest city. A primate city is the largest city within a region or nation that dominates not only in size, but also with regards to area of influence. It often serves as the political and financial hub of a country. It must also be twice as important, socially and economically. Moreover, a primate city needs to be on top in most aspects, including politics, universities, media and culture etc.

A city size distribution, in which the largest city is several times larger than the second largest is known as the primate city. Primate city expresses the national disposition more completely than any other city. Different urban geographers in use the concept of rank size rule world over to investigation of the ranking of cities. Stewart (1958), has applied this concept for analysing for the nature of 72 counties of the different continents. Mark Jefferson (1939), was the first geographer introduced the 'Law of Primate city'. The central place theory of Christaller is also associated with this concept. Vining (1955), Isard (1956), Allen (1954), Madden (1954), Garrison (1958), Beckmann (1958), Hagget (1965), Smailes (1967) also checked the relevance of the rank size rule in their work. Rank size rule concept is suitable for the investigation of the urban process of U. S. A., and Russia. In India, different urban geographers and administrators for examining the relationships of population and ranking of cities apply this concept. Reddy (1969), examined the rank-size relationship and effect of the primate city on the urban centers in Krishna-Godavari delta of Andhra Pradesh. Barai (1974), investigate the spatial distribution and rank-size relationship of the urban centres of settlements in Tamil Nadu State.

The rank-size rule (or rank-size distribution) of city populations, is a commonly observed statistical relationship between the population sizes and population ranks of a nation's cities. According to the rank-size rule, a rank 3 city would have ⅓ the population of a country's largest city, a rank four city would have ¼ the population of the largest city, and so on.

Study Area

The study area is Rajasthan, which is located at the western border of the country and is the largest state in terms of area (342.24 thousand km^2) but ranks only eighth in terms of population. More than half part of state is covered of Thar desert and hence the population distribution is very unequal. The population density of the state is one of the lowest at 165 persons per sq. km compared to 325 for India as a whole. The geographical location of Rajasthan and its topography and climatic condition plays an important role to determining the land use pattern. Rajasthan extends between 23 0 3' north to 30 0 12' north latitudes and 69 0 30'E to 78 0 17' east longitudes. The state displays a wide variation of physical features, which includes hills, plateau, plain, desert with a variable and extreme climatic conditions, and population distribution. It is bounded by Pakistan in the west and international border with Pakistan runs for about 1,070 kilometres. Its adjoining states also present a wide range of disparity in their level of development. Therefore, Rajasthan present a typical case of Indian urbanization system, where extreme socio economic characteristics exist and planned development has now visible to completed is more than sixty years under peaceful democratic set up. As Rajasthan is a largest state of India, accounting for 10.41 percent of geographical area. In the state of proportion of urban population (23.39%) is below the national average (27.78%). The adjoining state like Gujarat (37.4%), Punjab (34%), Haryana (29%). And Madhya Pradesh (27%) are more urbanized than Rajasthan.

Database and Methodology

The study is based on secondary source of data and source of data is Census of India 1991, 2001 and 2011.

To analyse the patterns and levels of urbanization, simple statistical methods has been used with the help of bars and graphs by arranging them with their rank of both the time period of 2001 and 2011 respectively. The rank size and expected population of the town or city is calculated by using the simple formula of Zipf's

Estimated population of rank city (Pn) = $\sum$ Pi ÷ $\sum$ (1/r)
Estimated population of first rank city (P1) = $\sum$ Pi ÷ $\sum$ (1/r)

where,

Pn= estimated population of X^{th} urban centre
Pi= the population of the largest city or urban centre
n= rank of urban centre

Then as stated by the rank-size rule, the estimated first rank city's population is divided by the rank for each city, which gives the estimated population for each city. This estimated population is the population estimated on the basis of rank-size rule. Now a log graph is plotted for the both actual population and estimate population of each city of two time period with a decadal a variation.

Analysis

History of Urbanization in Rajasthan

Ancient Period: The history of Rajasthan is as old as the Harappan Civilization and dates back to 1000 BC. Some excavated sites bring forth the records of this period. Several ruins and relics found in the region suggest that it was inhabited by Pre-Aryan race. This part of Indian sub continent was also influenced by the Jains and Buddhists and the faiths were spread at large here. In the bygone era Rajasthan has been ruled by different rulers at different periods of time. Some great dynasties that left behind their impressions here include the dynasties of Magadha, Kushana, Maurya (321-184BC) and Gupta (400 AD). From 6th century onwards Rajputs established their supreme power over this area and under them the region attained its present glory. Rajput rulers established several kingdoms throughout and the area came to be known as Rajputana or the state of Rajputs.

Medieval Period: Under the Muslim rule in 12th century, some part of Rajasthan came under the Muslim rulers but some who the Rajputs were able to resist their supremacy over Mughals. During 13th century, there were some of the powerful regions of Rajasthan were Nagaur, Ajmer and Mewar region.

Modern Period: During the 16th century under the Akbar supremacy, every province of Rajasthan was unified. But in the 18th century, with the decline of Mughal power, the political breakdown of Rajasthan started and some part of Rajasthan came

under the control of Marathas. In the mid-18th century, they occupied Ajmer. During early 19th century (1817-1818) independent Rajput kingdoms signed treaties with British Power to eliminate the Maratha threat. Hence, the rule of British over Rajasthan got established.

Post-Independence: Prior to independence Rajasthan comprised of 19 princely states, two small villages ruled which was chiefs of Lava and Kushalgarh and a British administrative territory i-e. Ajmer Merwar. All were ruled by different administrative ruling systems and were disintegrated. After independence, the state has undergone a long process of integration and exists as a state of Indian Union from the remarking year 1956. Under British control the region was popular as Rajputana (land of Rajputs). Then after 1956, it came to be known as Rajasthan. At present, there are 33 district, 105 sub-division and 241 tehsils.

Present Structure of Urban System in Rajasthan

Trend in Urbanisation

The percentage of urban population in 1901 census was 15.06 per cent with 150656, which has increased in 100 years to 23.39 per cent with urban population of 13214375 in the census of 2001. In the census of 2011, the share of urban population has reached to 17048085 with 24.87 per cent. It took more than six decades to double the urban population from 15. 06 lakh in 1901 to 32.81 lakh in 1961. The pace of urbanization in the state is not fast as it took more than six decades from 1901 to 1961 to double the urban population but it is steadily increasing. State has a long way to go to match the level of urbanization of national level. The total addition to urban population was 91 million during 2001-2011- the highest ever and for the first time urban population increment was higher than rural increment (90.5 million) since a uniform definition was followed since 1961.

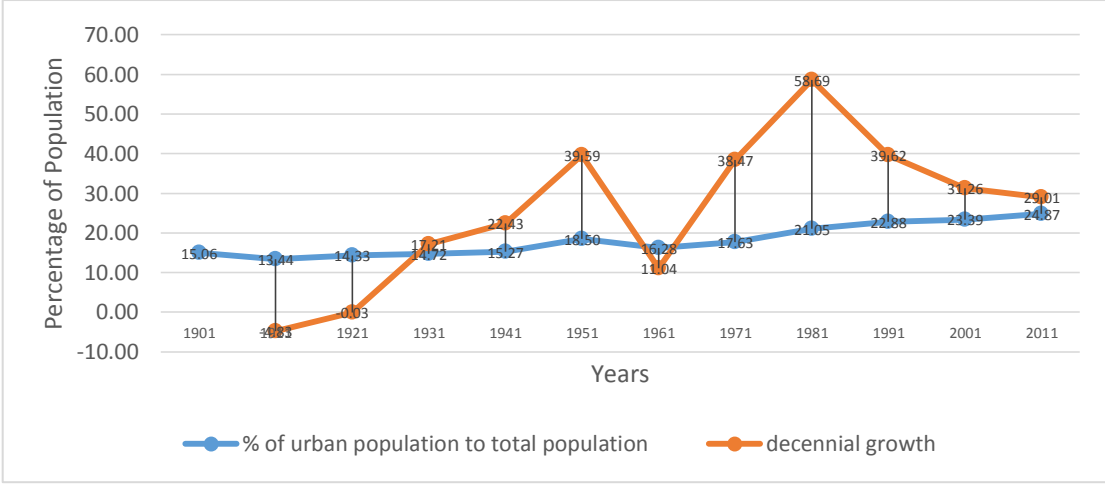

Fig. 1. Trends of Urbanization and Decennial Growth of Population in Rajasthan
Source: Constructed by Author

Pattern of Urbanization

The pattern of urbanization in Rajasthan is characterized by concentration of urban population in class towns and cities. The proportion of population in class I have increased from 10.33 percent in 1901 to 56.32 percent in 2001. For the first time in the census history of the state of the Jaipur was earned the distinction of being classified as a metropolitan city (1.45 million) in 1991census. However, in 1991the population of the city constituted 14.49 percent of the total urban population, whereas in 2001 the proportion was 17.58 percent. There were only two class I B cities with 500,000 to 999,999 population, namely Jodhpur (666279) and Kota (537371) in 1991 which combined from 11.95 percent to the total urban population in the state. In 2001 the numbers increased to three with the addition of Bikaner (529690) and thus accounted 15.78 percent to the total urban population of the state. On class IC cities with 100,00 to 499,999 population, it was seen that there were 11 such cities in 1991 census which increased to 15 in 2001, accounting for 23.10 percent and 22.79 percent respectively to the total urban population of the state. The proportion of class II towns of population of Size 50,000 to 99,999 decreased from 15.74 percent in 1921. Thereafter, the proportion fluctuated till 1991 and the 2001 census saw an increase in proportion of 14.67 percent over the 1991 proportion of 13.64 percent. However, there was a reverse trend in the class V and class VI towns where the proportion of the population to urban population fell rapidly from 27.77 percent in 1901 to 1.18 percent in 2001 and 8.07 percent to 0.15 percent in class VI towns. It may be observed that the number of towns has fluctuated decade to decade because of variation of definition and concept of urban areas in different census. Considering the distributions of towns by size classes, one would notice a continuous increasing trend in the number of towns in class I group while in other categories there is mixed trend. The number of class mixed I towns increased from one in nineteen in 2001.

Table 1. Rajasthan: Growth in the Number of Cities and Towns and Percentage of Population in Each Class to Total Urban Population: 1901-2001.

Census Year	I	II	III	IV	V	VI
1901	1	4	8	26	54	32
1911	1	3	9	24	60	41
1921	2	2	7	20	58	58
1931	2	2	9	26	64	47
1941	4	2	13	82	74	36
1951	4	4	20	36	96	67
1961	6	4	23	52	51	9
1971	7	7	31	67	41	4
1981	11	10	55	101	23	1
1991	14	20	74	87	55	2
2001	19	27	90	61	20	5
2011						

Source: Census in India 2001

Class I 1 lakh or more population	Class IV 10,000-19,999 population
Class II 50,000–99,999 population	Class V 5,000-9,999 population
Class III 20,000 - 49,999 population	Class VI Less than 5,000 population

Therefore, it can safety be concluded that there has been a rapid increase in the population of class I cities particularity after 1971 census. The important contributing factor in this phenomenon is the tendency of smaller towns to move in to the higher class owing in the sharp rise in the growth of population up to class III and rapid decrease in class IV, V, VI. The migration of rural people to the urban area is a result of industrial development and employment opportunities in towns, especially after the independence.

Urbanisation Pattern in Rajasthan: Comparative Analysis of 2001 and 2011

The spatial distribution of urbanization in Rajasthan shows disparity on district level. The concern on urbanization is not just of the space but mainly the disparity in the distribution of urbanization in Rajasthan. The spatial distribution of urbanization depends upon the social, economic and cultural setting of the region. Disparity of the urbanization setting is very high. The concern is not just the slow pace of urbanization but the patterns of urbanization also shows disparity in the distribution.

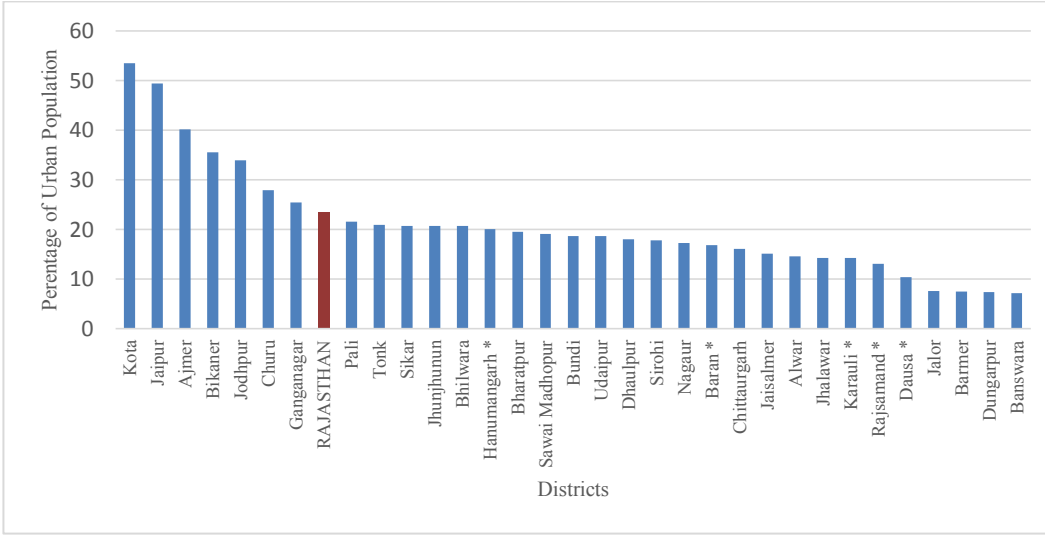

Fig. 2. District wise Percentage of Urban Population in Rajasthan, 2001
Source: Data Source – Census of India, 2001

Districts like Kota, Jaipur, Ajmer falls in the category of very high percentage of urban population. The emergence of urbanization in these districts are different. Kota has emerged as the urban center because of the employment provided by the education system and coaching institutes, various industrial set up. Jaipur was always an important nodal point of trade and communication from the Mughal period, it emerged as the capital city and major trade city with the status of heritage city.

Ajmer has a status of heritage and cultural tourism, which helped it to develop in urban growth. Districts like Jodhpur, Bikaner, Churu and Ganganagar falls in the category of high urbanized districts as these are the emerging cities with better infrastructure in agricultural set-up due to Indira Gandhi canal. Districts like Sikar, Jhunjhunu, Pali, Tonk, Bhilwara, Nagaur, Baran, Dhaulpur, Sirohi, Bundi, Sawaimadhopur, Udaipur, Hanumangarh, Bharatpur, Chittaurgarh, Alwar and Jhalawar are the the districts with moderate urbanization. These districts are upcoming urban centres with their different functions.

Sikar is emerging as center for educational institutes. Pali, Bhilwara and Dhaulpur are industrial urban centers. Udaipur and Chittaurgarh are heritage and tourist cities. Districts like Rajsamand, Karauli, Jaisalmer and Dausa have low level of urbanization centers with high potential of development but still the level of urbanization is low. Pratapgarh, Jalore, Banswara, Barmer and Dungarpur are the districts with lowest level of urbanization in Rajasthan due to their cultural and relative locational set up.

The disparity of urbanisational distribution is very clearly visible and shows the unequal distribution of development and infrastructure.

