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RESEARCH ARTICLE

CHANGE IN MORPHOLOGY AND ENVIRONMENT OF HUBLI- DHARWAD TWIN CITIES IN THE WAKE OF URBANIZATION – USING GEOSPATIAL TECHNIQUES

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Abstract

Most of the urban centers in the world are expanding to accommodate over flowing population, and this in turn is causing drastic change in the nature of the landscape of the cities. Urbanization is a process which is taking place at a drastic rate with or without proper planning strategies (Hagerstand, 1995). Unplanned expansion of cities have created unsolvable issues like conversion of agricultural lands, reclamation of water bodies, creation of slums, generation of urban solid and liquid waste etc. These issues are attracting the attention of Urban/ environmental researchers for finding appropriate measures to create a healthy environment for residents. In this direction the investigators have selected Hubli- Dharwad twin cities to study the process of urbanization and its impact on morphology and environment. In the recent past, morphology of the study region has been undergoing rapid change due to rapid growth of population and establishment of industries. This change has occurred all along the National High way, and in and around Hubli- Dharwad city for commercial, administrative and residential purposes. In the present study an attempt has been made to classify the satellite images for land use and land cover and find out the temporal variation, and an attempt is also made to understand the impact of urban changes on environment, particularly alteration in temperature and rainfall. The morphological changes have been analyzed by using LANDSAT, TM (1975 and 1989) and IRS LISS III (2011) images at different time period. The satellite images of 1975, 1989 and 2011 were analyzed to detect the temporal changes in the land use and land cover. The topographical maps (1:50,000), ARC GIS (10) and ERDAS (9.1) software packages were used to process the satellite images, generate data and preparation of final layout. The study makes use of Bands 1, 2, 3 and 4 of LANDSAT, TM and IRS LISS III data with spatial resolution of 30 M. and 23 M. respectively.

It has been noticed that land use in Hubli- Dharwad city has undergone significant changes within a span of three decades. This change is due to over flowing population and establishment of industries. The changes can be mainly observed through the agricultural area and water bodies reclaimed for built up area and industrial purposes. During 1975, the study area recorded about 4,914.11 hectares of Agricultural land, and in 2011 it has decreased to 2,320.39. It is witnessed that within a span of 36 years, about 2,593.72 hectares of agricultural land decreased. It is noticed that there is a phenomenal increase in the Built up area from 1,080.94 hectares (1975) to

3,852.78 (2011). The study area was known for its water bodies and there were more than 100 small and big water bodies and these water bodies maintained healthy climate of the city and fed water for its residents and domestic animals however, due to rapid growth of urbanization these water bodies are reclaimed for residential and industrial purposes. As a result of this, hardly few water bodies are left, and a visible change in temperature and rainfall can be noticed in the twin cities. Another aspect of these changes is that the cities are facing scarcity of drinking water which was once known for surplus water supply.
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INTRODUCTION

Urban area in all parts of the world is subjected to various changes such as physical landscape, socio-economic, environmental etc. These changes are universal phenomenon taking place due to over flowing population, industries, vehicles etc. The process of urbanization is taking place at a drastic rate with or without proper planning strategies (Hagerstand, 1995). Unplanned outgrowth and expansion of cities have serious impact on the local ecology and on the substances of natural resources (Ramachandra, 2012). The impact of urban expansion is observed on large scale on physical environment particularly on conversion of agricultural land, reclamation of water bodies, creation of slums, generation of solid and liquid wastes etc. These rapid changes are attracting the urban and environmental researchers for finding appropriate measures to create healthy environment for the residents.

Bharath (2012) examined that the rapid urbanizing landscapes with high population density often face several crises due to inadequate infrastructure and lack of basic amenities. Thus to check the growth of unplanned urban areas at local and global scale has become urgent task of urban researcher to find out the controlling measures in order to mitigate urban problems. Overall information pertaining to urban changes is critical to sustainable urban land use planning and management (Bannasly and Barr, 1996). Such information is available in documenting urban growth and improving urban land use plans (Bullard and Johnson, 1999).

Traditional survey and mapping methods have been used for urban planning and management for a long time. These methods are often time consuming, tedious and expansive (Rawashdeh and Saleh, 2006). Remotely sensed satellite data having a good spatial and spectral resolution required over frequent time interval is all the most widely used tool. The remote sensed data offer permanent and authentic record of spatial pattern, which is valuable for verification and assessment purpose (Prakash and Gupta, 1998). Keeping this , digital image processing techniques are used to detect the changes in land use of Hubli-Dharwad twin cities. This study may help in decision making for sustainable urban development.

Study Region:

Hubli- Dharwad twin cities are 20 km apart, lies on the Deccan plateau in North – western Karnataka. They were independent towns till they were merged into a single municipal corporation in 1962. Many villages like Rayapur, Unkal, Bairidevarkoppa, Navanagar, Nuggikeri, Kelgeri, Yettingudda etc were merged during the subsequent years and now it covers an area of 202.28 sq. kms and its population was 9,43,788 in 2011.The area covered by Hubli- Dharwad Municipal Corporation has undulating topography with height varying from 600 to 750 meters above mean sea level.

Hubli- Dharwad twin cities are located between $15^0\ 31^I\ 5^{II}$ North to $15^0\ 20^I\ 30^I$ North latitudes and $74^0\ 54^I\ 25^{II}$ East to $75^0\ 10^I\ 25^{II}$ East longitudes with total area of 214.28 sq. Kms (2011) as against 41.86 sq. Kms (1961) of earlier area (Fig. 1) After the merger of Hubli and Dharwad towns under a single municipal the growth has been enormous. The actual distance between Dharwad and Hubli is 20 kms. Today it is the fastest growing cities in Karnatak next to Bangalore. The climate in this area is pleasant though minimum temperature rise to 37^0 C in April. June to September is the main rainy season with about 60 per cent of total annual average rainfall of 81.9 cm at Dharwad and 69.68 cm at Hubli.

