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Spatio-Temporal Land use Changes along Mula-Mutha River Terraces within Pune Municipal Limits–A GIS Approach,Pune, India

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ABSTRACT: Mula-Mutha river banks and terraces are greatly modified/altered in last 15–20 years with undesired and use activities such as slums, brick kilns, waste dumping ground etc. Such a manmade control may cause more problems than they solve. The aesthetic look of these terraces has been altered with improper use and misuse. This work attempts to analyses spatio-temporal land use changes along Mula-Mutha River Terraces within Municipal Limits. It is suggested that wherever possible, the green belt should be preserved and enlarged. Valuable open area within Pune City along the river and in fringe areas should be put under good and beneficial landuse, for the inhabitants of the town. The sanitation and rehabilitation of slums along the river is of great importance, waste land, gullied nalas, irregular slopes could be changed by planting trees, good landscaping and proper surveillance.

KEYWORDS: Aesthetic use, alteration, encroachment, channel modification, land use terraces.

I. INTRODUCTION

River terrace landscapes provides a distinct armature for ecological and cultural relationships in a river valley like the upper terrace, with its farms, subdivisions, towns, and cities; the middle terrace, often which is the farmed or urbanized; and lying well below the middle terrace, the flood plain, which is the most transitory landscape. At some places channels have been widened and/or deepened, terraces have been flattened, cleared, and embanked. Such a manmade control may cause more problems than they solve. These modifications are seen more on river terraces. The aesthetic look of these terraces has been altered with improper use and misuse.

By studying the impact of urbanization and by analyzing the landuse change detection on the river terraces of a river, one can easily make out the appropriate use and misuse of river terraces. However rapid urbanization, partial growth of large cities, create many problems like health, pollution, water, transportation, poverty, unemployment, urban slum, salinity etc. Cities which located on river terraces, like Delhi, Varanasi, Agra, Patna, Kanpur, Kalkata, Surat, Nashik etc. are facing the land degradation problem on river terraces.

II. LITERATURE SURVEY

A fair amount of literature is available on geomorphological studies of river flood plains, flood levees, over bank flooding, river bank erosion, river bank widening, channel deepening, river terraces, and bench terraces from India.

Many of University departments, research centers, research institutes, research organizations, NGO's have been undertaking the urban impact studies, urban sprawl, change detection etc. All these research is focused on the impact of urban infrastructural development, pollution, river pollution; river ecology, river engineering, flood effects, flood inundation, and remedial measures to tackle these problems. The adverse impacts of channel modifications have been documented by Emerson (1979), Keller (1975), Morisawa and Vemuri (1975), and Ritter (1979). Many of the studies in various part of the world have concentrated on the fluvial geomorphology, impact of channel modification on river hydraulics, flows etc. In USA, river channel alterations, modifications, reclamation have been more emphasis in 1980s

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and 1990s. European researchers have well documented the hydrological impact of river flows, over bank flooding on the agricultural fields located along the river banks. As far as river terraces their use and misuse, impact of urban growth is concerned the author has not come across a single study related to it. Pune Municipal Corporation has prepared Environment Impact Assessment (EIA) report on the river bank reclamation for the road that will be laid along and within channel for a considerable distance. Mishra N. C. (1996) in her Master Dissertation has done the project on "Use of River Terraces of Mula and Mutha River around Pune City" has mapped the landuse of river terraces and showed the use and abuse of terraces. She has also suggested some of better and aesthetic use of river terraces.

III. STUDY AREA

Pune City is one of the most developing metropolitan cities in Western Maharashtra. It is situated on the bank of River Mula – Mutha and River Pavana. Pune city lies between $18^0$25' N to $18^0$37' N latitude and $73^0$45' E to $73^0$55' E longitude. Covering 229.42 sq. km. area composed of 144 general electoral wards. The city is located in saucer shaped basin at an average altitude of 560 m. above MSL. The area surrounded by offshoots of Sahyadri hills extends mostly from west to east. For the study purpose, the area of interest lies within 560 m contour along the Mula-Mutha River. Present work attempts to examine and to map spatiotemporal land use change along the river terraces of Mula-Mutha River within Pune Municipal boundary, to study impact of urbanization on the natural/aesthetic look of river terraces and to suggest appropriate use and/or remedial measures for the preservation of their natural ecological functionality.