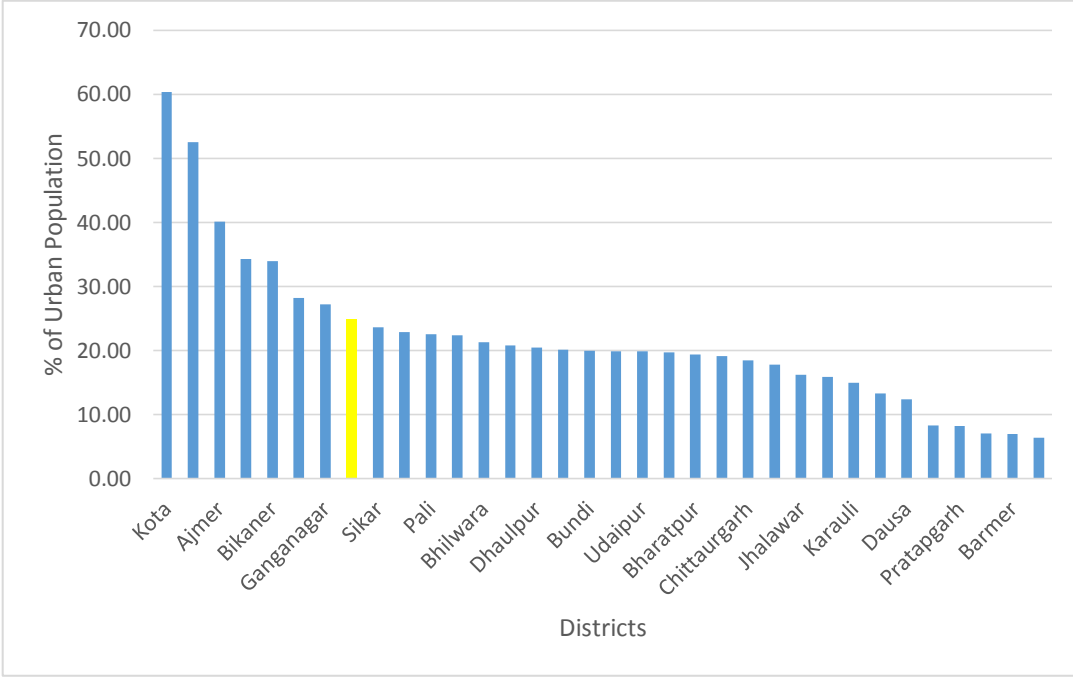

Fig. 3. District wise Percentage of Urban Population in Rajasthan, 2011
Source: Data Source – Census of India, 2011

Comparative Analysis of Rank Size Distribution in Rajasthan2001 1nd 2011.

The concept of rank size rule is given by Zipf and the law of primate city was initiated by Jefferson. They allow us to understand the concept of distribution of cities and their hierarch in urban system. The ideal situation of rank size distribution of cities in an urban system indicates economic activities are more developed and integrated urban system, whereas, the concept of primate city distribution indicates underdevelopment and imbalances situations in the distribution of urban areas.

Fig. 4. Actual and Expected Population of Rajasthan - 2001
Source: Census of India, 2001

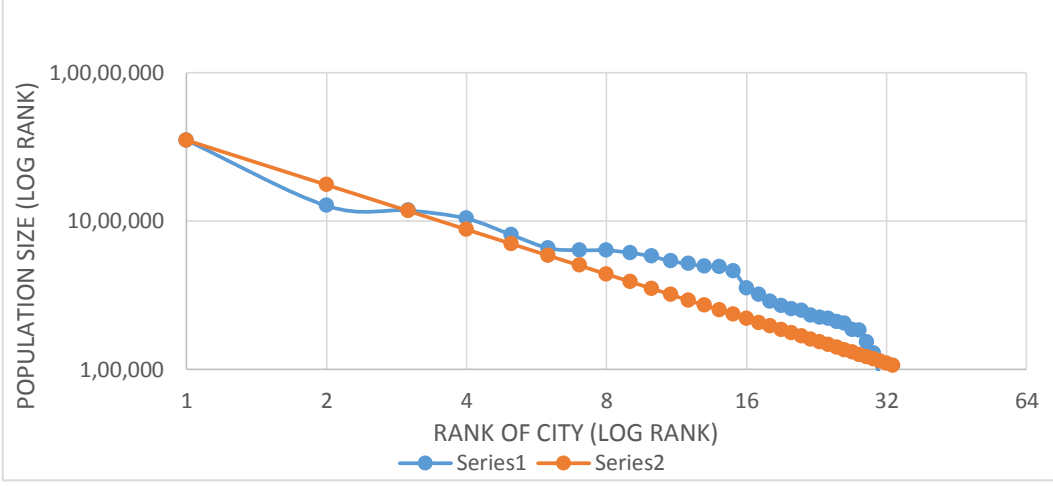

Fig. 5. Actual and Expected Population of Rajasthan - 2011
Source: Census of India, 2011

From the above two graphs for rank size of 2001 and 2011, it is very clearly visible that the capital city is primacy city and the other districts do not follow the rank size rule. There is some change in population structure hierarchy from 2001 to 2011 for small districts but the major and large districts population hierarchy is similar in 2001 and 2011. From the above graph, it is clearly visible that Jaipur has very high primacy and it is a primate city. Jaipur is a capital city, its area of influence is very high and it is surrounded by the areas of low categories of the primacy index. Jodhpur is the second largest urban district after Jaipur and it was the former capital of Marwar. Jodhpur has comparatively low urban population to the expected urban population. Kota, Ajmer, Bikaner and Alwar are the districts that follows the rank size rule, although their actual population is more than the expected urban population but the deviation is not very high. The remaining districts has high actual urban population than their expected urban population. The above graph shows that Jaipur is the primate city and the major districts with high urban centers follow the rank size but the remaining districts do not follow the rank size rule as they positively deviate from the expected urban population.

Conclusions

The distribution of cities in Rajasthan urban system clearly visualize that Million cities have grown at a higher rate than the small cities. The rank size distribution indicates the forces of unification and diversification have balanced each other in ideal situation, has never been true in Rajasthan urban system. It also indicates that the big cities are growing at a much faster rate as comparison to the small cities. It disallows the small cities to follow a log linear relationship with the large cities of Rajasthan urban system. The rank size rule is also explains the size distribution of settlements in relation to economic activities. The disequilibrium between the growth of small and big cities as explained by rank size graphs and slope values indicates dominance of large cities. So, after analysis data of Rajasthan. The increase in urban population in Rajasthan from 1901 to 2011 is more than eleven times. The level of urbanization in Rajasthan shows increasing trends but it is still very low in comparison to India. The level of urbanization is lower in Rajasthan than the other states. Even within the state the trends and patterns of urbanization have huge disparity. But in recent decades, data has shown that the rate of urbanization is increasing and Rajasthan has performed like an inspirational state as it was in BIMARU states and now it is showing positive growth in economic drivers. The rank rule in Rajasthan on district level is not applicable on all districts as Jaipur is a primate city and only highly urbanized districts follow the rank size rule like Jodhpur, Kota, Ajmer and Bikaner but after with districts with urbanization level there is a positive deviation from rank size rule. Thus, Rajasthan follows rank size rule only with high urbanised districts and after that the districts positively deviate from the rank size rule. So it's very much clear that if two or three medium size town can grow and developed parallel with time that should give better prospects of growth in economic activities and it's reduced the dependency on a primate / particular cities.

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CHANGING THE TREND OF FUNCTIONAL CLASSIFICATION IN JAIPUR REGION, RAJASTHAN

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Abstract

In the present study the changing pattern of occupational structure and economic activity is analysed in this study that is an essential to observe the economic development. A significant consequential relationship between the establishment of Industrial andService activities and the Employment trend is also analyzed here. In modern times there are different ways to classify towns. Classification can be based on geographical location, stage and the size o population. But in many ways the most meaningful basis of classification is that of function determined principally by occupational structure. A Ternary diagram was, however found the most suitable device for classification of large number of Indian towns in 1961 census. In the present area, Ternary diagram is use ie. Primary, secondary and tertiary activities under which particularly cultivators, agricultural laborers, workers involved in household industries and others area examined. Along "A" apex shows primary activity "B" apex of triangle shows secondary and 'C' apex of triangle shows tertiary activity. The percentage of activities are then plotted on a ternary diagram, along with categories on sub triangle and this position in the triangle was taken as the main determinant of this functional classification. Functional classification of six tehsils of Jaipur district is done on the basis of dominance of economic activity preventing in each tehsils. Future depending on the categorized of workers involved in each economic activity, six sub divisions ie. I, II, III,IV, V,VI are categorised.

Keywords: Occupational structure, Ternary diagram, Functional classification

Introduction

In recent period the economic development has been major concern in the economic process. With the rapid development, the economic activities structure is also changing. Eerier it was primary activity, which was dominantly activity, but over the years it has been found that other activities are growing and developing in the regions thus reducing the work participation of primary workers and primary activities. The high degree of specialization and high levels of labour wages of other sector are the driving force behind this change, on the basis of Census 1971, it is found that the study area had out of total workers population 57% and7% agriculture labour and cultivators respectively. But in year 2011 the work participation of workers involved in agricultural and cultivators has reduced to - and - respectively with increased participation of 36 % in others.

The present paper aims to examine and analysis the push and pull factors that have led to the changes in the functional classification in Jaipur region from 1971 till 2011 over the forty years slavery.

Study Area

Jaipur region is located on 26° 30' to 27° 20' north latitude and 75° 30' to 76° 15' east longitude. The study area has spreading in 4500 sq.km. It includes total 725 revenue villages and 15 growth centers which are under the Jaipur Development Authority. The region is drained by number of seasonal river, of which is Banganga, Dhund and Bandi are prominent. The Jaipur is located in the semi-Arid Zone of India. It has characterized by high temperature, low rainfall and mild winter. Maximum literacy of 80% is concentrated in central and south west of the region due to more educational institutions in the capital city.

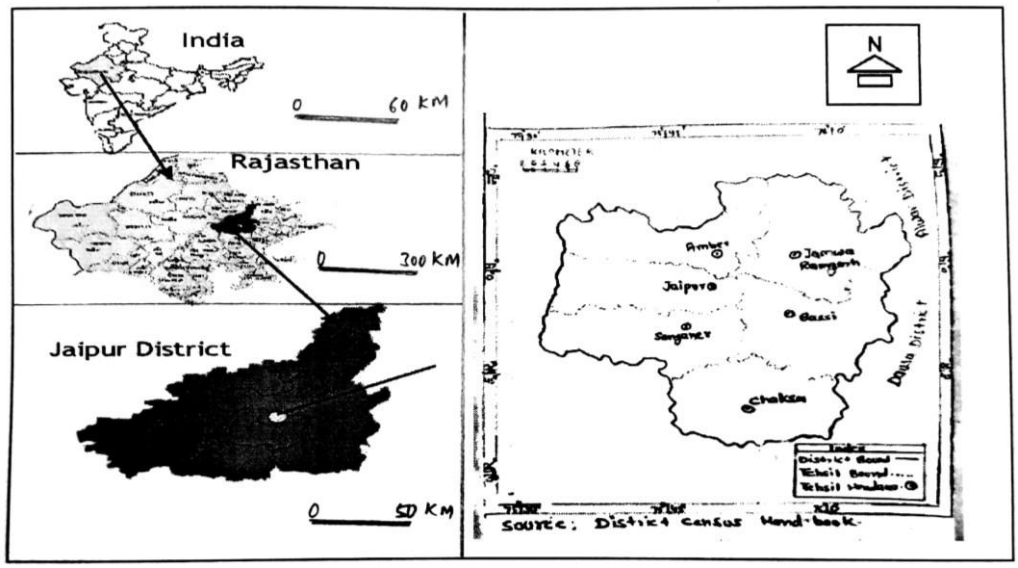


Fig. 1. Location of Study Area

Database and Methodology

An attempt is made to examine the changes that have occurred in occupational characteristics during the 40 years (1971- 2011). Primary and secondary sources of data are collected for the purpose by the researcher with the help of schedule survey villages. Simple random sampling technique is employed in the selection of the villages of six tehsils of Jaipur district. For the present study data of four major categories of occupational structure have been analyzed. The data of secondary sources are obtained from- district census year's handbooks and district gazetteers. Statistical tools like percentage, average, charts and tables used in the study.

Occupational Structure

Occupational structure is a type of Index that has ratio of workers, which are practiced in different economic activities of a particular area. This changing structure of human activities in villages is increasing wasteland in a region as villagers are now engaged in non agricultural activities, without paying any attention for reclamation of this productive land. Working population is classified as main and marginal workers on the basis for the calculation of occupational structure. In census 2001, the working population was classified into four categories- Cultivators, Agricultural Laborer, Households Industry and Other workers.

Cultivators : A person who has been engaged and supervised as an employer in cultivation of land that may be owned or held from any private or government or institutions for payment in cash or share in cultivation like food grain, fodder and other crops raw material. In 1971, the 57.2 percent population was engaged in cultivation that was further decreased by 18.82 percent in2011.More than 50 percent of cultivators out of the total workers. Bassi, Chaksu and Jamwa Ramgarh tehsils are the areas where main occupation is cultivation and prepare engaged in agriculture activity. Figure 2 shows tehsil wise occupational structure of 1971and 2011. Major categories are cultivators, agricultural, household industrial workers and others. Amber tehsil is an area of fertile land with moderate irrigation facilities and therefore 40.50% of cultivators are found. Out of total cultivators maximum cultivators are found at Amber tehsil which comprise of 40.50% of the total cultivators of the Jaipur District. This is owing to the fertile land moderate irrigation facilities found at this region. Simultaneously, Jaipur and Sanganer tehsil has only 3.75 % and 11.43 % respectively working population under this category. The reason is that these tehsils are prone to repeal urbanization and infrastructure development from 1971 to 2011.

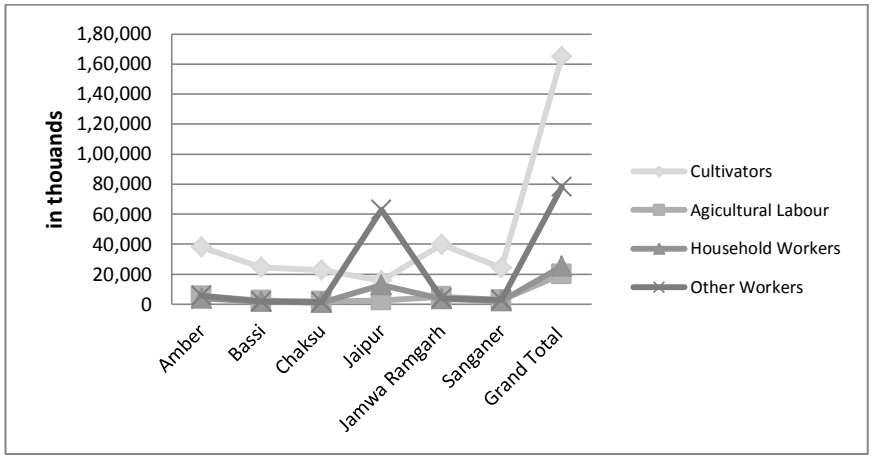


Fig. 1. Occupational Structure of Jaipur Region - 1971

Source: Varied Census Handbook of Jaipur District

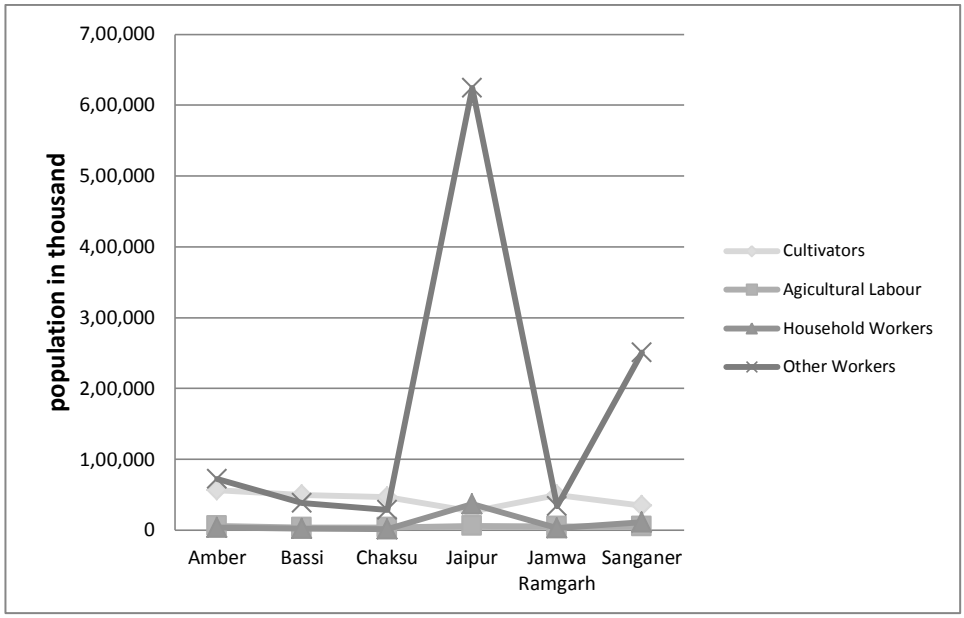


Fig. 2. Occupational Structure of Jaipur region - 2011

Source: Varied Census Handbook of Jaipur District

Agriculture Labourer: A person who works on another person's land for wages in cash or share in agriculture profit is considered as an agricultural laborer. Out of total working population the agricultural labourer consists of only 2.15% share in year 2011. This show a decline in its share over the preceeding years as it was 2.86% in year 2001.The maximum percentage of agricultural labour is in south- east part of the region particularly in Jamwa Ramgarh, Chaksu and Bassi tehsils. In northern area, Amber tehsil has only 4.34% agriculture labour out of total working population. Jaipur and its nearby tehsils have less number of agriculture labours due to less net sown area. The total percentage share of agriculture labour shows functions in the trends over the decadal year. In year 1981it was 2.80% which further increased to 3.98% in year 1991 and later decreased to 2.86% in 2001. Agriculture labour percent was increased in 1991 by 3.98 than 2.80 percent in 1981 due to cultivators transformed their job into labour.