Objectives:

The specific objectives of the present investigation are:

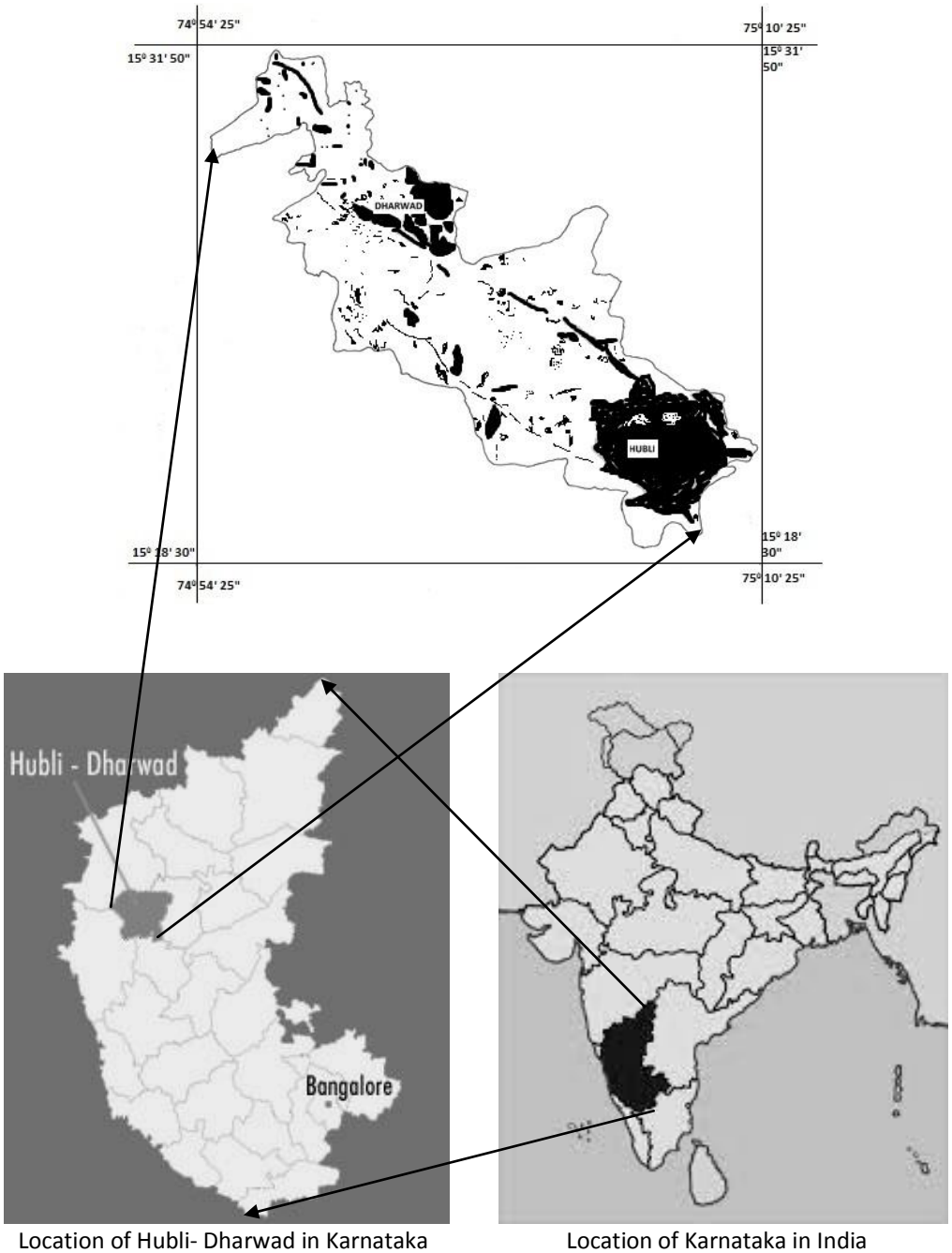
- To identify the spatio- temporal dynamics of land use of Hubli- Dharwad twin cities using satellite images and geospatial techniques.
- To analyze the process of urbanization and factors responsible for environmental changes
- To identify the morphological units and changes
- To analyze the changes in climatic conditions particularly temperature, rainfall, humidity, etc.

Hypothesis:

The following hypotheses are being formulated to achieve the above mentioned objectives.

- There is positive correlation between the process of urbanization and environment of Hubli and Dharwad twin cities.
- The areal expansion is associated with size of population and negative impact on existence of water bodies, agricultural land, waste land etc.,

LOCATION MAP OF HUBLI- DHARWAD TWIN CITIES



Location of Hubli- Dharwad in Karnataka Location of Karnataka in India

Fig. 1

Data Base and Methodology:

The change in land use and land cover for about 36 years of time period was analyzed by using satellite images of 1975, 1989 and 2011. The two year image i.e. 1975 and 1989 LANDSAT TM images are downloaded from Earth Explorer and IRS LISS III (2011) image was downloaded from Bhuvan. After scanning topographical map (1: 50,000) of study area it was georefered by using Arc GIS 10 software.

At the beginning the base map of the study region was prepared with the help of topographical map 1: 50,000 scale. The study area spread over four topographical maps i.e. 48 M/2, 48 M/3, 48 M/14 and 48 I/15. To analyze the changes in land use and land cover and their spatio- temporal pattern, a set of three satellite images were acquired for the years 1975, 1989 and 2011. LAND SAT. Thematic mapper (TM) images were downloaded through Earth Explorer for the year 1975 and 1989. For the year 2011 IRS P6 LISS III image was selected for the analysis.

The sub setting of satellite image was performed for extracting study area by taking geo referred out line boundary of Hubli- Dharwad municipal corporation map. The subset images were then re-projected. The downloaded satellite images were used to plan the survey in the study area using FCC (False Color Composite) format. The tracing data were collected form field using GPS survey technique. The GPS points were downloaded and overlaid on the imagery and used for further image processing.

Digital analysis of land use and land cover changes has been carried out through FCCs of study region. The rectified satellite images of the study area were then classified in ERADAS 9.1 software, and with the help of training data collected from various training sites were applied to entire image, and multispectral pixels of the study area images were classified into five broad land use classes i.e. 1) Builtup area, 2) Agricultural land, 3) Water bodies, 4) Waste land (open shrubs and terrain), and 5) Vegetation. Secondary data has been collected from Hubli- Dahrwad urban development authority and Municipal Corporation. Data relating to climatic elements has been collected from University of agricultural sciences

Results and Discussions:

Built-up area, water bodies, adjusted agricultural land, waste land (open shrubs and terrain), and vegetation are some of the important salient features of major urban areas and it is generally accepted as the parameters for quantifying urban sprawl (Torrens and Alberti, 2000). Image extraction, rectification, restoration, and classification are the standard image processing techniques used in the present study to delineated land use and land cover of Hubli-Dharwad twin cities. Sampling training points were identified in the field by using Global Positioning System (GPS) receiver and corresponding attribute data was obtained by field observation and interacted with the local people. Based on these evidences, and various land features, image classification was done and land use and land cover area zones were extracted for the year 1975, 1989 and 2011. Fig. 2a.b and c

Land use and Land cover changes.