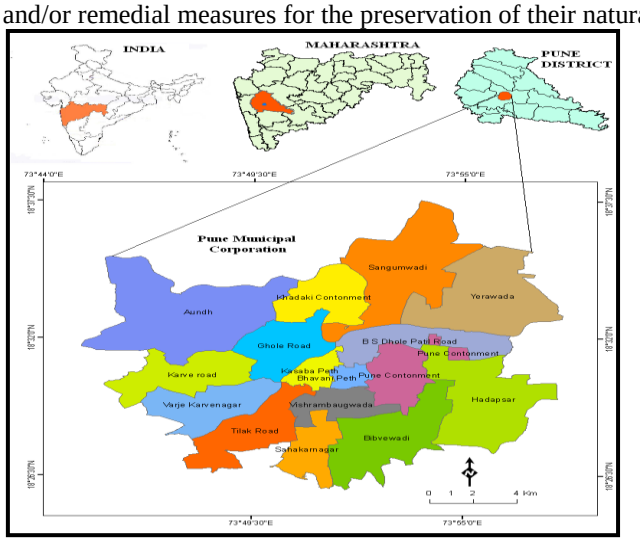

Figure 1: Study Area- Pune City

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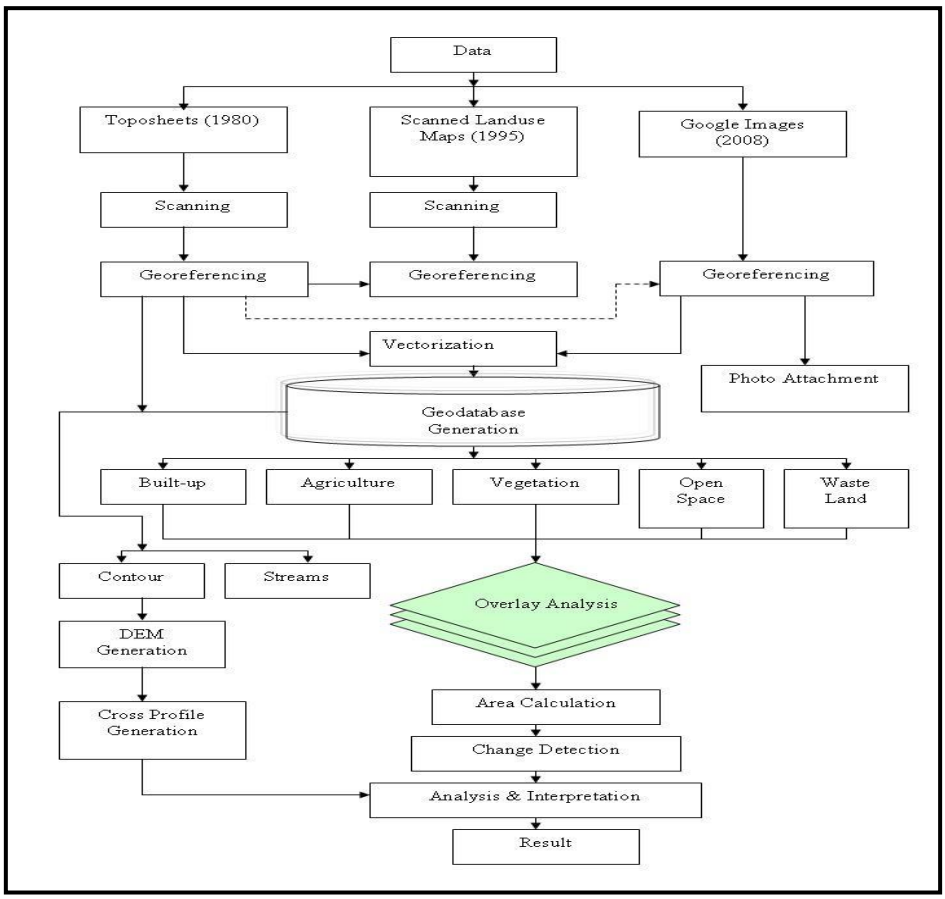

Figure 2: Flow Chart Methodology

On the basis of slope, contours, measurements and fields observations, river terraces have been classified in to upper terrace with height of approx. 6-8 m above river bed and extend up to 560 m contour comprising brown, black and relatively thick soil cover. Whereas lower terrace is not very regular and extensive. It is approx. 2-3 m in height above river bed with varying width of 8 to 12 m. In the study area, lower terrace is of two types, viz: erosional terrace having rocky benches depositional terrace comprising reddish brown silty and clay soil. It is very fertile and mostly used for agricultural and gardening purpose.

Extensive field survey was carried out to obtain actual land use. For this purpose study area was divided into nine zones along the river channel. Photographs, sketch maps, actual measurements, GPS Survey, Ground Truthing was carried out. Google Earth images were also used to compare with old maps and old images. These zones are :

A. Shivane-Nanded Bridge to Varje Bridge (Mutha River)
B. Varje Bridge to Mhatre Bridge (Mutha River)
C. Mhatre Bridge to Sangam Bridge (Mutha River)
D. Sangam Bridge to Vadgaonsheri-Mundhwa Bridge (Mula-Mutha River)
E. Vadgaonsheri-Mundhwa Bridge to Kharadi (Mula-Mutha River)
F. Sangam Bridge to Holkar Bridge (Mula River)
G. Holkar Bridge to Harris Bridge (Mula River)
H. Harris Bridge to Aundh Bridge (Mula River)
I. Aundh Bridge to Wakad Bridge (Mula River)