Household Industry: it is an activity in which head of the household at home or within the village is engaged in house industrial activity. This type of workers are engaged in the production, processing, servicing, repairing and selling of Goods by making at house hold level. Only 4.19 percent population engaged in house industry in 2011. The work participation of household industry was more in year 1971 that accounts for 9% of the total occupational structure of the district. But, this further decreased to 4.96%, 3.35% and 4.85% and 4.19% in year 1981, 1991, 2000 and 2001 respectively.

The maximum percentage of this category is in central and southern part of the area particularly in Jaipur, Sanganar tehsils. In Jaipur tehsil many are doing their work such as Jewellery, Embroidery while in Sanganar tehsil, people are doing paper making, cloth printing jobs in their houses. In other tehsils, the percentage of household industry worker ranges between 2.0 to 3.63 percent (Figure 2).

Other workers: This category covers all such workers those who do not come under any of the categories that are mentioned in the above classification of workers and also those whose activities have not been detailed. In the study area the maximum percentage out of the total workers comes in this category with almost 75 percent. This fourth type of workers percentage was continuously increased i.e. 27.2, 56.16, 62.41, 66.54 and 74.82 percent from 1971 to 2011. Jaipur region has the maximum number of the other workers especially in Jaipur, Sanganar and Amber tehsil. In Jaipur tehsil many Central, State, Semi government offices and NGO'S are situated. In Sanganar tehsil most of the working population is engaged in Business, Transport, Trade and Industries. It is a hinterland of capital city Jaipur. The moderate percentage of other workers in Bassi, Jamwa Ramgarh is 40.92%, 36.99% and 35.43% of the total working population. These are the areas of with lesser Industrial development than others.

Streams of Migration

Migration has played as a prominent factor functional structure and has witnessed large share in economic activities. The migrants living in the peri-urban areas have migrated to Jaipur city rural areas. Some have migrated from rural to rural area while others have migrated from rural to urban and so and so forth. It is evident from the data that the migrant's contribution ratio of the state increasing with the decades. In 1971-80 16.4% of the total migrants settled in urban areas, which further increased to 22.4% in 1981-90 and went up to 25.4% in the duration of 1991-2000. Rate of urbanisation of Jaipur district is great due to increasing rural migrants and shifting in urban areas. 74% migration contributed to urban population. In Jaipur, the percentage share of migrant's setting in urban areas to the total migrant's is comparatively very high. The pull factors are better education, employment opportunities, infrastructure facilities and other are found in the district.

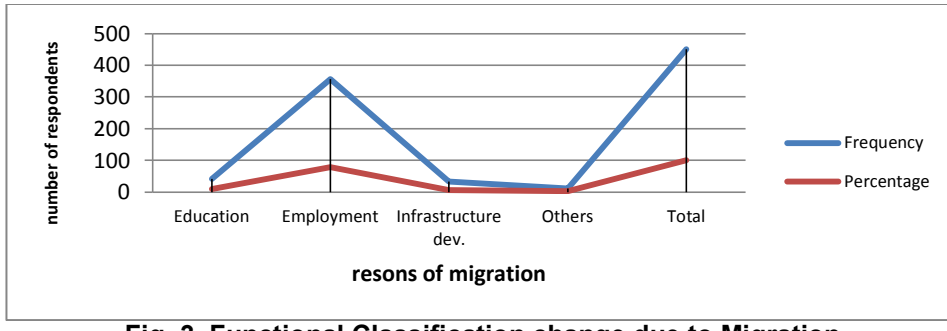


Fig. 3. Functional Classification change due to Migration

Physical Circumstances Reasoned for Non-Farming

Human beings are dependent on nature and environmental resources for their primary survivals. Agriculture land not only provide base to the occupational structure and human based industries but also linked to biodiversity, social well being and complex issued of the economy of country. It has impact and challenges for the economy of clearly. Therefore agriculture land conversions in Jaipur region also have impacts on economic growth, employment creation and society development. It is also responsible for the loss of natural biodiversity and the quality of ground water. Conversion pattern presented in its accidental or with planning, extension, nature and possible trends of development for future that may be required to promote sustainable use of agriculture land in the study area. The pattern of sustainable land use according to landscape and ecological principles are encouraging in land use conversion decisions.

Table 1. Physical Conditions Effecting Farming According to Respondents

Reasons	No. of Respondents	Percentage (%)
Rain	216	48
Climate Change	45	3
Soil Fertility	54	12
Ground Water	165	37
total	450	100

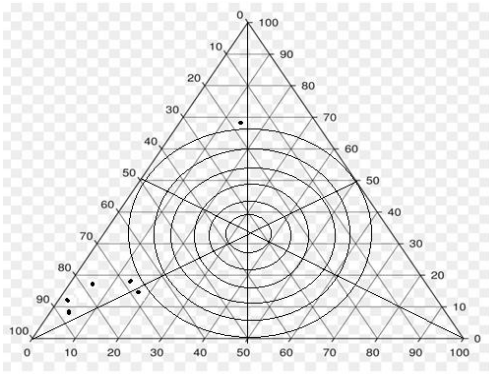
Source: Compiled by the Author

Conclusion of respondents have cleared that agriculture activities are not enough for farmers lives requirements. According to primary survey of villages result come at the front that last fifteen years. The salary is net increased sufficiently comparison than values of the things in the market. Today land prices becoming very high due to unavailability land for residential and commercial purpose so the farmers taking interest in the price feature. Another recent reason is government policies for development increasing land value.

Physical: - (i) soil fertility: - physical expansion of the study area covered semi-arid agricultural region that has average rainfall and temperature. The unawareness of the new generation of farmers has the soil fertility crossing the land of cultivation. (ii) Rainfall and ground water: - agro- economy mostly depends on monsoon that is uncertain by time and quality ground water table directly connected with the conservation and rainfall. From the both dimensions great metropolitan area of Jaipur performance is poor urban population complete their demanding with water tanks and other supplies but the rural population mostly, farmer depends on tube wells which are not responding.

Seasonal crops disease besides of economic and physical reasons. Crops disease also responsible for change of farmers views of calibration for example: Wheat (tunddu), Bajra(green ear) and groundnut (tikka) etc. are suffering these unfavorable challenges government political issues or land conversion act.

It is clear that most of these developments of industry and service sector are promising to generate limits wonders of permanent job with only about one quarter creating pressure on urban economic conditions and then proposed the master development plans being relatively insignificant.



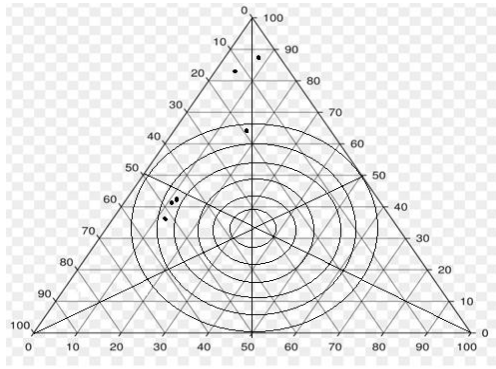


Fig. 4. Functional Classification of Jaipur Region - 1971
Fig. 5. Functional Classification of Jaipur Region - 2011

The Functional Interpretation of Towns

Urban centers being the focus of human population perform certain essential functions. The functional classification of towns is significant aspect of study as it provides a good basis for regional planning. In the present study, an attempt has been made to select an appropriate statistical method for the functional classification of towns of this region. The 2011 census data is extremely inadequate for purpose of functional of urban centers as vital heads have been grouped together. Therefore, 1991 census data has been used in which the data of nine activity groups of workers has been given. All the categories have been in the percent classification is used for the comparative analysis of these towns of 1971 and 2011.

Following this method the towns have been classified as follows.

1. Agricultural towns: Bassi, Chaksu, Jamwa Ramgarh.
2. Construction towns: Jaipur, Sanganer.
3. Trade and commerce towns: Jaipur, Sanganer, Amber.
4. Transport and communication town: Sanagner.
5. Other services town: Jaipur.

The analyses of functional classification of towns in the preceding pages reveals that through the region commands rich agricultural tract, agricultural not been developed on modern lines and therefore, several towns still continuous as agricultural towns and Urbanization is increasing in the region, therefore, construction of building has increased in the region.

Conclusion

Change of functional classification has answered about the rapid urbanization that cultivator and agriculture labour have adopted new source of income. Maximum number of workers are in tertiary group because of primary activities are based on physical conditions. It is examined that Bassi, Chaksu and Jamwa Ramgarh tehsils have low house hold workers, moderate other workers and high predominant workers though Jaipur, Sanganer and amber tehsil has low household workers, moderate predominant workers and high other workers due to rapid Industrialization. The functional classification represents the regional disparities due to urban development. There is a linkage between urbanization and functional classification it is observed that those towns have came in urban class I they changed working structure for good standard of life as like to urban people.

Due to rapid urbanization and unfavorable physical conditions, people going to abundant their primary work for good standard of life. There is observed a great danger for agriculture sector for continue reducing percent of workers. Jaipur tehsil has maximum pressure of land due to people migrants here for different purpose. It is observed that Sanganer is also on the way that is pressurized by the rapid industrialization and urbanization. Farmers near the urban area utilize their land for construction purposes because they want to earn stable income as farming is nothing but gamble cultivable waste land is used for the ware houses in the village. Therefore the cultivators have joined to another economic activity due to land is acquired for income to small scale industries and favourable hydro conditions. It is observed that the number of cultivators and agricultural laborers' has rapidly decreased during four decades by 18.82 and 2.15 percent respectively.

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ASSESSMENT OF RAINFALL VARIABILITY IN DIFFERENT TALUKS OF ARKAVATHY WATERSHED USING GEOGRAPHIC INFORMATION SYSTEM, KARNATAKA, INDIA

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Abstract

There are many elements that make up both the weather and the climate of a geographical location. Out of the various climatic elements, Rainfall is in the first index. It is the most important single factor which determines the cropping patterns of an area, the type of crop to be cultivated and its success and failure in particular. As a result, careful observation and analysis of meteorological data is very essential. Therefore, the present study deals with the rainfall characteristics of Arkavathy Watershed of Karnataka which include the spatial distribution, rainfall, pattern and variability through different seasons. The present study is based on 30 years of monthly rainfall data. Therefore, a throughout study of long-term record is made to evaluate the relations between amount and duration of rainfall that strikes the surface. Daily Rainfall Data for the years (1988-2018) has been collected for Bangalore North, Devanahalli, Doddaballapur, Nelamangala and Madadi taluk from the Rain Gauge Stations of the Indian Meteorological Department and Directorate of Economics and Statistics; Govt. of Karnataka Govt. of India

***Keywords**:* Rainfall Variability, Watershed, Seasonal and Annual Rainfall

Introduction

The study of rainfall pattern helps drought and flood risk assessment, relief and rehabilitation during extreme events and also local level contingency planning. The distribution pattern of rainfall in the state of Karnataka is most uneven and varies considerably from year to year and from region to region. Rainfall is the only input source of the hydrological system in the Arkavathy Watershed. The situation of the Arkavathy basin, especially the upper Arkavathy or Thippagondana Halli reservoir provides rich insights into the complex problem of water management in urbanising basins (Ashoka Trust for Research in Ecology and the Environment (ATREE)), Bengaluru. Furthermost, the rainfall in the Arkavathy watershed is also still vague and uncertain according to the available data sources. Therefore, a throughout study of long-term record is essential to evaluate the relations between the amount and duration of rainfall that strikes the surface. The main objective of this study is to assess the rainfall distribution (seasonal and annual), pattern and variabilities of the study area.

Study Area

The Arkawathy is a tributary which flows through Bangalore Urban, Bangalore Rural and Ramanagara district in general direction from North to South. The Arkawathy watershed lies between latitudes 12 55' 44.50'N and 13 22' 47.346'N and longitudes 77 19' 26.11''E and 77 41' 16.047''E. The study covers the entire area of the watershed. The study area also covers parts ofDoddaballapur, Devenahalli, Nelmangala, Magdi and Bangalore North.

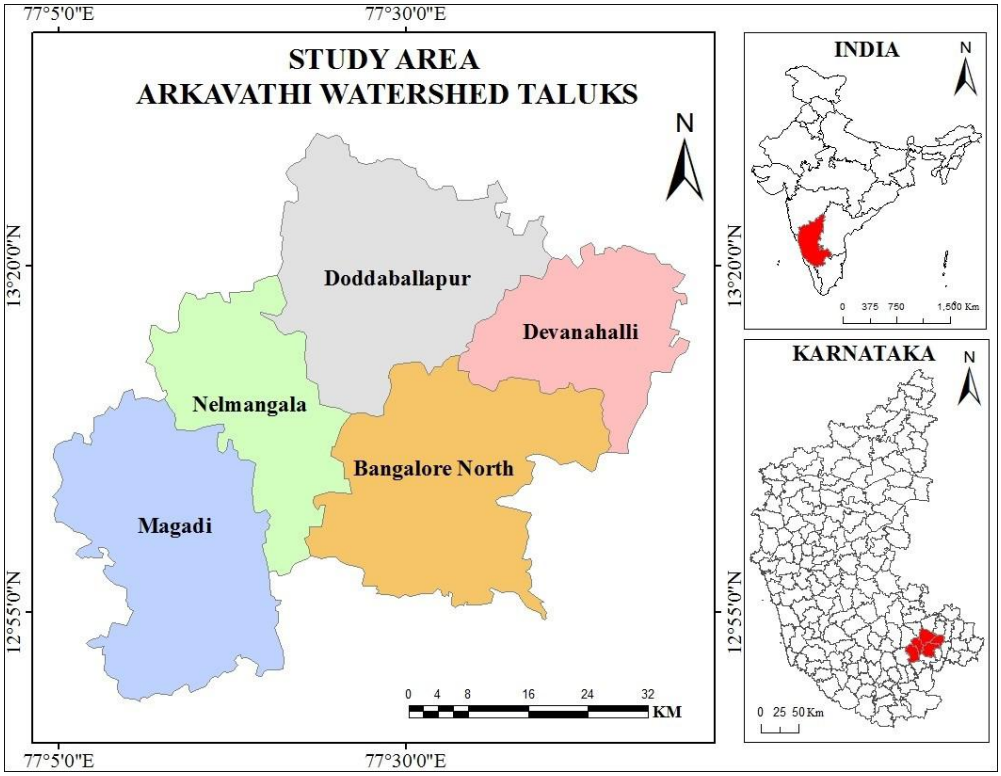

Fig. 1. Location of the Study Area

Methodology

The rainfall variation analysis has been carried out based on the rainfall data from last 30 years (1988-2018). Daily rainfall data for the years (1988-2018) has been collected from the Rain Gauge Stations of the Indian Meteorological Department and Directorate of Economics and Statistics; Govt. of Karnataka Govt. of India. The base map of different taluks of Arkavathy Watershed has been prepared based on top sheets No. 57 G/7, 57 G/8, 57 6/11 of the Survey of India. The statistical analysis including correlation, standard deviation and their interpretation have been carried out. The collected rainfall data has been mapped using Arc GIS 10.3 and Interpolation IDW software.

Results and Discussion

Seasonal distribution of rainfall in the Arkavathy Watershed receives 18.16 per cent of the total rainfall during the Pre-Monsoon Season, 55.82 per cent in the Monsoon Season and 26.02 per cent of rainfall in the Post-Monsoon Season. It can be seen that maximum amount of rainfall in the watershed seems to happen during the month of June- September.