Land use and Land cover are dynamic words used for the analysis of salient features of land. These are closely related but not mutually exclusive. They are interchangeable as the land use is inferred based on the land cover but there should not be any confusion in the use and interpretation of these two terms.

Land use: Series of activities on land carried out by humans with intension to obtain products or benefits through the use of land.

Land cover: Land cover refers to the characteristics Earth's surface, as represented by natural elements. Vegetation, Ice, water, sand etc. is some of the examples

The total geographical area along with its land use and land cover has changed over the decades. The administrative boundary the Hubli – Dharwad district has also increased after 1989. From the Figure 1 and Table 1, it can be clearly seen that the total geographical area has increased to 7875.9 hectares from 1975 to 2011.

Phase I 1975 to 1989: This phase covers a period of 14 years. The land use and Land cover change pattern have been identified with the help of survey of Indian toposheets, and Satellite images were downloaded from earth explorer for 1975 and 1989.The study area covers an area of 21,757.416 hectors. During this phase positive changes are noticed in built up area, vegetation and wastelands and negative changes were recorded in agriculture and water bodies. Table. I &II show that total area under agriculture was about 4,914.11hectares in 1975 which decreased to 3582.92 hectares in 1989, the net decrease by 2,593.72 hectares (27.09 %) within a span of 14 years. This