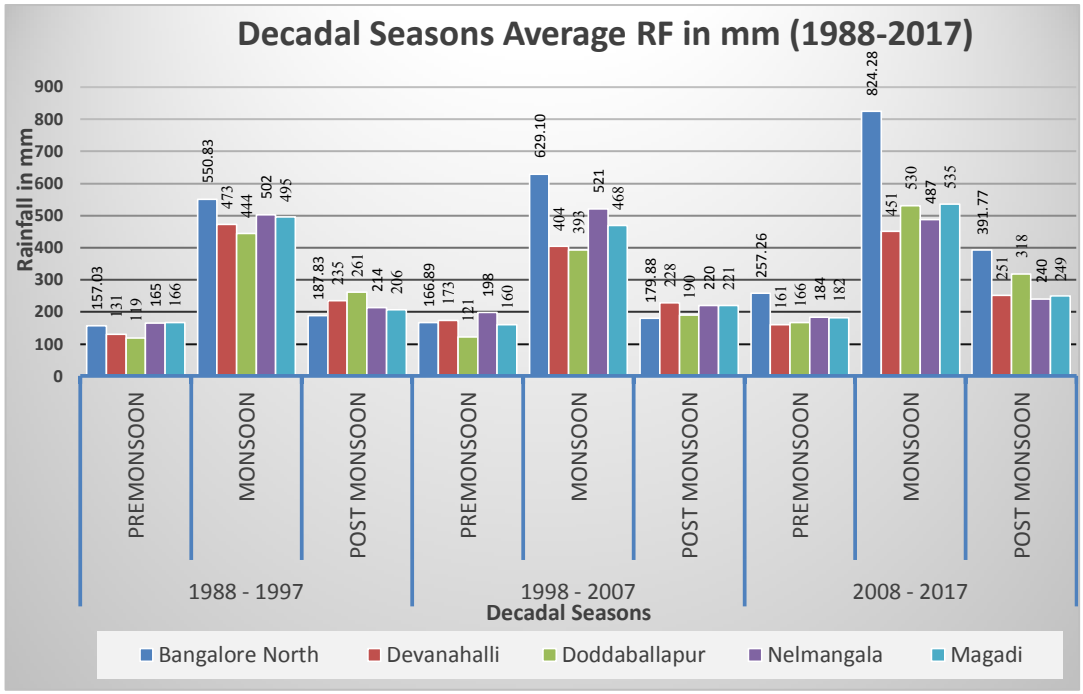

Fig. 2. Decadal Average Rainfall (1988 - 2017)

Source: Indian Meteorological Department and Directorate of Economics and Statistics from the year 1988 to 2017.

Seasonal co-efficient of variation has been calculated and computed values indicated that it is more varying during the post-monsoon seasons compared to other seasons. During the other seasons, coefficient variation ranges from 20 to 100 percent. In the pre-monsoon the co-efficient variation ranges from 40 to 70 percent, whereas in monsoon variation ranges from 30 to 50 percent. However, there were no much variation can be seen in the post monsoon period and the variation can be seen from 40 to 100 percent.

Annual Rainfall Trends by Taluks

Data on annual rainfall trend have been plotted on Figure 3 to 7 and the results shows that except Nelamangala all other taluks have shown increasing trends of rainfall. But from the data collected from Indian Meteorological Department it can be seen that in the Bangalore North taluk (Figure 3) trends of rainfall is increasing gradually and in the year

from 2014-2016 it received the highest rainfall in the three decades whereas in the Devenahalli taluk (Figure 4) the trend of rainfall is seen to be fluctuating. In Doddaballapur and Magadi Taluk (Figure 5 and 6) the trend of rainfall is seen to be decreasing in the mid decades but again started increasing gradually whereas in Nelamangala (Figure 6) it is seen to have an increasing rainfall trend.

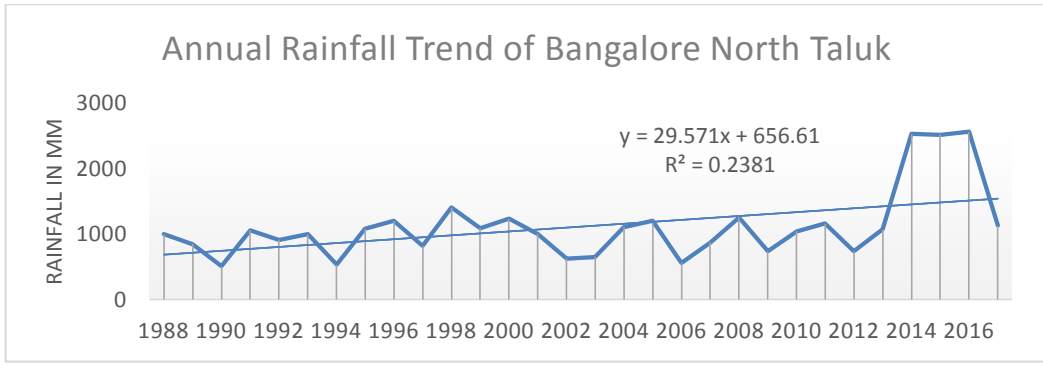

Fig. 3. Annual Rainfall Trend of Bangalore North Taluk

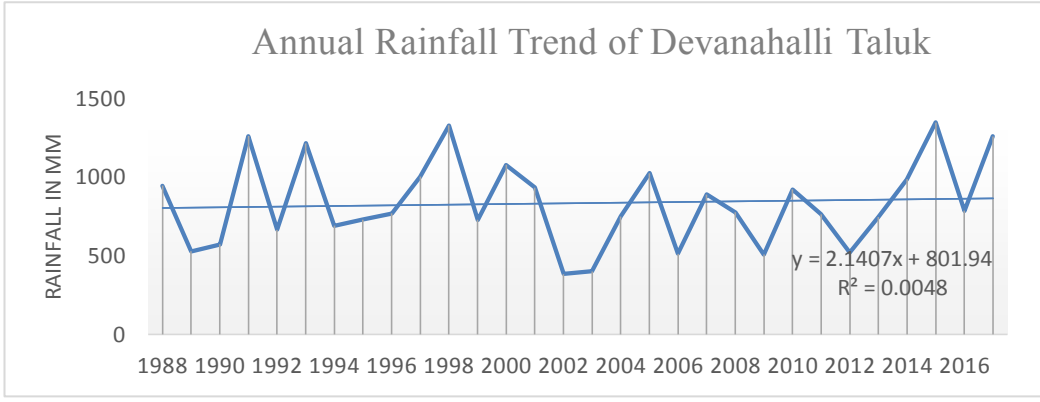

Fig. 4. Annual Rainfall Trend of Devanahalli Taluk

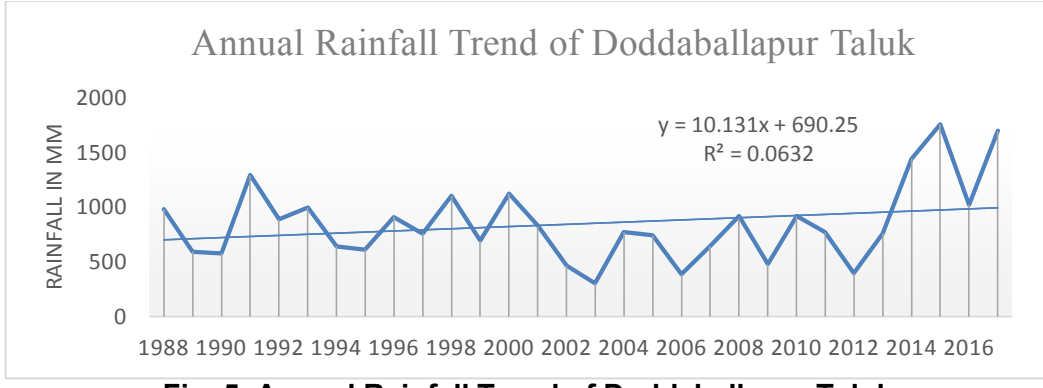

Fig. 5. Annual Rainfall Trend of Doddaballapur Taluk

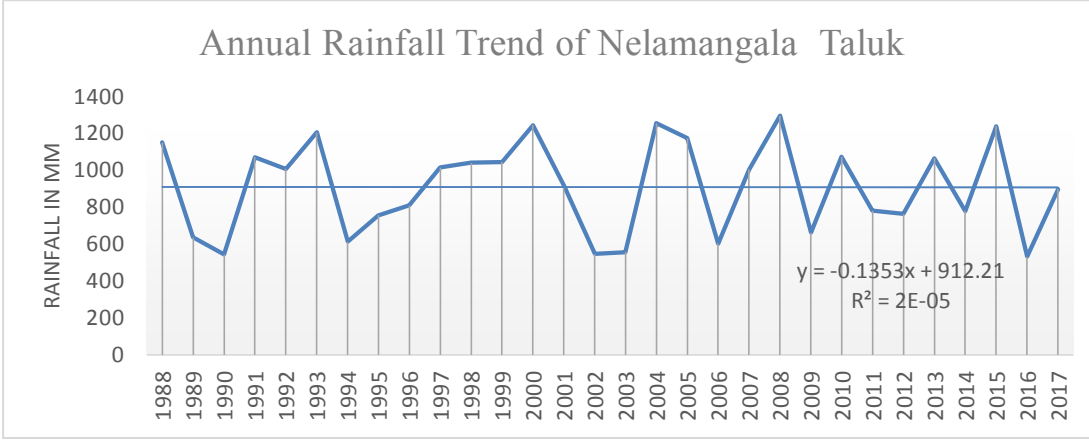

Fig. 6. Annual Rainfall Trend of Nelamangala Taluk

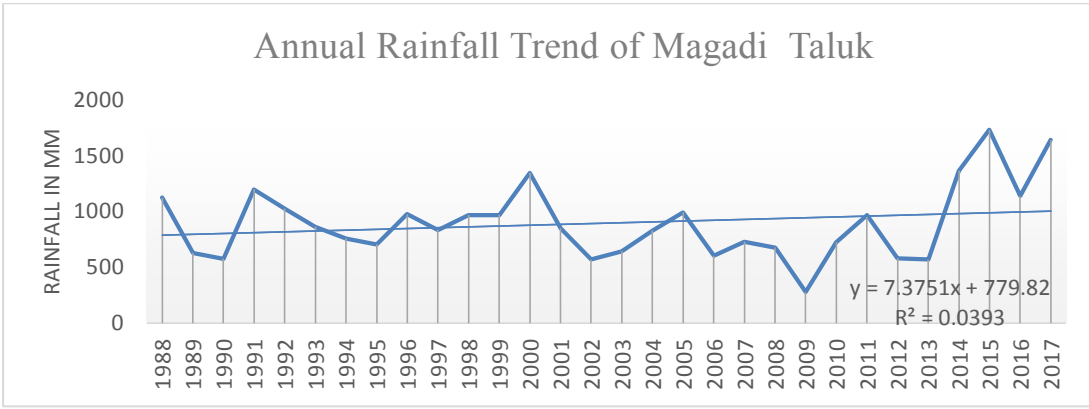

Fig. 7. Annual Rainfall Trend of Magadi Taluk

The Arkavathy Watershed Average Rainfall (1988-2017)

Figure 8 shows the average rainfall of the study area during 1988-2018, in which Bangalore North (1115.0mm) received the highest amount of rainfall in three decades followed by Nelamangala (910.1 mm), Magadi comes third receiving (894.1mm) followed by Doddaballapur (847.3) and Devanahalli (835.1 mm).

Seasonal Distribution of Rainfall

As far as the rainfall is concerned, the year is divided into 3 Seasons. These are January- May (Pre-Monsoon), June-September (Monsoon) and October-December (Post -Monsoon). Seasonal distribution of rainfall in the Arkavathy Watershed receives 18.15% of the total rainfall during the Pre-Monsoon Season, 55.82% in the Monsoon Season and 26.01% of rainfall in the Post -Monsoon Season. It can be seen that maximum amount of rainfall in the watershed seems to happen during the month of June- September.

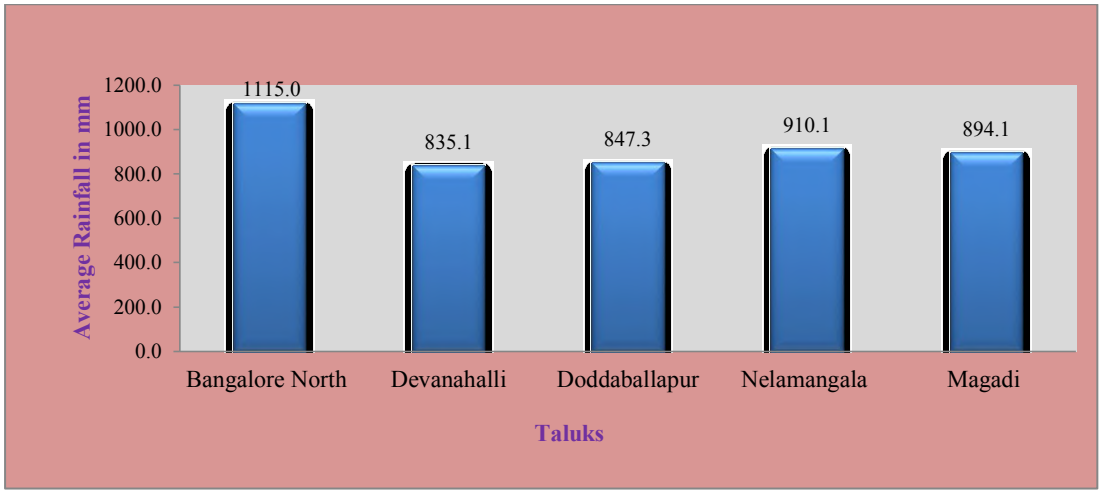

Fig. 8. Average Rainfall in mm (1988-2017)

Pre-Monsoon

In the three decades from (1988-2018), the pre-monsoon is seen to be highest in the Bangalore North (193.7 mm) taluk, followed by Nelmangala (182.3 mm), Magadi (169.6 mm), Devenahalli (154.9 mm) and Doddaballapur (135.2 mm). Among all the decades the rainfall seems to be highest from the year 2007-2018. In the first decades, among all the taluks in the watershed the rainfall seems to be low and started increasing between the years of 1998-2007. But it experiences the highest rainfall between the years of 2007-2018. In the first decade (1988-1997), among all the taluk Magadi (166.3mm) received the highest rainfall followed by Nelamangala (165.1 mm), Bangalore North (157.0 mm), Devenahalli (130.9 mm) and Doddaballapur (118.5 mm). In the mid-decade of pre-monsoon (1998-2007), Nelamagala (198.4 mm) received the highest rainfall and Doddaballapur (121.1 mm) received the lowest. And in the last decade (2007-2018), Bangalore North (257.2 mm) received the highest amount of rainfall, 182.3 mm in Magadi, 173.5 mm in Nelamangala, 165.9 mm in Doddaballapur and 159.0 mm in Devenahalli.

Monsoon

During the monsoon, in last three decades Bangalore North (668.1 mm) received the highest amount of rainfall, followed by Nelamanagala (503.2 mm), Magadi (499.3 mm), Doddaballapur (455.7 mm) and Devenahalli (442.4 mm). In the first, second and third decade, Bangalore North received the highest rainfall of 559mm, 629 mm and 824mm respectively. During the first decade (1988-1997), it was 473mm in Devenahalli, 444mm in Doddaballapur, 502mm in Nelamangala and 495mm in Magadi. In the mid-decade (1998-2007), the rainfall recorded was 404 mm in Devenahalli, 393mm in Doddaballapur, 521mm in Nelamangala and 468mm in Madagi. And during the last decade (2008-2017), the rainfall recorded was 451mm in Davenahalli, 530 mm in Doddaballapur, 487mm in Nelamangala and 535mm in Magadi.

Post-Monsoon:

Post-Monsoon average decadal rainfall during 1988-1997 was 188 mm in Bangalore North, 235mm in Devenahalli, 261mm in Doddaballapur, 214 mm in Nelamangala and 206 mm in Magadi. During the mid -decade (1998-2007), 180mm in Bangalore North, 228 mm in Devenahalli, 190 mm in Doddaballapur, 220 mm in Nelamangala and 221 mm in Magadi. And in the post-monsoon in the last decade, the rainfall recorded was 392 mm in Bangalore North, 2257 mm in Devenahalli, 318 mm in Doddaballapur, 240 mm in Nelamangala and 249 mm in Magadi.