LAND USE AND LAND COVER, 1975-2011

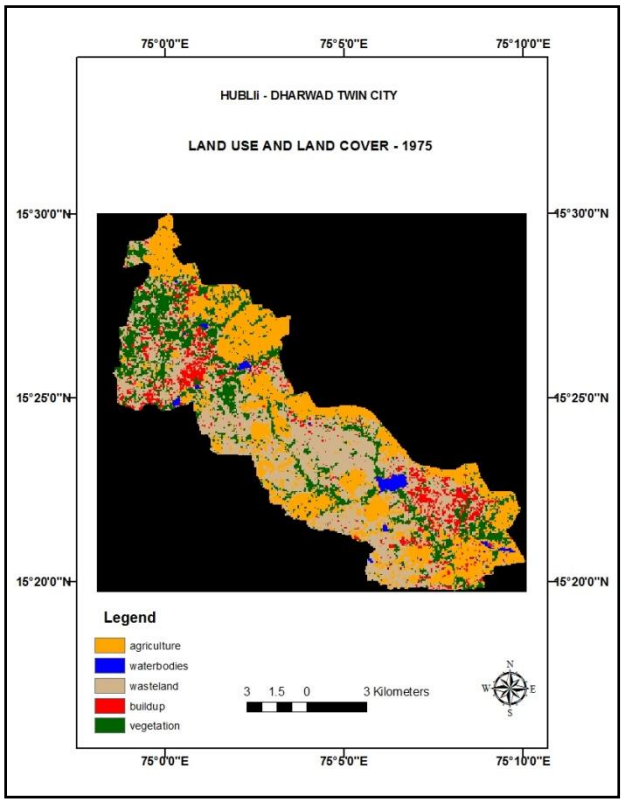


Fig. 2a

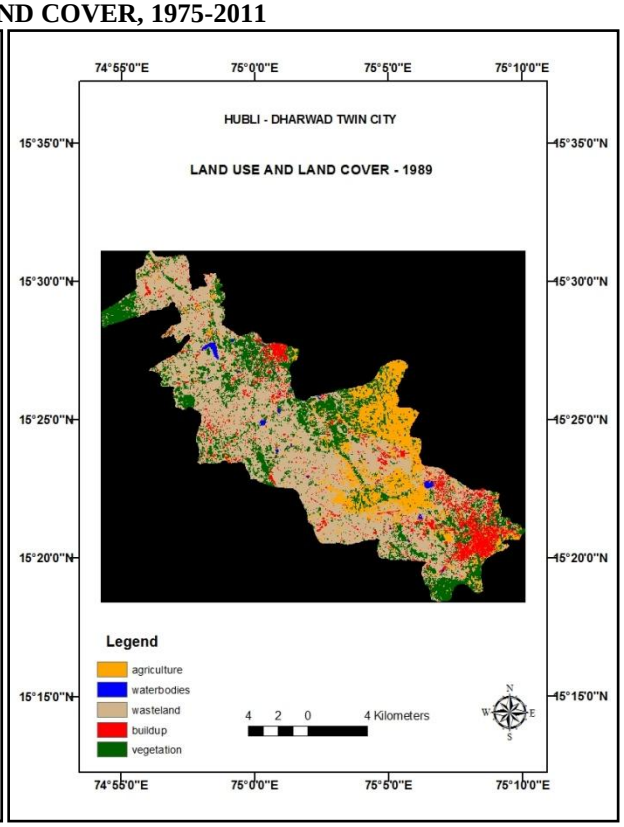


Fig.2b

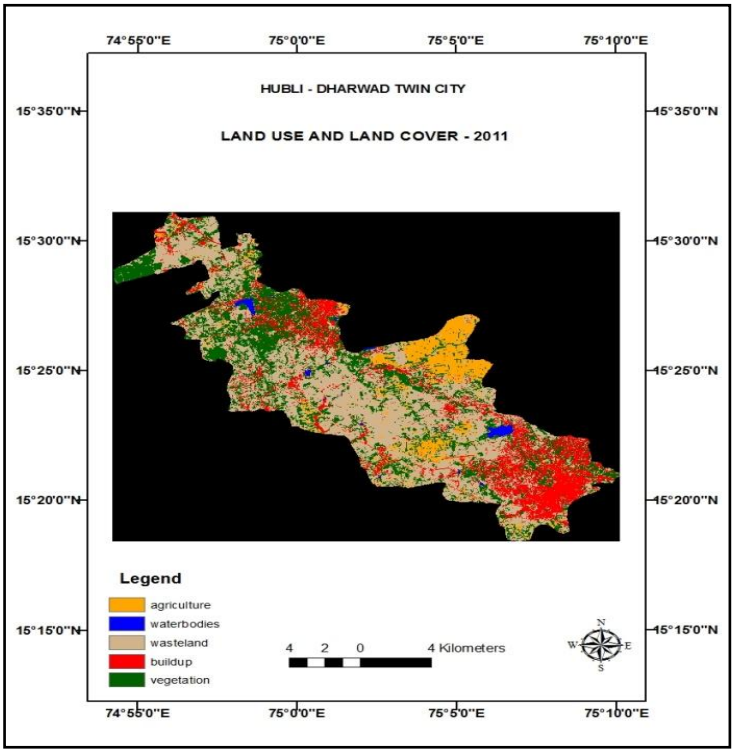


Fig.2.c

happened because of the increase in the built up area, waste land and area under vegetation. During this period many water bodies are reclaimed for residential, commercial and industrial purpose, which results in decrease of water bodies by 65 hectares (29.51%). It has been noticed that about 285.3 (126.78) %) hectares of wasteland increased.

Normally the trend for wasteland shows negative growth as the built up area increases and occupies the waste lands but in the present study along with growth of built –up there is growth in waste land too. It may be due to the fact that many surrounding villages come into the city limit, and many builders purchased the land and kept vacant. Total area of built up area has increased from 1,080.94 hectares in 1975 to 1928.93 hectares in 1989. This particular category reported net increase by 847.99 hectares. There is no deforestation activities reported in the study area as a result, the area under vegetation has increased from 2146.24 hectares in 1975 to 4846.37 in 1989. This is due to the fact that many mango orchards have come up at the out skirts of the city. It is a healthy sign to maintain the balance in the environment

Hubli city has developed predominantly in South, West and all along the National High way No. 4 towards Dharwad city where as, Dharwad city is developing in all direction, however, there is very slow development towards its North as the area does not show favorable condition for built up. Between both cities, most of the central and state government offices have come into existence. Apart from this industrial area has also developed.

Table. 1 Land use and Land cover in Hubli-Dharwad twin cities (Area in Hectares)

S. No.	Land use and land cover cotegories	1975	1989	Changes from 1975 to 1989	2011	Changes from 1989 to 2011	Overall Changes (1975 – 2011)
1	Agricultural land	4914.11 (35.42 %)	3582.92 (16.47 %)	-1331.19 (27.09 %)	2320.39 (10.67 %)	-1262.53 (35.24 %)	-2593.72 (52.78 %)
2	Water bodies	221.582 (1.60 %)	156.196 (0.72 %)	-65.386 (29.51 %)	202.207 (0.93 %)	46.011 (29.46 %)	-19.375 (8.74 %)
3	Waste lands (open shrubs and terrain)	4,957.65 (35.73 %)	11,243 (51.67 %)	6285.35 (126.78 %)	9480.39 (43.61 %)	-1762.61 (15.68 %)	4522.74 (91.23 %)
4	Buildup	1080.94 (7.79 %)	1928.93 (8.87 %)	847.99 (78.45 %)	3852.78 (17.72 %)	1923.85 (99.74 %)	2771.84 (256.43 %)
5	Vegetation	2700.24 (19.46 %)	4846.37 (22.27 %)	2146.13 (79.48 %)	5884.77 (27.07 %)	1038.4 (21.43 %)	3184.53 (117.94 %)
Total		13,874.522 (100 %)	21,757.416 (100 %)		21,740.537 (100 %)		

Sources: Author computed from the LISS III (23 meter resolution) and Land sat TM (30 meter) resolution. Note: Figures in the brocket show percentile of area

Table. II Changes in Land use and Land cover in Hubli-Dharwad twin cities, 1975-2011

S. No.	Years	Agricultural land (%)	Water bodies(%)	Waste lands (open shrubs and terrain)(%)	Buildup (%)	Vegetation (%)
1	**Changes from 1975 to 1989**	27.09 (- ve)	29.51 (- ve)	126.78 (+ ve)	78.45 (+ve)	79.48 (+ ve)
2	**Changes from 1989 to 2011**	35.24 (- ve)	29.46 (+ ve)	15.68 (- ve)	99.74 (+ ve)	21.43 (+ ve)
3	**Overall Changes (1975 – 2011)**	52.78 (- ve)	8.74 (- ve)	91.23 (+ ve)	256.43 (+ ve)	117.94 (+ ve)

Sources: Author computed from the LISS III (23 meter resolution) and Land sat TM (30 meter) resolution

Phase II. 1989 to 2011: Second phase studies the changes of land use and land cover which took place during 1989 to 2011. This notable period follow the same pattern of changes as in the first phase. Built up area, water bodies, and vegetation show positive changes where as agricultural land and waste lands show negative changes as most of the land converted in to build up. The land under agriculture was decreased by 35.24 per cent, during 1989 it was 3582.92 hectares and it decreased to 1262.53 hectares in 2011 (Table. II), the built up area was increase by 99.74 per cent. The trend and extent of twin cities is likely to continue with development of water bodies and vegetation by 29.46 per cent and 21.43 per cent respectively. Changes show that the corporation has taken certain measures to develop the existing tanks and maintain greenery in the cities by increasing area under vegetation during 1989-2011. Waste land occupied 11,243 hectares in 1989 and it reduced to 9480.39 hectares. The decrease in waste land is considered as healthy sign as the waste land is utilized for one or the other purposes (Fig.3).

The overall changes in land use and land cover for a period of 36 years show negative change in agriculture(-52.78 %), and water bodies by 52.78 per cent and 8.74 per cent respectively. Built up area indicates maximum change with 256.43 per cent followed by vegetation by 117.94 per cent.

Land use and land cover changes are essential components for the development of a district. It has negative consequences but, it is necessary to balance the natural environment and developmental activities. Degradation of environment, depletion of natural resources i.e. vegetation, water bodies, etc, increasing buildings and climatic change are some of the changes faced by this district.