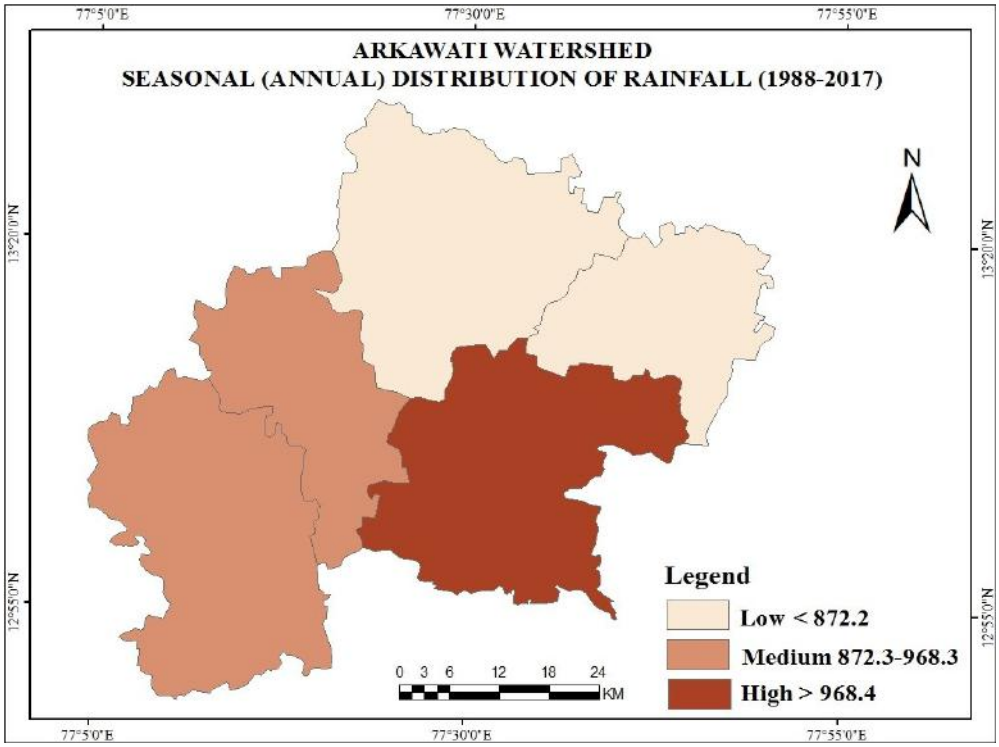

Fig. 9. Seasonal (Annual) Distribution of Rainfall (1988-1917)

Table 1 Seasonal Distribution of Rainfall

Taluks	Pre-monsoon	Monsoon	Post- monsoon	Mean Annual
Bangalore North	193.7	668.1	253.2	1115.0
Devanahalli	154.9	442.4	237.8	835.1
Doddaballapur	135.2	455.7	256.3	847.3
Nelmangala	182.3	503.2	224.6	910.1
Magadi	169.6	499.3	225.2	894.1

Source: Indian Meteorological Department and Directorate of Economics and Statistics from the year 1988 to 2017

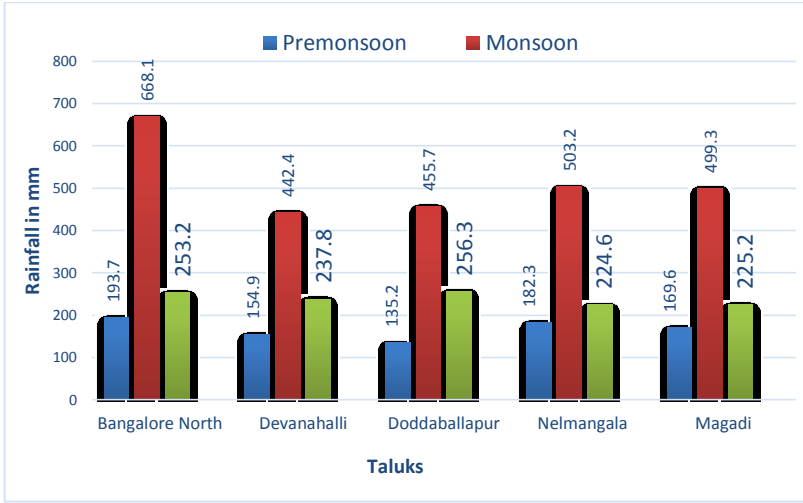

Fig. 10. Average Seasonal Rainfall in mm (1988-2017)

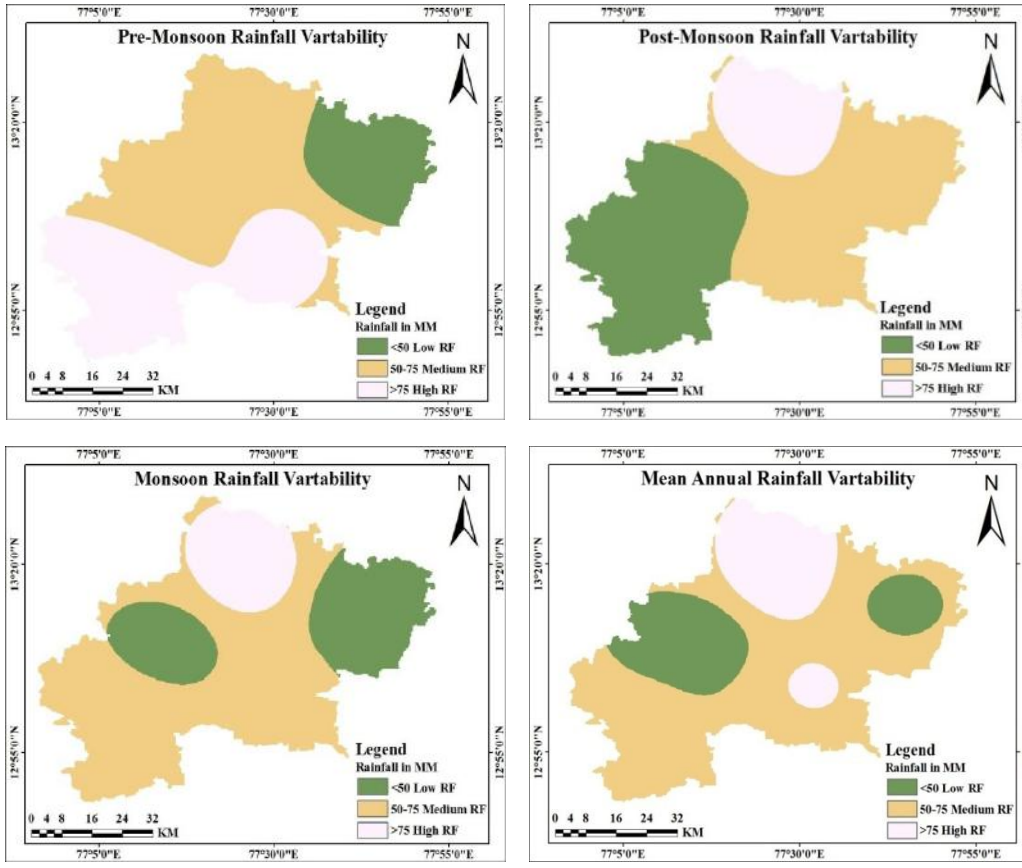

Fig. 12. Seasonal and Annual Rainfall Variability

Source: Indian Meteorological Department and Directorate of Economics and Statistics from the year 1988 to 2017

Rainfall Class	Range
Excess (E)	> +20%
Normal (N)	minus 20% to plus 20%
Below Normal (B)	< -20%

Source: Indian Meteorological Department, year 2000

Based on the mean rainfall, Northern part of Doddaballapur and some inner parts of Bangalore North taluks of the watershed experiences heavy rainfall. The northern part of Magaditaluk, north-western part of Nelamangala and north-eastern part of Devanahallitaluk receives rainfall below average whereas other parts of the taluks received medium rainfall. with reference to average rainfall of each station and the percentage of deviation has been calculated and the result has been classified into three ranges as shown above.

Conclusion

The study concludes that in all the Taluks of the Arkavathy Watershed receiveshigh rainfall during the monsoon and the rain tends to decrease by post monsoon and then pre-monsoon. Among all the taluks in the study area, Bangalore North experiences highest rainfall, followed by Nelamngala, Magadi, Doddaballapur and Devenahalli.It is recommended that the analysis of rainfall pattern and increase the natural storage in Arkavathy Watershed is significant to manage the water shortage problem in the Bangalore city particularly during the drought season.

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MAPPING OF FLOOD HAZARD ZONES OF TUTHAPUZHA SUB-BASIN, KERALA, INDIA - A GEO-SPATIAL APPROACH

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Abstract

Flood is one of the major disasters among the all-natural hazards. It is an overflow of water over the dry areas within a short period of time and create lots of damages over the catchment areas. The present study aims to identify the flood hazard zones to create awareness to those who reside in the nearby areas of the river. The Tuthapuzha sub-basin has been selected for the current study for flood hazard mapping which covers two districts of Kerala called Palakkad and Malappuram. The GIS and Remote Sensing techniques have been used to delineate the flood hazard zones of the Tuthapuzha sub-basin area. The flood zones can be identified with the help of different thematic layers like geomorphology, geology, slope, aspect, soil, LULC, drainage density, rainfall intensity, flow accumulation etc., with help of Remote Sensing and GIS. The normalized weights of the individual themes and their different features were obtained through the Saaty's Analytical Hierarchy Process (AHP). This study is carried out to highlight the scenario of the flood hazard zones over the basin area which will help to reduce the damages that occur during the flood.

Keywords: Flood Hazards, Analytical Hierarchy Process (AHP), Remote Sensing and GIS, Hazard Zonation

Introduction

Flood became the common major natural disaster over the world at present. Studies on vulnerabilities related to natural hazards have been conducted by many researchers (Blaikie, 2004). The flood vulnerability assessment is very necessary action for the prevention of this natural disaster. India is one of the worst flood-affected countries, being second in the world after Bangladesh and accounts for one fifth of global death count due to floods (Bapalu, 2005). Many studies have been carried out on flood vulnerability assessment on different parts of Kerala. Prevention and reduction are appropriate strategies in disaster management for reducing the effects of flood disasters. Through the spatial information system regarding the vulnerability on infrastructure and areas, the level of vulnerability and the factors liable for vulnerability is necessary to proceeds toward the flood mitigation programs.

The vulnerability assessment can help us to mitigate the effect of floods on people, property, and the environment. Floods also leave in their wake epidemiological threats, breakdown of social order, migration (temporary and permanent) and a constant obstacle to the local development programs (Singh, 2013).The main aim of the study is to identify the flood vulnerable zones Tuthapuzha sub-basin of Bharathapuzha a tropical river basin in Kerala.

Study Area

Tuthapuzha sub-basin, located within the Palakkad and Malappuram Districts of Kerala, is a sixth-order sub-basin of Bharathapuzha covering an area of 1,018 km^2. Tuthapuzha is about 63 km in length and has four tributaries draining to it, namely Kuntipuzha, Nellipuzha, Kanhirapuzha and Thuppanadpuzha. The study area falls within the midland (7.5-75 m elevation above mean sea level) and the highlands (>75 m elevation above mean sea level) region of Kerala and experiences a humid tropical climate.

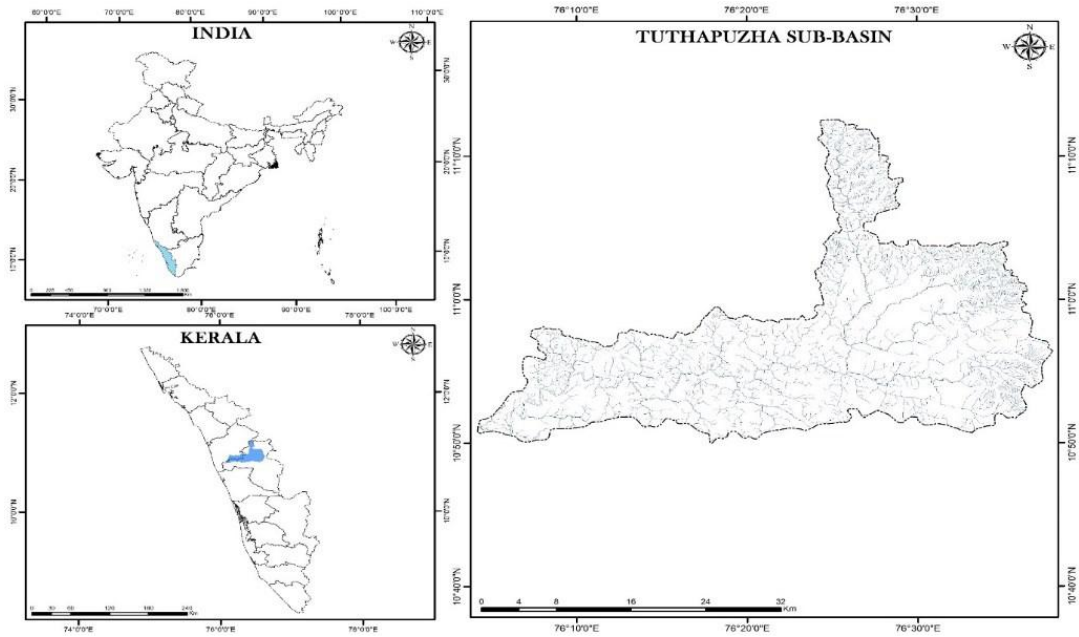

Fig. 1. Location of Tuthapuzha Sub-Basin

Materials and Methods

The satellite data used in this study include images from LANDSAT 8 and ASTER. LANDSAT data is used for preparation of thematic layer of land use/land cover. Drainage, elevation, flow accumulation and slope maps are extracted from ASTER DEM data. The secondary data on Geomorphology is obtained from Geological Survey of India. Rainfall Data has been collected from IMD Pune for 15 years. Soil Data have been taken from National Bureau of Soil Survey and Land Use planning (NBSS&LUP). ArcGIS and ERDAS Imagine (v. 2015) are the software used to process and generate the thematic layers.

The flow chart showing the methodology used in the present study is shown in Figure 2. Suitable weights were assigned to the eight themes and their individual classes after understanding their hydrogeological importance in causing Flood in the study area. The normalized weights of the individual themes and their different features were obtained through the Saaty's analytical hierarchy process (Saaty, 1980). Each layers of the theme were given appropriate ranking depending on their significance in groundwater prospect. The weights assigned to the respective features of the individual themes and the ranks of each units of particular theme are presented in Table 1.

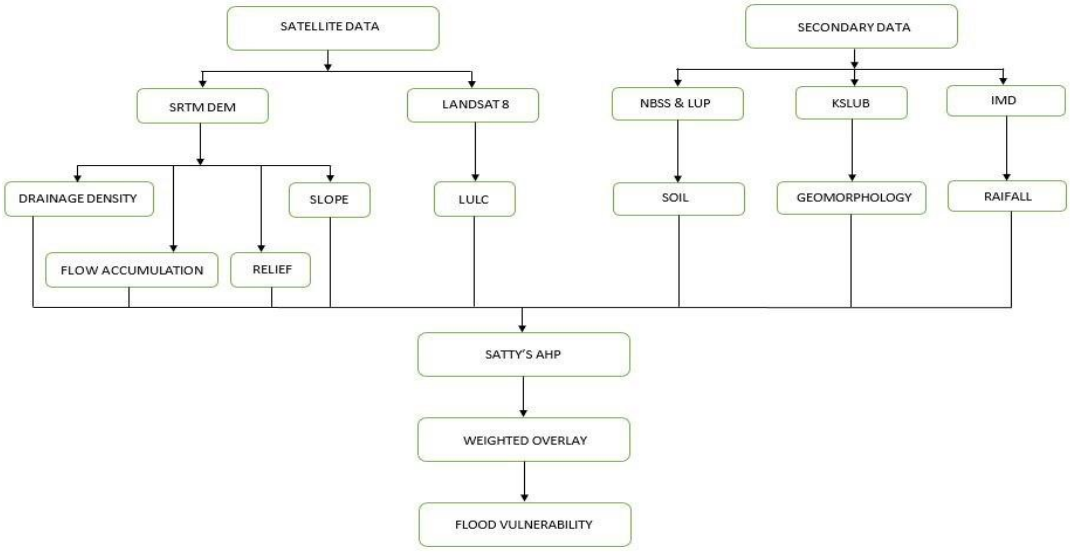

Fig. 2. Methodology Flow Chart

Results and Discussion

Drainage Density

Drainage density indicates the closeness of spacing of streams and a key detrimental factor for water to travel from source to sink. Drainage density is an inverse function of infiltration, lesser the infiltration of rainfall, which conversely tends to be concentrated in surface run-off. Drainage density is classified into five categories, high drainage density values are favourable for runoff, and hence indicate low flood chance. Higher weights are assigned to high drainage density area and lower weights were assigned to areas with low drainage density.

Flow Accumulation

The flow accumulation calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. The flow accumulation pixels were classified into five classes.

Elevation

Elevation is an important factor that plays a role in the variation of plant cover, causing temperature changes, particularly in highlands. Elevation was determined from the SRTM DEM data. The higher the elevation lower the chances of flooding. Hence, higher elevation was given lower ranks.