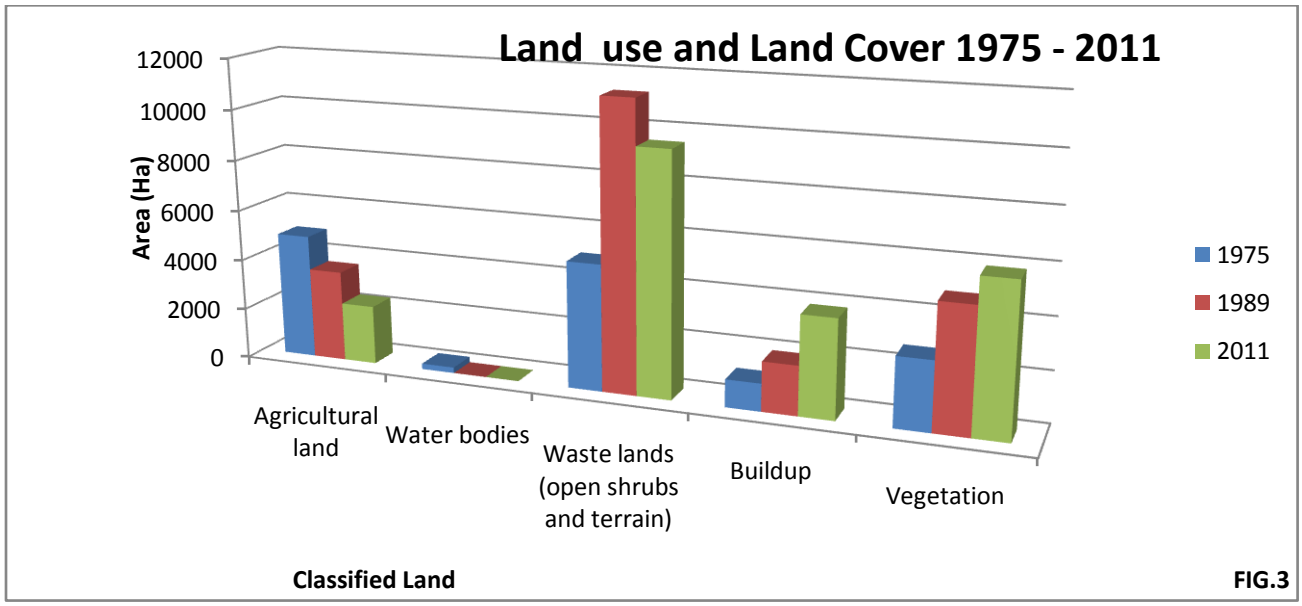


FIG.3

As per the above result, it can easily be marked out that built-up area has been increasing tremendously because of developmental phenomena. Increase in built up area causes increase in pollution and creates heat zone area. Considerably agriculture land is decreasing, which in turn causes decrease in greenery and scarcity of food to fulfill the needs of growing population. This is causing imbalance in ecosystem. It is need of today that development growth should increase in planned and balanced way. Agricultural land should not be used for built up or other purposes, instead of that land can be taken from waste land. So that agriculture area would not be wasted. Vegetation in Hubli – Dharwad district shows the increasing trend, which is good but it should not be at the cost of agriculture land. There are many wasteland area including open shrubs, which can be turned into greenery by using it for the purpose of growing trees. There were many water bodies in Hubli – Dharwad district, but because of careless attitude of the people and lack of information they are drying and many are reclaimed for other purposes like buildings. These are natural resources, so it has to be maintained and authorities and even public should run the restoration programme for recovering at least existing- water bodies.

CHANGE IN MORPHOLOGICAL UNITS AND POPULATION

Hubli and Dharwad were two separate towns before 1962. On March 2nd, 1962 these towns were merged into one municipal corporation, at that time the total area was 180.1 sq kms with a population of 2,48,489. Urban Development Authority was constituted in 1966 for proper and planned growth of Hubli-Dharwad municipal corporation area. The total area of twin cities was 182.30 sq kms in 1975 but the population was 3,80,100. In 1981 the total area of Hubli-Dharwad twin cities was increased to 192.03 sq.km and the population had increased to 5, 28,011, during this period of time 15 surrounding villages were merged into municipal corporation area. In the year 2001, the total area of twin cities was increased to 202.00 sq km. and the population was reached to 7, 86,089. During 2011 as many as 25 small villages came into municipal limitation, as a result the total area rose to 214 sq km. and population was 9,43,788.

Since the establishment of Hubli-Dharwad urban development authority various morphological units are rapidly developed which is responsible for diversified urban activities accommodating ever increasing population. Residential area, Commercial centers, Industrial area, and Transport network, Public and semi-public functions, Parks and open space etc. are the main morphological units identified in Hubli-Dharwad twin cities. The

continuously increasing urban population and their needs paved the way for the development of urban morphological units in various directions.

1. CHANGE IN RESIDENTIAL AREAS:

In the year 1975 the total are under residential use was 1,405 hectares which accounts for 35 per cent of the total area of the twin city, and 3,75,532 population resided in 66,063 houses. In 1989 the total residential area increased to 1,491 hectares and population was 6, 48,298 and 93,337 houses. In 2011 the residential area spread over 5,883 hectares which accounts for 43 per cent of its total area and population of 9, 43,788 residing in more than one lakh houses. Since 1989 to 2011, 63 surrounding villages were incorporated in Hubli-Dharwad corporation limitation. There is a rapid increase in the residential area, population and number of houses as well, due to better facilities, good condition and localities. The present growth of Hubli-Dharwad twin cities is towards university (west) all along the national highway No 4. i.e, towards Belgaum, Haveri. It is observed that the residential area and industrial is extending in agricultural land and as a result agricultural land is shrinking day by day.(Table.III)

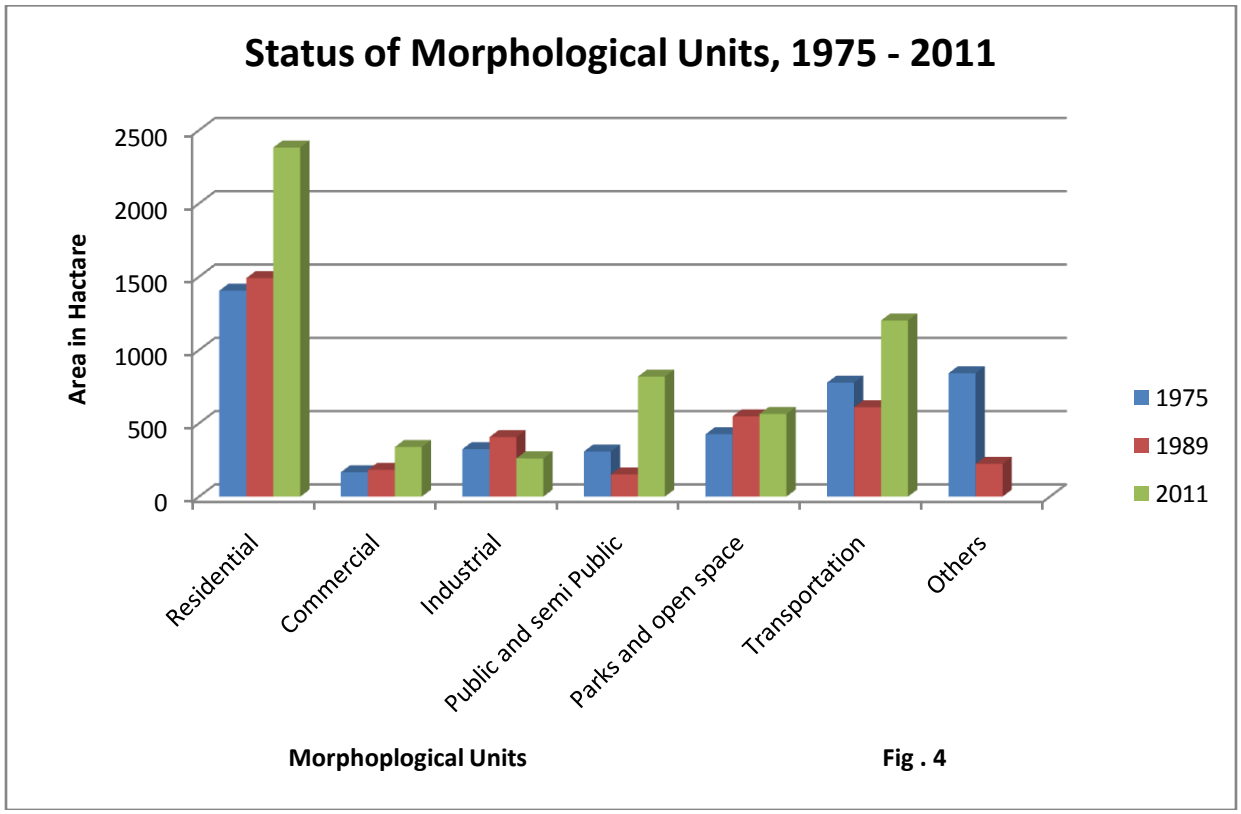


Fig . 4

2.CHANGE IN COMMERCIAL AREAS:

Since Mogal and British period Hubli city is known for business and commerce activities and serving commercial activities to the people of entire North Karnatak region, hence, it is called as Chota Bombay of Karnataka. The area under commercial activities was 165.99 hectares in 1975 and in 1989 it increased to 182.18 hectares; during 2011 this figure rose to 338 hectares which accounts 6.06 per cent of the total land use. It is observed that about 172 hectares of area under commercial activities was increased within a span of 36 years, which indicate that the growth was about 103. 62 per cent. It is due to the fact that the areas of market centers have spread in various sizes in both the cities. The commercial activities have been developed in central parts of both cities in order to cater to the need of the people Apart from these area the extension areas are also having the business which includes variety of shops fulfilling daily needs of people. Recently wholesale business of cotton, chilies, some vegetables, onion etc, are shifted to the newly constructed spacious areas called APMC located between Hubli-Dharwad.

Table. III: Change in morphological units – 1975- 2011 – (Area in hectares)

Sl No	Land use/morphological units	1975	1989	Change 1975-1989	2011	Change 1989-2011	Over all changes 1975-2011
1	Residential	1404.85 (33.07)	1490.68 (42.27)	85.83 (5.75)	2382.02 (42.77)	891.34 (0.37)	977.17 (69.55)
2	Commercial	165.99 (3.90)	182.18 (5.04)	16.19 (8.88)	338.00 (6.06)	155.82 (46.10)	172.01 (103.62
3	Industrial	323.88 (7.62)	405.66 (11.23)	81.78 (20.15)	260.61 (4.68)	-145.05 (-55.65)	-63.27 (-24.19))
4	Public and semi Public	307.69 (7.24)	151.82 (4.20)	-155.87 (-102.66)	819.35 (14.72)	667.53 (81.47)	511.66 (166.29)
5	Parks and open space	425.10 (10.00)	547.36 (15.15)	122.26 (22.33)	563.76 (10.13)	16.4 (2.90)	138.66 (32.61)
6	Transportation	777.32 (18.30)	610.52 (16.89)	-166.8 (-27.32)	1201.96 (21.60)	590.48 (49.12)	424.64 (54.62)
7	Others	842.10 (19.82)	223.07 (6.17)	-619.03 (-277.54)			
	Total	4246.93	3611.29 (100.00)		5568.70		1321.77 (31.12)

Source: Hubli- Dharwad Urban development authority 2012. Figures in the bracket indicate percentile

3. CHANGE IN INDUSTRIAL AREAS:

Industrial activities are universal features for the growth of urban centers irrespective of urban size. Concentration of industrial activities in the study area was over 323.88 hectares in 1975, where as in 1989 this figure reached to 405.66 hectors with a net increase of 81.78 hectares. In the year 2011 the total area under industrial activities was decreased to 260.60 hectors (Table-III), due to closing of some of industries. Food processing, cotton ginning, wood working, steel furniture, printing, railway workshop, service industries, KSRTC regional workshop are some of the important industries found in Hubli city where as Dharwad city having oil mills, ginning and processing factories, Tiwac factory etc.(Fig. 4)

4. CHANGE IN PUBLIC AND SEM-PUBLIC AREAS:

Cities are hub of social and cultural activities where education, recreation, art, pageantry etc are important features to attain the needs of people,. Various types of institutions are functioning in the cities, government and non government offices, and social institutions, clubs, theatres, educational institutions are common features in all the urban centers. These features which occupy a large part of urban land use are found in all the morphological units.

In the year 1975 the area under public and semi- public activities was 307 hectares; in 1989 it increased by 155.87 hectares. In 2011 it has increased to 819.35 hectares which accounts 14.72 per cent of the total area. Within a span of 36 years the area under public and semi- public was increased by 511.66 hectares. This increase was mainly due to many new buildings like hospitals, libraries, schools and other public offices have resulted in concentration of area meant for public and semi-public uses.