Table 1. Ranks and Weightages of Attributes of Various Themes

Theme	Weight	Identified factors	Sources	Rank	Flood vulnerability
Drainage Density	35	Very low	USGS	1	Very poor
		Low	Earth	2	Poor
		Medium	Explorer	4	High
		High		4	High
		Very High		5	Very high
Flow Accumulation	20	Very low	USGS	1	Very poor
		Low	Earth	2	Poor
		Medium	Explorer	3	Medium
		High		4	High
		Very High		5	Very high
Elevation	14	Very low	USGS	5	Very high
		Low	Earth	4	High
		Medium	Explorer	3	Medium
		High		2	Poor
		Very High		1	Very poor
Slope	8	Very low	USGS	5	Very high
		Low	Earth	4	High
		Medium	Explorer	3	Medium
		High		2	Poor
		Very High		1	Very Poor
Rainfall	8	Very low	IMD	1	Very Poor
		Low		2	Poor
		Medium		3	Medium
		High		4	High
		Very High		5	Very high
Soil	6	Clay	NBSS	4	High
		Gravelly clay	&	3	Medium
		Gravelly loam	LUP	1	Very Poor
		Loam		2	Poor
		Marshy		5	Very high
Geomorphology	5	Denudational Hills	Kerala	1	Very poor
		Denudational Structural Hills	State Land	1	Very poor
		Flood Plain	use Board	5	Very high
		Pedi plain		4	High
		Piedmont zone		3	Medium
		Plateau		3	Medium
		Residual hill		2	Poor
		Rock Exposure		1	Very poor
		Structural hill		2	Poor
		Water body		5	Very high
Land Use Land Cover	4	Agricultural land	USGS	4	High
		Built-up land	Earth	3	Medium
		Forest	Explorer	2	Poor
		Wasteland		3	Medium
		Water body		5	Very high

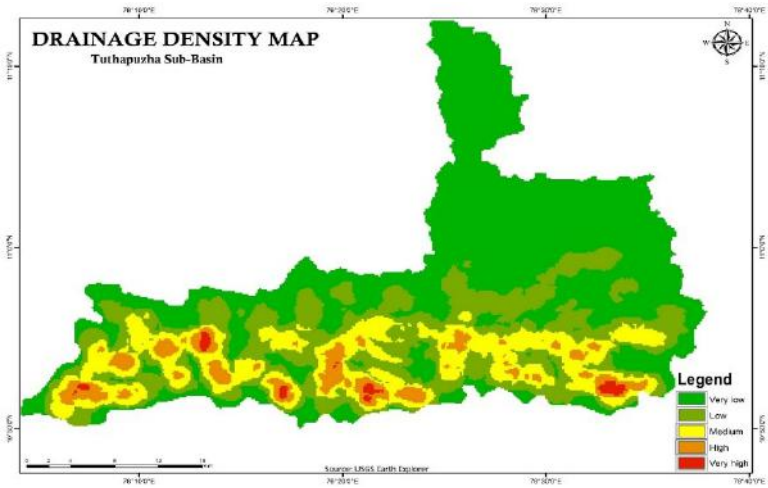

Fig. 3. Drainage Density of Tuthapuzha Sub-Basin

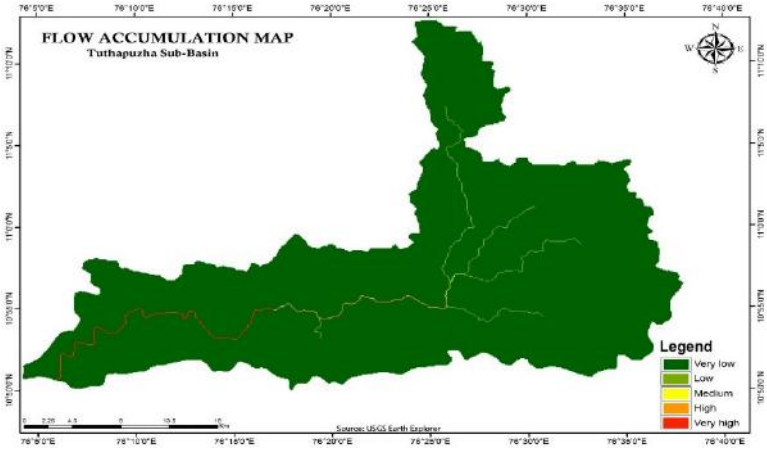

Fig. 4. Flow Accumulation of Tuthapuzha Sub-Basin

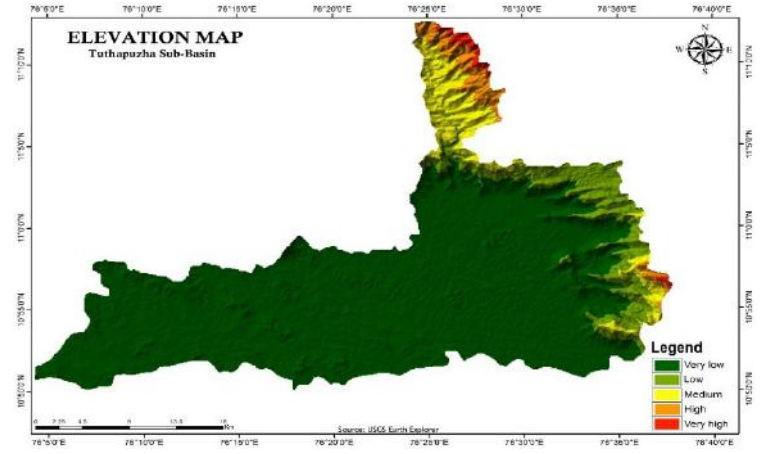

Fig. 5. Elevation of Tuthapuzha Sub-Basin

Slope

The slope influences the direction and amount of surface runoff or subsurface drainage reaching a site. Slope has a dominant effect on the contribution of rainfall to stream flow. It controls the duration of overland flow, infiltration and subsurface flow. The slope refers to the topography of the area or indicators of the geomorphological properties of the soil. The thickness of the soil layer decreases with the increase of the slope. The slope have been calculated from the maximum rate of change between each cell and its neighbours. Every cell in the output raster had a slope value. A lower slope value indicates a flatter terrain and a higher slope value indicates a steeper terrain. The slope map was generated using SRTM DEM data.

Rainfall

Rainfall is another important parameter to find out the flood risk zones. Rainfall Data have been taken from IMD Pune for last 15 Years and the average has been calculated. The average rainfall of last 15 years have been interpolated using ARC GIS and reclassified in to five classes. The area coming under high rainfall will have high chances of flooding.

Soil

The soil types in an area is important as they control the amount of water that can infiltrate into the soil, and hence the amount of water which becomes flow. The chance of Flood hazard increases with decrease in soil infiltration capacity, which causes increase in surface runoff. When water is supplied at a rate that exceeds the soil's infiltration capacity, it moves down slope as runoff on sloping land, and can lead to flooding. Ranks are assigned for soil categories based on infiltration capacity. The clay soils are less porous and hold water longer than sandy soils. This implies that areas characterized by clay soils are more affected by flooding and are likely to become waterlogged in rainy season. Clay loam contains more clay hence it tends to get heavy. It has poor drainage as it gets wet, it swells to retain it. Loamy sand contains all the three size particles. Hence, it has good drainage. Most of the areas in the sub basin is covered by clay and gravelly clay and clay soils.

Geomorphology

The geomorphic units delineated in the present study area denudational hills, flood plain, pediplain, piedmont zone, plateau, residual hill, rock exposure, structural hills. Piedmont zone are rock floured plains in the uplands and areas adjacent to hills into which the rainwater from the hills drains. Major part of the basin is covered by piedmont zone. Pediplain is the flat surface with good weathered profile covering thick vegetation. This unit occupies the topographically low-lying area. Flood plains are the most suitable area for the occurrence of flood.

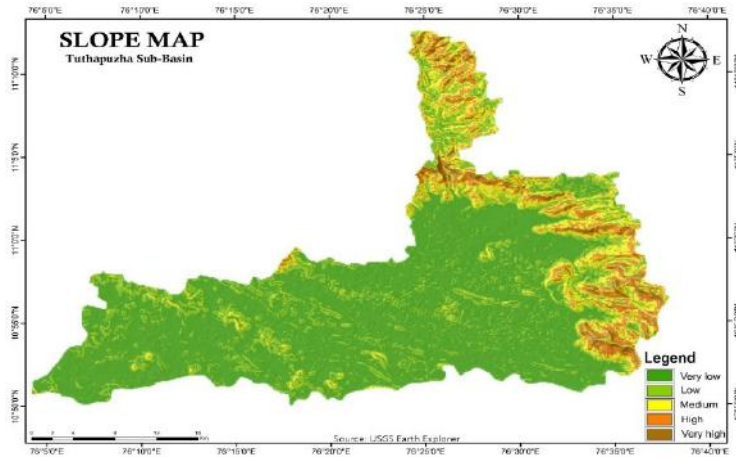

Fig. 6. Slope of Tuthapuzha Sub-Basin

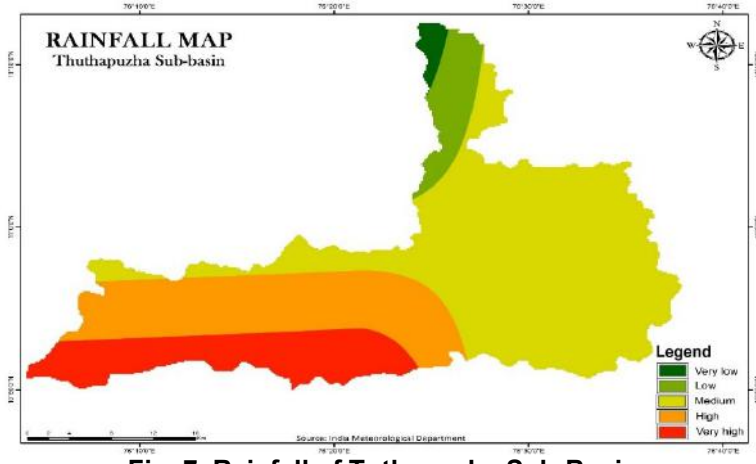

Fig. 7. Rainfall of Tuthapuzha Sub-Basin

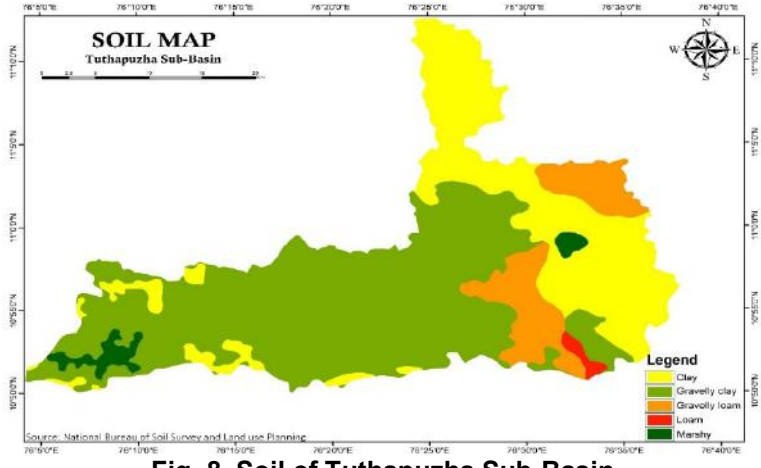

Fig. 8. Soil of Tuthapuzha Sub-Basin

Land use / Land Cover

The land use/land cover classes like built-up land, agricultural land, waste lands and water bodies are delineated in the study area. Major part of the basin is covered with the Agriculture. Whereas the Northern part of the basin is having thick forest cover.

Flood Hazard Zonation

The area has been classified into five different categories as above mentioned i.e., Very Low, Low, Medium, High and very Highly Vulnerable zones. Very high and Highly vulnerable zones for flood has been identified in the Southern part of the basin which is around 17 percentage of the total area. The area adjacent to highly vulnerable zones comes under moderate flood zones of around 37 percent of the total area. The Northern Part of the Basin Comes under safer zone. Flood vulnerability zone map was compared with the flood prone locations found in Tuthapuzha Sub basin to assess the accuracy of result. Flood prone locations in Tuthapuzha study area were surveyed by author and identified based on local information, news of flooding in newspapers and other available literature that recorded the past events of flood prone areas.

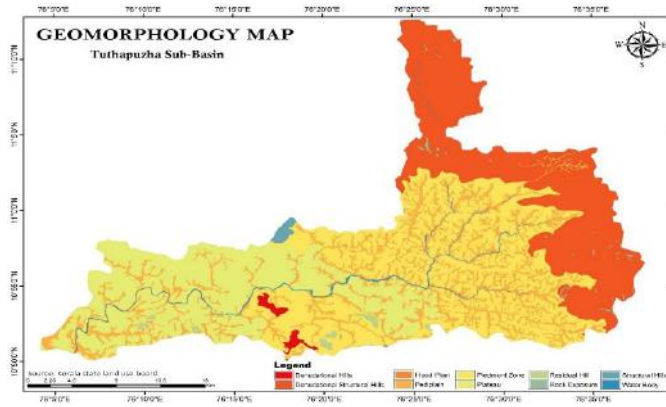

Fig. 9. Geomorphology of Tuthapuzha Sub-Basin

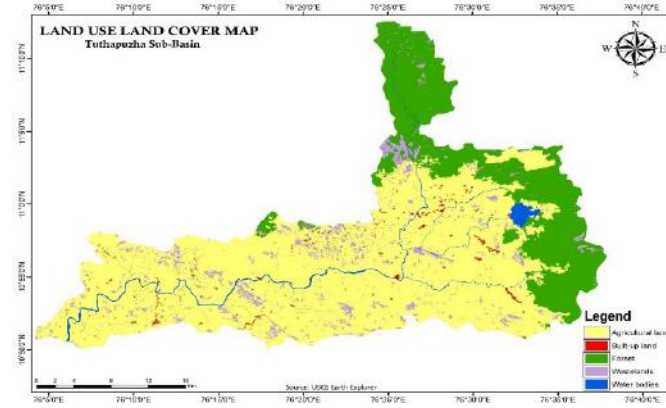

Fig. 10. Land use / Land cover of Tuthapuzha Sub-Basin

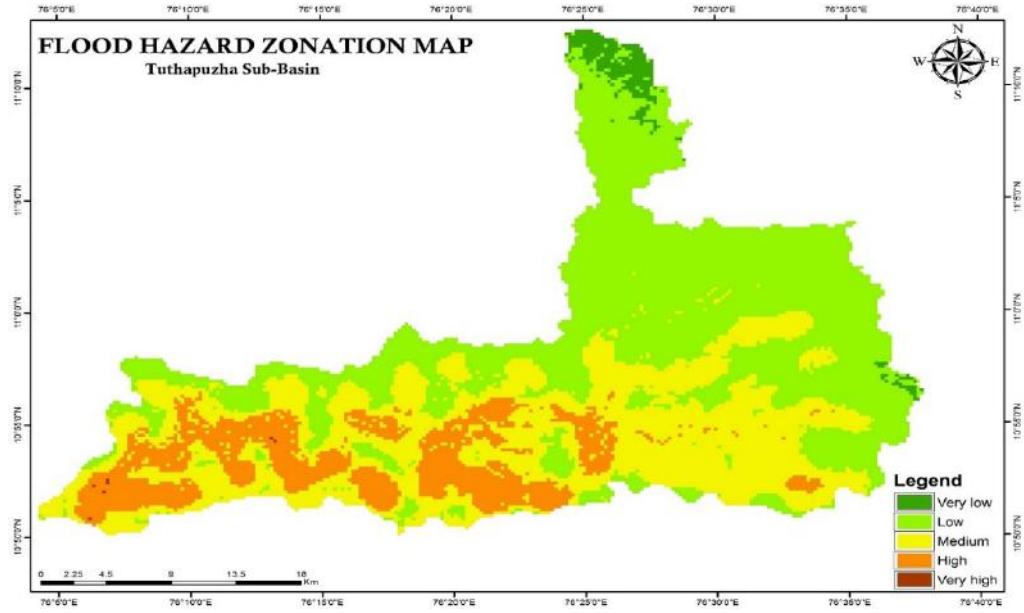

Fig. 11. Flood Hazard Zonation

Table 2. Flood Risk Areas According to the Different Classes.

Flood Risk Zones	Area (Sq. Km.)
Very low	23.7914
Low	449.9163
Medium	373.5691
High	157.3001
Very high	9.423081

The area which Shares boundary between Palakkad and Malappuram Districts is more vulnerable to Floods. During 2018 and 2019 Kerala floods, these areas were highly affected by the flood. Places like Anakkara and Kumbidi which comes under High risk zones were affected mostly during the 2018 and 2019 flood. Tuthapuzha which is a Sub Basin of Bharathapuzha is frequently affected by the floods during Monsoon.

Conclusion

Flood vulnerability is the process of determining the degree of susceptibility of a given place for flooding. The flood vulnerability zones of the study area were generated through the integration of various thematic maps like geomorphology, rainfall, flow accumulation, drainage density, elevation, soil, slope and land use using weighted overlay analysis. The 'weighted overlay' is a tool built inside ArcGIS software and this tool has been used to perform an overlay analysis.

The weighted overlay tool overlays several raster using a common measurement scale and weights each according to its important. Delineating the Flood Vulnerability Zone (FVZ) in Tuthapuzha Sub Basin of Bharathapuzha using AHP, GIS and remote sensing techniques can be a major aid in quick decision-making for sustainable flood management. The proposed methodology would be suitable for mapping flood vulnerability zones through Analytical Hierarchy Process (AHP) approach. The present paper shows a simple and cost-effective empirical method for delineating flood vulnerability zones using remote sensing and GIS from the available data. The present work identified zones required for flood disaster management.

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CHALLENGE OF PROVIDING CLEAN AIR IN URBAN AREAS IN INDIA

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Abstract

This paper examines the increasing levels of air pollution in Indian cities. Indian cities are compared to the world scenario and it is found that industries, unregulated transport by sometimes highly polluting diesel fueled vehicles, construction activity, indiscriminate burning of garbage, smoke from the crematoria, besides other factors are responsible for this. The impact of poor air quality on the elderly and child population besides the sick is quite appalling. While awareness, precaution and regulatory protocols are definitely required to address this issue, yet an alternative approach like purifying the air in addition will go a long way in tacking the issue. This requires technological intervention for a human welfare issue.

Keywords: Air quality index, Air pollution, Poor air quality, Unrestrained industrialization, Health and well-being, High population density.

Introduction

India and many developing countries of the world are witnessing huge streams of rural to urban migration owing to the pangs of finding employment in a rural setting. The mélange of poor prospects in rural areas, the magnetism of urban areas and migration lead to huge population densities. This become perilous to the health and welfare of people when the urban areas are also engaged in unrestrained industrialization where the industries spew out fumes besides toxic fluids and now also where the urban areas are engaged with the IT sector. The vehicles which transport the IT workers have an endless run five days a week and are a major cause of unhealthy air along the roads, at road intersections and even in the residential areas that they traverse in the course of picking up the employees of the IT sector and dropping them back home. Not to be left out from the equation is the increasing number of private vehicles hitting the road in most cities and cutting down of trees to facilitate construction activity besides burning of garbage and other factors.

Health and well-being of people in urban areas which not only have a high population density but also more of new construction, renovation, demolition, and emissions are likely to be impacted. Elevated levels of formaldehyde, PM2.5 (Particulate Matter which is 2.5 micrometers or smaller) and asbestos lead to poor air quality. All of them can lead to

serious health hazards impacting lungs and heart when inhaled besides causing eye, throat and nose irritation among other inconveniences (1). 'The particulate matter is able to penetrate deeply into the respiratory tract, creating health risks by increasing mortality from respiratory infections and diseases, lung cancer, and selected cardiovascular diseases' (15:172). PM2.5 defines inhalable particles with a diameter of generally 2.5 micrometers and smaller, PM10 particles with a diameter of 10 micrometers and smaller, irritate exposed mucous such as the eyes and throat and PM2.5 particles travel all the way through the lungs into the alveoli. The World Health Organization (WHO) reports airborne particulate matter as a Group 1 carcinogen and as the biggest environmental risk to health, with responsibility for about one in every nine deaths annually (2).

India had three of the 20 urban areas with the worst air quality at the time of measurement (2011-15). Among mega-cities, Delhi had the highest levels of air pollution (Fig 1). Thirteen of the top twenty most polluted cities in the world, according a World Health Organization (WHO) report from 2013, are in India. This has led to fears for the health of children living in Asia's third largest economy (3) more so as most children walk or cycle to school and are exposed to air pollution (4).

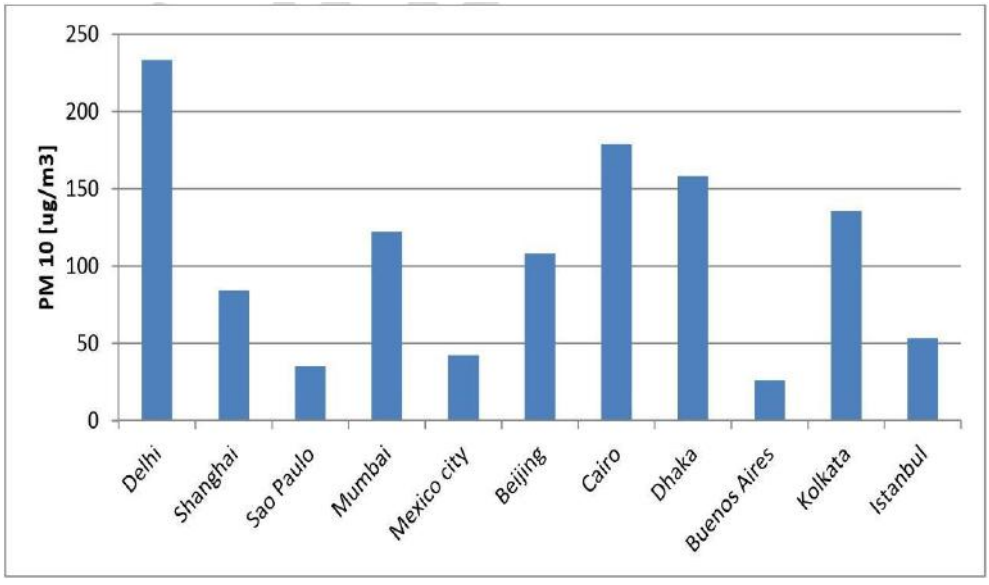

Fig. 1. Highest Levels of Air Pollution

Source: WHO

The present study is based on data collected on a date and time basis in select cities and towns in India where they have been compared to the worldwide scenario.

Data was collected from the AirVisual website which is Switzerland based and uses Big Data and Artificial Intelligence to provide real time data for a very large number of locations in the world.

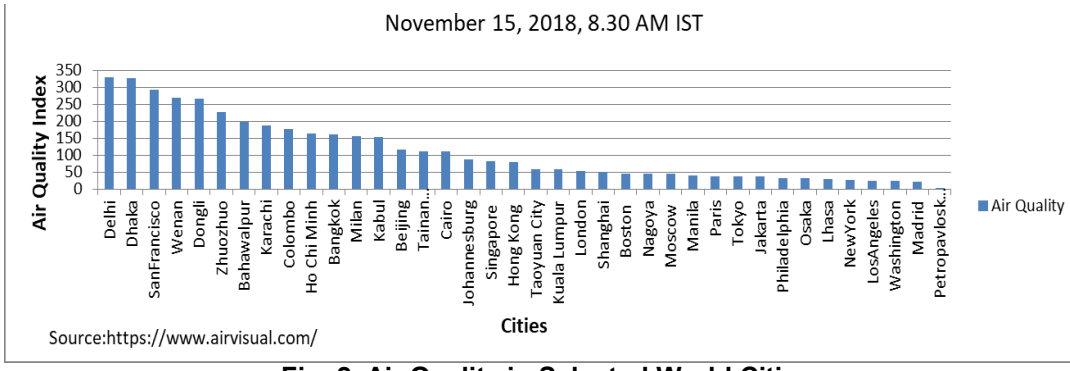

Fig. 2. Air Quality in Selected World Cities

'AQI, or Air Quality Index, is a system for translating sometimes confusing or unintuitive pollutant concentration measurements, into one easy-to-understand scale to clearly represent the health risk posed by air pollution. The index formula usually considers up to 6 main pollutants (PM2.5, PM10, carbon monoxide, sulfur dioxide, nitrogen dioxide and ground level ozone), and calculates the respective health risk (or AQI number) for each one. The overall AQI number at a given moment is dictated by the 'riskiest' pollutant, with the highest AQI number.

The index ranges from 0 to 500, where high index values indicate higher levels of air pollution and higher potential for adverse health effects. Any value larger than 300, for example, is considered to be hazardous, while an AQI value of 0-50, on the other hand, represents good air quality.' (5) Air quality ranges from Good, Moderate, Unhealthy for Sensitive groups, Unhealthy, Very Unhealthy, Hazardous on the 0 to 500 scale with better air quality in descending level of magnitude. While a value of 0-50 signifies 'good' air, a value of 51-100, indicates 'moderate' air quality which poses little health risk. "Sensitive groups like the sick, aged and children may experience mild adverse effects and should limit protracted outdoor exposure." A value of 151-200, is indicative of 'unhealthy' air quality, it may cause increased aggravation of the heart and lung issues. Sensitive groups are at high risk to experience adverse health effects of air pollution. A value of 201-300, specifies 'Very Unhealthy' air quality and may cause increased aggravation of the heart and lung conditions. Sensitive groups are at high risk to experience adverse health effects of air pollution. Values in the range of 301-500+, are indicative of 'hazardous' air quality that is deemed toxic and pose serious risk to the heart and lungs. Everyone should avoid all outdoor exertion.

A glance at Figure 2 reveals that Indian cities are at the top of air pollution rankings in a worldwide context. The intensity of the problem can be gauged from the fact that Delhi was almost at par with San Francisco which faced a severe hazard of smoke for about two weeks owing to wildfires in California highlands from November 8, 2018. Post that incident San Francisco has reverted back to a safe and healthy air condition; Indian cities, however, seem to be cyclically in the 'Unhealthy air' situation. Even Beijing which had earned notoriety for high levels of air pollution has reversed the situation by resorting to technology.

In fact, China has harnessed the situation to its advantage by constructing towers that ingest the polluted air, filter it and release it back to the atmosphere, the carbon so collected in the towers is used to make 'diamonds'.

Figure 3 further reinforces the point that most Indian cities have unbearable and unhealthy levels of air pollution making the population vulnerable to various diseases. The sample has been collected pan-India. Most of the cities figuring in this graph are large metropolises that attract migrants from rural and other urban areas. Also included are industrial towns besides many of the state capitals. The data is collected for a weekday - Thursday and for weekend - Sunday and it is found that though in most cases there is a slight dip in pollution levels on weekend compared to a weekday, pollution is high in certain cases even on weekends. Quite often they happen to be tourist places and weekend related tourist traffic could add to the woes of already existing air pollution. Quite interestingly, it is noticed that the difference between the air pollution levels of a weekday and weekend is remarkable in the case of Hyderabad and Chennai, both of which happen to be IT centres in addition to checking several other boxes. Thus, the multitudes of vehicles that throng the roads on weekdays to transport the IT employees are absent on weekends which perceptibly leads to a dip in the air pollution levels in these two metropolises at the weekend.

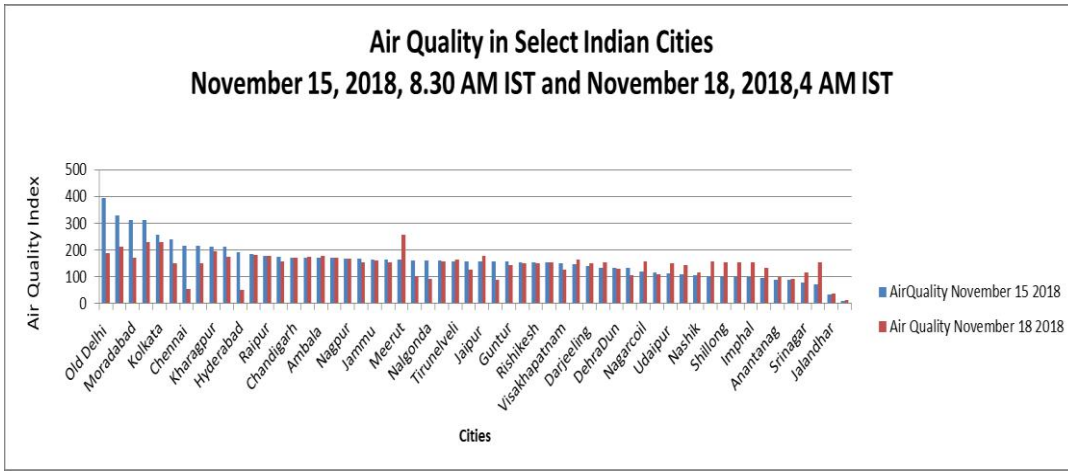

Fig. 3. Air Quality in Selected Indian Cities

Climaxing levels of air pollution continue throughout the day with little abatement (Figure 4). This is again an atypical phenomenon where very little ebbing of pollution levels is found during night times even in smaller towns like Nalgonda which is taken at random for comparison. Thus, there is not only a spatial but also an almost perpetual temporal peaking of pollution causing severe challenges to the health and well-being of the residents of these cities. According to a study carried out in the context of Hyderabad, observations of residents in the IT hub of the city reveal that air pollution carries negative implications for the livability of the area. For them, their concern about air pollution besides other issues is closely intertwined with that of its negative effects on their health and wellbeing (6).

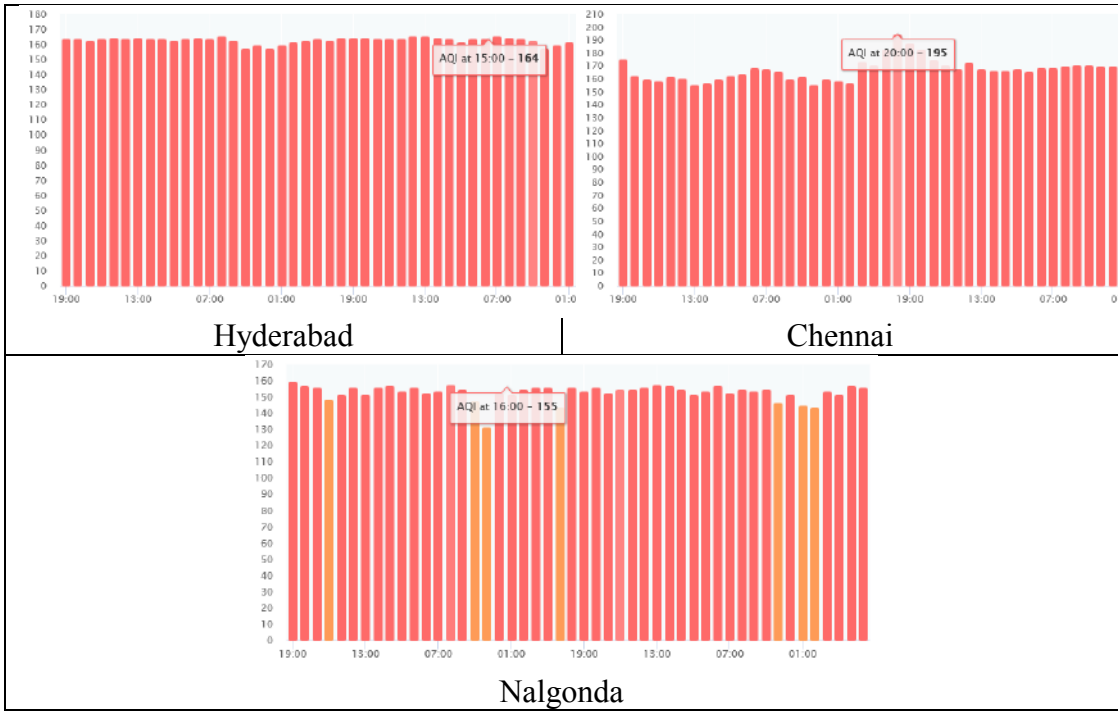

Fig. 4. Air Quality Index: 10 and 11.12.2018

It has been pointed out in the context of Hyderabad that air pollution among other factors poses ecological risks to the mega- cities and also a challenge to sustainable infrastructure (7 and 8). 'The stationary sources of air pollution such as power plants, industrial activities, and residential and commercial buildings along with mobile sources such as vehicles which are poorly maintained and use poor fuel quality and inadequate traffic management is an emerging problem due to urban growth in developing countries. Air pollution in Asia causes as many as 519,000 premature deaths every year'. (7) Due to unrestrained urbanization, environmental degradation is taking place very fast leading to air pollution among other challenges that it poses (8). In an index of countries' environmental health from Yale and Columbia universities, India ranks a dismal 177th out of 180.