5. CHANGES IN PARKS, PLAY GROUND AND OPEN SPACE:

To maintain the urban beauty and balance, environment parks, playground and open space are essential components. Parks are the lungs of urban place where people meet and spend their time. The study area meant 425 hectares of land for open space and parks during 1975 which accounts 10 per cent of total area but it increased to 547.36 hectors in 1989 accounting 15.15 per cent of the total area. In 2011 the area under the same category rose to 563,76 hectares with a increase of 16.4 hector. Changes of area under parks, playground and open space from 1975-2011 was 138.66 hectares which indicates 32.61 per cent of increase. The aerodrome, the Nehru stadium, the rail play ground, KMC grounds are the important recreational points in Hubli. Azad park, Botanical gardens and university, Kittur Chennamma park, R.N.Shetty stadium, KCD play ground, university ground are the important open space which are maintained and located in different parts of the twin cities.

6. CHANGES IN TRANSPORT SYSTEM

Well planned and maintained transport network system within the urban area helps in development of different activities in the urban area. In the year 1975 twin cities covered 777.32 hectares of area by transport network which contributes 18.30 per cent of the total area used for different purposes. By the year 2011, the area under transport system was increased to 1,201 hectares which account for about 21.60 per cent of the total area. The national highway No-4 passes through the twin cities, and the state highways such as SH-28, SH-65, SH-34, SH-42 connects Bagalkot District, Bijapur District, Bellary and Goa State respectively. The 6 lane road transport network between Hubli-Dharwad cities is in progress. The roads within the twin cities are also in good condition and connect many surrounding villages. Apart from road transport Railway station, the junction and head quarters of South Western railway zone is connected by the major interior roads.

CHANGE IN CLIMATIC CONDITION:

Ever increasing urban population, vehicles, industries etc have responsible for most of the agglomeration of the world have become heat islands consuming large quantity of energy and consequently releasing large account of polluting substance which have been added into atmosphere, water and soil. The quality of weather in the urban areas can be measured by assessing the presence of foreign sustains which are present in the normal air. This present paper examines the climatic conditions including temperature, rainfall, humidity etc and pollution condition the investigator chosen the period form 1975-2011 i e a duration of 36 years. This is the period during which drastic changes in Hubli- Dharwad have been taken place in terms of modern industrialization, development in infrastructural facilities and morphological development.

Table IV.MEAN MONTHLY AND ANNUAL ELEMENTS OF CLIMATE- 1975, 1989 AND 2011

1975

Elements	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annu
Max c^o	29.8	32.6	32.6	36.3	36.7	27.6	26.2	25.6	28.6	31.4	29.8	29.3	30.5
Min c^o	14.7	17.7	19.2	21.0	21.4	21.2	20.7	20.2	19.7	19.0	16.6	13.9	18.8
R.H.%	71	73	61	85	90	92	84	90	83	64	61	56	76
R.F	0.0	0.0	0.0	109.5	33.5	159.2	202.2	149.4	127.2	43.5	23.0	0.5	848%

1989

Elements	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annu
Max c^o	30.3	33.2	34.3	37.2	35.7	28.3	27.3	26.4	28.8	31.2	29.8	29.1	31.0
Min c^o	76	15.0	18.4	20.2	20.7	20.3	20.0	19.6	19.2	18.3	14.9	13.7	17.8
R.H.%	0.0	70	67	64	65	83	86	87	80	73	78	77	75
R.F	12.1	0.0	3.8	7.2	46.8	97.7	185.7	61.6	82.9	7.5	44.4	7.4	545.6

2011

Elements	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annu
Max c^o	30.7	33.2	36.0	36.3	37.0	30.9	27.4	27.1	27.5	29.6	29.4	28.9	31.16
Min c^o	15.0	16.3	18.9	21.3	21.5	21.5	21.4	20.4	20.3	19.1	14.9	13.1	18.60
R.H.%	49	43	42	53	55	76	83.0	81	85	70	51	53	62
R.F	4.8	Tr	Tr	75.0	29.4	151.0	290.2	138.8	194.5	89.4	38	Tr	1011.1

Source: Indian meteorological Dept. University of Agricultural Science, Dharwad.

It is generally believed that interactions of human with the environment are enormously complex and subsequently changes in the environment. The agglomeration of industry and housing in urban complexes creates.

The industry, housing, vehicle etc important urban complexes create local modifications to the earth's surface and atmosphere. In most urban areas air temperature recorded near their centers of activity where building density and height are usually greatest are frequently higher than in the surrounding sub-urban areas. The alteration of the earth's surface always represents the direct re shaping of land form by urbanization if not the creation of entirely artificial land forms. Here an attempt has been made where in the local climate of Hubli-Dharwad has been analyzed considering the annual average pertaining to temperature and rainfall. During 1975 the mean annual temperature of Hubli-Dharwd urban region was 30.5^oc. The mean maximum temperature of the study varies from 27^oc to 33^oc and the minimum temperature varies from 16^oc to 25^oc . (Fig. 5) In 1989 and 2011 the mean annual temperature has been increased to 31^oc and 31.16^oc respectively. The mean annual temperature recorded for the entire region as whole reflects marginal changing temperature by 0.16^o c during a period of 36 years ie from 1975-2011. But the temperature recorded in the entire parts of Hubli-Dharwd urban system exhibits variable temperature conditions. The measurement has been made to know the temperature variation between central streets and surrounding areas. The record shows 1.9^oc higher temperature than surrounding areas.(Table. IV)

The occurrence of rainfall in the area under study was highly magnitude of uncertainty. The year 1975 received an annual rain fall of 848 mm. During 1989 it has decreased to 545.6 mm and in 2011 it increased to 1011.1. It is observed that though there is high fluctuation in the rain fall from year to year and decade to decade there are no drastic changes in weather condition of Hubli-Dharwad region.

MEASUREMENT OF AIR QUALITY

Air is a natural gift to the living organism. If it gets polluted it can cause serious respiratory diseases, physical damage, loss of vision, even death etc. The air quality degrade mainly due to the developmental progress especially industrial emission, increasing number of motor vehicles and poorly maintained vehicles use of unleaded petrol etc.