This does not just make life unpleasant for a lot of Indians. It kills them. Recent estimates put the annual death toll from breathing PM 2.5 alone at 1.2m-2.2m a year. The lifespan of Delhi-dwellers is shortened by more than ten years, says the University of Chicago' (9). 'Urban microclimate and atmospheric pollution are intimately interwoven. As the warm polluted air rises, it may form what is called a 'dust dome' over a city and the pollutants are trapped closer to the ground surface. It has been even reported that uncomfortably high air temperatures during summer months can contribute to higher than-average death rates especially among older people' (10). It is said in the context of Pune, Hyderabad and Bengaluru which were once laidback pensioners' paradise and are now hustling IT centres that ' the dazzling growth of these cities has not just brought in dollars

and malls, but also large-scale migration, traffic jams, pollution, creaking infrastructure and discontent' (11) The main culprit cited here is auto pollution. Vehicular pollution levels are rising above the permissible limits at all major traffic junctions (12) in Hyderabad. 'Further lack of adequate road infrastructure and massive increase in number of vehicles has resulted in massive traffic congestion at major traffic points along with increasing vehicular pollution within the city' (13).

'The spatial expansion of cities renders increase in the average trip length, and excessive dependence on automobiles leads to traffic congestion, air pollution, rising greenhouse gas emissions, and poor public health. There is an increase in the incidence of urban health related issues because of the poor quality of air, drinking water, improper sanitation facilities, open defecation and inadequate solid waste management' (15:172).

Most of the cities of the developing countries are going through a phase of severe air pollution. Industries, unregulated transport by sometimes highly polluting diesel-fueled vehicles, construction activity, indiscriminate burning of garbage, smoke from the crematoria, besides other factors are responsible for this. While awareness, precaution and regulatory protocols are definitely required to address this issue, yet an alternative approach like purifying the air in addition will go a long way in tacking the issue in its incipient stages, thus improving the overall situation.

Thoughtful action has to go into improving this situation, which impacts the vast majority of the Indian population which is increasingly living in towns and cities. It is not an unsurmountable problem as is seen from cases of other countries. The initiative has to come at an early date to subvert the ongoing damage to the most important asset of the people – which is their health.

Some of the measures suggested at the BRICS summit are 'renewable/biofuels energy, energy efficiency, mobility and sustainable urban transport, reduction of the effects of climate change and pollution, sustainable production (clean technologies, eco-design) waste recycling and environmental sanitation, construction and sustainable urban infrastructure, social technologies, biodiversity and biomes, socio-biodiversity networks, and electric vehicles and/or hybrids' (14: 314). Policy-makers at international, national and city level are advised to promote cleaner transport, more efficient energy production and waste management (15). Awareness, precaution and proactive measures can help ameliorate the problematic situation.

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY

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

Announcement of 10th Talent Test - 2020 for Geography Students on 22th February, 2020

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The Indian Geographical Society is organizing the state wide **Tenth Talent Test - 2020** for final year UG and PG students of the Geography Departments in Tamil Nadu on **Wednesday, the 22th Feburary, 2020**. 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. R. Jegankumar (Central and Western Tamil Nadu)**
Head, Department of Geography, Bharathidasan University, Tiruchirappalli - 620 024,
***Mobile**: 98947 48564, **E-mail**: jegankumar@bdu.ac.in*

3. **Dr. K. Balasubramani (Eastern Tamil Nadu)**
Assistant Professor, Department of Geography, Central University of Tamil Nadu,
Thiruvarur - 610 005, ***Mobile**: 99440 60319, **E-mail**: geobalas@gmail.com*

The Heads of the Geography Departments to contact the coordinator / regional coordinators and conduct the Talent Test successfully.

General Information

1. Talent Test **will be conducted in English language only for PG students and in English and Tamil for UG students** for 1.30 hours consisting of 100 questions without any choice.
2. Syllabi for UG and PG talent tests are UGC NET Paper II & III respectively.
3. Final year UG and PG students of Geography are eligible for Talent Test.
4. The students should enroll their names with the concerned Head of the Geography Department on or before 22th Feburary, 2020.
5. The co-ordinators would contact the Heads of nearby Geography Departments and send the representatives for conducting Talent Test.
6. The Head of the Geography Departments would collect the registration fee from the students of their Department and inform the coordinators accordingly.
7. Talent Test is scheduled on 22th Feburary**, 2020 (Wednesday) between 11.00 a.m. and 12.30 p.m.**
8. Registration fee for UG Students is Rs.50/- and for PG Students it is Rs.75/-. Only Cash should be collected from the interested candidates.

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 *IGS Annual Conference* to be held at Department of Geography, University of Madras, Guindy Campus, Chennai on Sunday, the 8th March, 2020. All other participants will be given Certificate of Participation. Please visit IGS website for registration forms and further information: http://www.igschennai.org/

Dates to Remember

Last Date for the Enrolment: 20-01-2020 (Monday)

Date of the Talent Test: 22-01-2020 (Wednesday)

Award of ICSSR - Senior Fellowship

Dr. K. Kumaraswamy, UGC BSR Faculty Fellow, Department of Geography, Bharathidasan University, Tiruchirappalli and the present Editor of The Indian Geographical Journal is awarded with the **ICSSR - Senior Fellowship** to conduct research on '**Water Quality and Human Health**' in the Department of Geography, Bharathidasan University, Tiruchirappalli for two years (December, 2019 - December, 2021).

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News and Notes

THE INDIAN GEOGRAPHICAL SOCIETY CONGRATULATES

THE FIRST INDIAN AND THE SECOND ASIAN BEING ELECTED AS
THE SECRETARY GENERAL AND TREASURER OF
THE INTERNATIONAL GEOGRAPHICAL UNION (IGU)

"PROFESSOR R.B. SINGH"

(**Mobile:** 9971950226; **E-mail:** rbsgeo@hotmail.com)

Dr. R.B. Singh is Professor of Geography since 2002 and presently Head in the Department of Geography, Delhi School of Economics, University of Delhi, India. Earlier he served as UGC Research Scientist-C / Professor (1996-2002), UGC Research Scientist-B/Reader (1988-1996) and Lecturer (1985-1988); Coordinator UGC-SAP-DRS III and Head, Department of Geography during 2013-2016. Recently, Prof. Singh got elected as the first Indian and the second Asian Secretary General and Treasurer of the International Geographical Union for 2018-2022. Dr. Singh is presently Chair, Research Council, CSIR-Central Food Technological Research Institute, Mysuru; Member-Research Council of CSIR - Central Institute of Medicinal and Aromatic Plants, Lucknow; Member of International Science Council (earlier ICSU) Prestigious Scientific Committee of Health and Wellbeing in Changing Urban Environment - System Analysis Approach.

Prof. Singh was Vice-President, International Geographical Union (IGU) since 2012 and is elected again for second consecutive term (2016-2018) of the highest world geographical body. He is invited by IAP-Global Network of Science Academies to join Working Group for statement on Science and Technology for Disaster Risk Reduction. He was unanimously elected as President of the Earth System Science Section of the Indian Science Congress Association for 2019-2020. The NITI Aayog, Government of India has invited him as Member of the prestigious committee for preparing Vision India - 2035.

He is the First Indian Geographer bearing dual distinction of the IGU Secretary General and ISC Scientific Committee Member. Under his Headship during 2013-2016 the Department of Geography has received two prestigious recognitions: i) Second position among all the Departments of the University of Delhi in showcasing good practices at Antardhwani-2014 and ii) Under QS World University Ranking the Department featured Rank 1 as the Best Institution in India for Geography discipline. He is the Springer Series Editor of Advances in Geographical

and Environmental Sciences; and Sustainable Development Goals (SDGs), IAP–Global Network of Science Academies representative on Disaster Risk Reduction. Invited by UN to Moderate a Working Group on Exposure and Vulnerability at UNISDR Science and Technology Conference on DRR, 2015-2030, Geneva during January, 2016 and IAP also invited him as Panelist on Science Advise in Times of Disaster Emergencies in South Africa during 28 February – 2 March, 2016; Science Council of Japan together with UNISDR invited him for Tokyo Global Forum on Disaster Resilience during November 23-25, 2017 for contributing towards Disaster Risk Mapping. He is also associated with prestigious programme such as Chair - ISC-CODATA-PASTED and Member Earth System Governance.

He was awarded the prestigious Japan Society for Promotion of Science (JSPS)'s Research Fellowship at Hiroshima in 2013 and Several Travel Fellowships / Support from UNEP, UNITAR, UNISDR, IAP, UNU, UNCRD, WCRP, IAHS, IGU, NASDA, INSA, UGC, SICI, MAIRS and University of Delhi etc. for participating and presenting papers, Chairing sessions and discussing research projects in about 40 countries like USA, Canada, Mexico, Japan, Australia, France, Finland, Denmark, Spain, U.K., the Netherlands, Norway, Germany, Switzerland, Russia, Georgia, Armenia, Poland, Czech Republic, Mongolia, Malaysia, Thailand, Egypt, China, Taiwan, Tunisia, Sweden, Israel, South Korea, Ireland, South Africa, Brazil, Singapore, Italy, Luxembourg, Sri Lanka, Indonesia, Turkey, Nepal and Bhutan. Prof. Singh is specialised in Landuse, Water and Environmental Studies, Climate Change, Urban and Regional Development, Disaster Management, Remote Sensing and GIS.

To his credit, he has contributed 15 books, 35 edited research volumes and more than 235 research papers in national and international journals (i.e. Climate Dynamics, Current Science, Singapore Journal of Tropical Geography, Energies, Theoretical and Applied Climatology, Environmental Science and Policy, Physical Geography, Advances in Meteorology, Physics and Chemistry of the Earth, Agriculture, Ecosystem and Environment, Hydrological Processes, Mountain Research and Development, Journal of Mountain Science, Climate, Advances in Earth Science, Advances in Limnology, Asian Geographer, Environmental Economics, Tourism Recreation Research etc.). He was Special Series Editor of the prestigious journals like Sustainability, Advances in Meteorology, Physics and Chemistry of the Earth and NAM Today. He is Editorial Committee Member of Journal of Mountain Science. In 1988, the UNESCO / ISSC (Paris) awarded him Research and Study Grants Award in Social and Human Sciences. He was also associated with some of the prestigious international collaborative research programs such as ICSSR-IDPAD, CIDA-SICI, DFID and Ministry of Agriculture. He has supervised 35 Ph.D. and 81 M.Phil Scholars. He was also associated with Nordic Institute of Asian Studies, Copenhagen (Denmark) in 1998 and Visiting Professor for delivering invited Lectures at the University of Turku (Finland). He was one of the contributors in the famous 'The World Atlas - Earth Concise', Millennium House Ltd., Douglas IM2 4RW, Isle of Man, Australia. He was invited by UGC for preparing National Level CBCS Syllabus for Undergraduate Geography Programme in 2015. He is also Chair of the UGC's prestigious committee for preparing Learning Outcome based Curriculum Framework since July 2018. Recently UGC-Consortium for Educational Communication invited him as Academic Advisory Council for CEC MOOCS on SWAYAM. He has been expert in the prestigious Committees of the Government of India- Ministry of Environment and Forests, Department of Science and Technology, National Disaster Management Authority (NDMA), ICSSR, CSIR etc.

The Indian Geographical Society congratulates the Vice-President, Dr. R.B. Singh for his sustained and multi-faced activities for the development of Science and Technology in general and Geography in particular. Prof. Singh will lead us for the Centenary Celebrations of the Indian Geographical Society in 2024-2025.

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NRDMS-DST - Winter School on GEOSPATIAL TECHNOLOGIES

(Equivalent to Refresher Course)

NRDMS-DST, Government of India, New Delhi Sponsored

21 days Winter School on Geospatial Technologies

(17th February 2020 – 08th March 2020)

सत्यमेव जयते

Department of Science & Technology
Govt. of India

Organized by

Department of Geography
University of Madras
Guindy Campus, Guindy
Chennai – 600 025

Introduction

Geospatial Technologies are integrated approaches of exploration, analysis and problem solving methodologies applicable to Earth, Atmospheric, Social and other integrated sciences. The application needs knowledge in cartography, GIS, Remote Sensing, GPS, Geo computation areas and sound understanding of the respective subject domains (like Geography, Service provision, Disaster Management, Criminology, etc.,) OOP, Database Management and Web Technologies are other interest areas of Geospatial technologies.

There are Copyright, Proprietary software, Open Source initiatives, and Community based developments competing each other in the fields of training, development and applications of Geospatial Technologies. Open source and community based tools provide scope for research activities apart from zero cost investment and maintenance free resource setup for learning and applications. The winter school proposes to use QGIS, SAGA, PAST3, GeoDA and other Open Source tools for hands-on experience as part of the programme.

The candidates are expected to fairly versed with usage of computer software. There is need for open mind learning open source software tools and practicing them.

Programme

The Programme is studded with special lectures from key note speakers, theoretical presentations from subject experts and intensive practical hands-on experience of geospatial technology tools. This Winter School can be a great training experience for the participants. Preferably all afternoon sessions are practical sessions; morning sessions are theoretical perspective and software startup programmes. There is also field visit and mini project completion schedule.

Who can Apply?

This Winter School is open for faculty members of Universities, Colleges, Research Organizations, Urban Planners and practicing geospatial initiators in Municipal Corporation, Central and State Government Organizations.

The Outline of the Programme

(a) Introduction to geospatial technologies – Geomatics, Geoinformation and Geospatial analysis – Modelling
(b) Cartography, Projections, UTM System, Types of Maps, Number of Classes and Class Interval Selection
(c) QGIS – Basics, Analysis and Applications
(d) Remote Sensing – Satellites, Sensors, Data Products, Resolutions and Applications
(e) SAGA – Basics, Display, Ratioing, Classification, Visualization and Modelling
(f) Socio-economic GIS and GeoDA
(g) Understanding Statistics, Statistical Diagrams, Analysis and Applications – PAST3
(h) Introduction to DBMS – OORDBMS – use of PostGreSQL and SpatialLITE
(i) Project Management – Mini Project Organization
(j) Participants interaction and observations

The Institution and the Department

University of Madras is historical and well-known institution all over the world. It had won several laurels and produced eminent personalities in academic, industrial, political, social and public welfare fields. Historically, it is known as Mother of many Universities in the South. The University of Madras is spread over in six campuses. The Physical, Chemical and Earth & Atmospheric Sciences Departments are housed in Guindy Campus – surrounded by Anna University, IIT Madras, Central Leather Research Institute (CLRI), and MGR Medical University and also the states prestigious Centenary Library. Opportunities are available for training and research in several branches of Arts, Science, Technology, Paramedical and Languages.

The Department of Geography, is one of the oldest Geography Departments in the country. First of its kind, it introduced courses in M.Sc. Applied Geography, M.Sc. Spatial Information Technology, M.Tech. Geoinformatics and PG Diploma in GIS Management. In recent years, It also offers courses on M.Sc. Geoinformatics (Private Study), M.Sc. Geography under Distance Education. Department is the house

of the prestigious Indian Geographical Society (IGS). The Department is fortunate to get funding from DST-FIST, UGC-SAP, UGC-CPEPA for its infrastructural development and strengthening teaching programmes. The Department has state of the art lab for GIS and Remote Sensing Applications. To train 40 – 50 candidates at the same time, it has lab facilities with necessary software installed and internet connectivity.

The Application Process

Link to the Website: http://www.dst-iget.in/

Application form Page: http://dst-iget.in/index.php/applicationform

Accommodation

Accommodation shall be provided only to the outstation participants on sharing basis. Request for family accommodation may be arranged with extra charges depending upon the availability / outside hotel or guest house.

Travel

For travel allowance a maximum of AC three-tire fare or travel by Duranto (whichever is shortest between the origin and destination) shall be reimbursed on production of original travel documents (Tickets). Those who are travelling by bus the expenses shall be reimbursed on production of tickets.

NO TRAVEL FARE by Taxi, Car or Private Luxury van shall be entertained.

Contact

Department Office: 044 22202891
HOD Office : 044 22202286

Coordinator
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Statement about ownership and other particulars about

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

Form IV

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5.	Editor's Name Nationality Address	Dr. K. Kumaraswamy Indian ICSSR - Senior Fellow Department of Geography Bharathidasan University Tiruchirappalli - 620 024
6.	Names and Address of Individuals who own the journal and society	The Indian Geographical Society Department of Geography University of Madras, Guindy Campus Chennai - 600 025

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