CLIMATIC ELEMENTS - ANNUAL AVERAGE

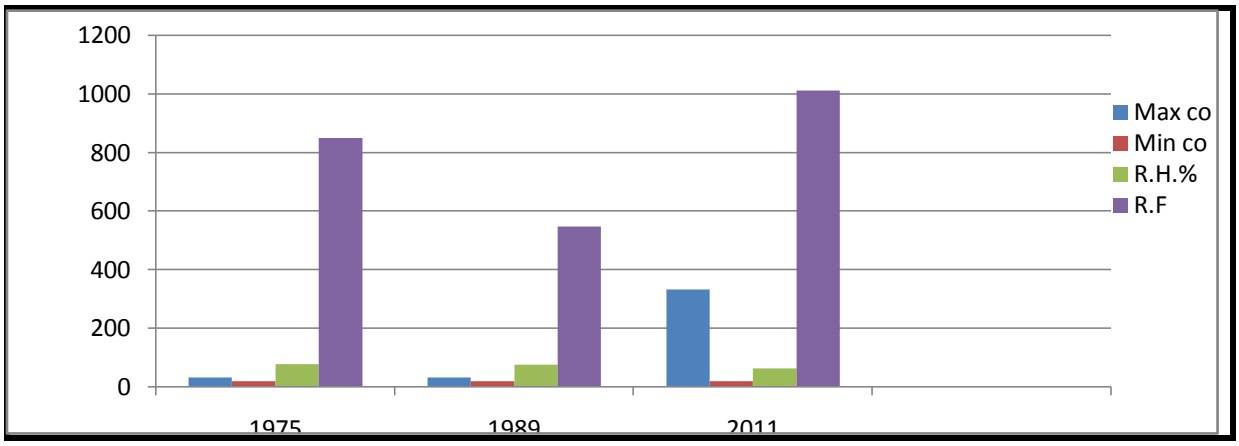


Fig.5

The study area, registered 939 industries, in 2011 where as in 1989 there were 485, most them are engineering in nature, of there only 71 and 21 industries covered under hazardous waste management rules and under plastic manufacturing rules respectively The total number f vehicles registered at RTO are 1,78,571 which includes two wheelers, three wheelers, cars, trucks etc. The increase in number of vehicles gives rise to serious congestion problems on the road and also pollutes the air.

Hubli-Dharwd twin cities system is the second largest urban agglomeration in Karnatak state, spreading over an area of 214.28 sq kms. The population of Hubli-Dharwad twin cities has increased from 81143 in 1901 to 7, 86,078 in 2011. The number of vehicles were 99800 (1989) and are increased to 2,58,495 under NAMP (National Air monitoring program) 14 station are being monitored in Karnataka state of these two stations are located in the study region one at Ranichanamma circle Hubli (Commercial area) and other one at Lakamanhalli industrial area. The air quality monitoring in these two locations is being carried out a frequently of twice a week for 24 hours for suspended for suspended matter, (spm), Respirable suspended particulate matter (Rspm), sulpher dioxide (SO_2) and Nitrogen Oxides(NO_x), and the air quality index is calculated from the observed elements by using the formulas. The air quality was caluculated for both the selected stations. The air quality index is classified into two categories ie. 0-25 clean air and 26 and above light air pollultion.

SL.No	Selected Stations	TSPM	RSPM	NO_x	SO_2	AQI Value	State of Air Based on AQI
1	Ranichannnamma circle-Hubli (Com and Heavy traffic zone)	954	293	23	10	29	Light Air pollution AQI-264 and above
2	Lakamanahalli Industrial Area	92	47	06	02	05	Clean Air AQI blow 22

Table: Air quality index values of two station of Hubli-Dharwad twin cities- Mg/m^3

It is noticed that the Rani Channamma circle Hubli has maximum concentration TSPCM and RSPM-2010. It is one of the oldest spot where different places road takes diversion and most of the vehicles pass through the city form this circle. The maximum concentration of 5 pm in Rani channamma circle was 392 and 26 Mg/m^3 is the minimum concentration while maximum RSPM in this place is 162 and12 mg/m^3 is the minimum. Lakamanahalli industrial area has maximum TSPM concentration of 550 and 32 mg/m^3 of minimum and the TSPM concentration of maximum RSPM are 224 and minimum of 12 mg/m^3. The stations were found within the permissible limit of 80 mg/m^3.

CONCLUDING REMARKS

It can be concluded that proper planning and management of urban space can minimize the adverse effect of environment. The land use and land cover of Hubli- Dharwad cities has been extended over a large area after merging of two towns in single Municipal Corporation and the establishment of urban development authority. A lot of negative changes have taken place in agricultural land where as, build up area recorded tremendous positive change. Similarly negative and positive changes are also marked in other urban features. Before 1962, the total area was 180.1 sq km. with a population of 2, 48,489. In 1981 the total area of Hubli-Dharwad twin cities had increased to 192.03 sq.km and the population increased to 5, 28,011, during this period of time 15 surrounding villages were merged into municipal corporation. In the year 2001 the total area of twin cities increased to 202.00 sq km. and the population reached to 7, 86,089. During 2011 as many as 25 small villages came into municipal limitation, as a result the total area rose to 214.24 sq km. and population shot to 9, 43,788.

Among all the morphological units agricultural land show declining trends from 4,914.11hectares in 1975 to1, 262.53 in 2011 hectares, within a span of 36 years more than 50 per cent of land has decreased and built up area has increased from 1080.94 hectares in 1975 to 3852.78 hectares in 2011, it depicts that more than 100 per cent change has taken place in this category. Land under vegetation has recorded impressive positive change and that is healthy symbol for the urban growth and its environment. It is a general trend that the city grow by utilizing agricultural and waste land as a result the area of these two urban feature certainly decrease, but it is not so in case of waste land of the study region. In fact waste land has increased rather than decrease, the fact is that many builders purchased the agricultural, and other land, residential and industrial lay out but due to one or the other reasons the land was kept vacant for decades and hence waste lands maintained its pace of growth.

Human activities certainly have its impact on any kind of land forms and the urban land undoubtedly changes. The record shows 1.9^{o}c higher temperature than surrounding areas. Urban heart land generates the heat due to human activities and vehicles. It is recorded that the temperature of the heart land Hubli- Dharwad cities is 1.9^{o}c higher than the surrounding areas. It is observed that the average annual rainfall has decreased by 30-40 mm. The concentration of Respirable suspended particulate matter (Rspm), sulpher dioxide (SO_2) and Nitrogen Oxides(NO_x) and other particulates have increased as a result not only air quality lost but also temperature has gradually increased.

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