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Table 1: Database

Types of Data	Source
Toposheets no. 47 F/14/2, 47 F/14/3, 47 F/14/6, 47 F/15/NE, 47 F/15/NW	Survey of India, Scale 1:25,000
Google Earth Pro Satellite Image	Google Earth Pro, Height at 1400 mts.
Landuse map of Pune City (1995-96)	M.A. Dissertation Report of Miss. Nirupama C. Mishra, "Use of River Terraces of Mula and Mutha River around Pune City", 1996

IV. ANALYSIS AND RESULTS

Land use in 1980 – Figure 3 shows distribution of various land use categories in 1980. More than one quarter of the total area i.e. 35 % (22.93 sq. km.) and 31 % (20.70 sq. km.) area is covered by agriculture and open space, respectively, followed by 20 % (12.99 sq. km) built up area which includes settlements, roads, railway line, temples, bridges, cremation land. Waste land covers 10 % (6.50 sq. km.) area that includes barren and marshy land. Whereas vegetation only covers 4% (2.68 sq. km.) of total area. It is 7 to 8 times less than area covered by agriculture and open space.

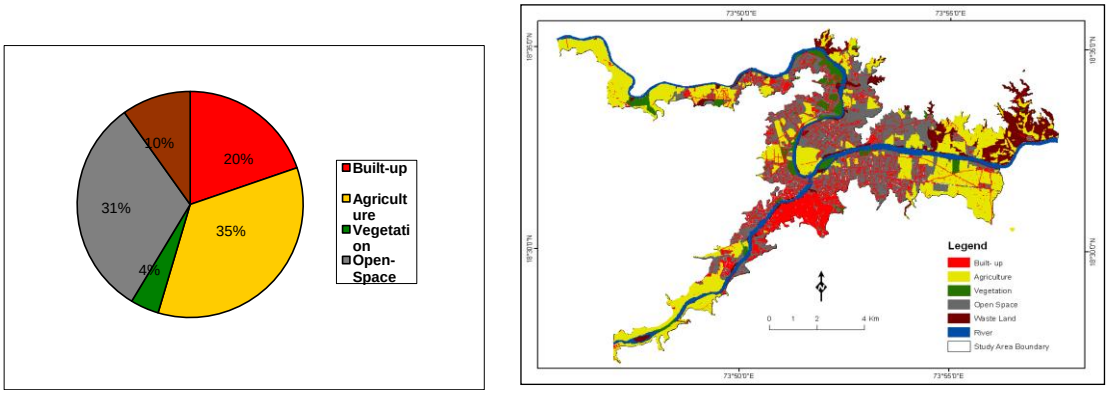

Fig 3. Land use in 1980 (based on Toposheets)

Agriculture is dominant between Shivane-Nanded bridge (Shivane, Nanded, Vitthalwadi, Varje, Wadgaon-Dhayari, Karvenagar, Hingane), Wakad Bridge to Harris Bridge (Baner, Balewadi, Aundh, Bopodi) and between Aagakhan Bridge to Kharadi Bandhara (Aagakhan Palace, Mundhwa, Ramwadi, Kharadi InfoTech Park and Kharadi Gaon. Some agriculture is observed along Sangamwadi at the confluence of Mula-Mutha River and some small patches found in the scattered form. Agriculture practices can be observed along the river terraces, dominantly on the upper terraces, because of the availability of the fertile soil.

The upper terrace covered by built-up area is mainly observed between Mhatre Bridge to Sangam Bridge, because of the availability of facilities like education, transport, hospitals, shops, markets etc. Some industries and colleges are situated on the upper terrace such as like Kirloskar Oil Engines near Harris Bridge on the right bank of the Mula River, Motilal Poona Mill/ Cotton mill near Naidu Hospital on the right bank of the river Mula-Mutha River, Boat club, College of Engineering, etc. Cantonment area along the Mula Mutha left bank is remained undeveloped.

Another category the Open Space includes play ground, open area in the city, private land, government reserved land etc. The open spaces are found in the city and outside the core area, mostly on the upper terrace between Sangam Bridge to Vadgaonsheri-Mundhwa Bridge on both banks of the river and along Holkar Bridge to Khadki-Shantinagar Bridge. .

Upper terrace zone along Vadgaon sheri- Kharadi comprised waste land. It is along upper terrace and along the confluence areas of nalas. The island, downstream to Shivane-Nanded Bridge formed after 1960's flood, is also considered as waste land. Vegetation cover is very less as compared to other land use categories. It includes gardens or parks, orchards, vine yards, reserved forests etc. It is found in patches along the river terraces of Varje-Malwadi,

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Dinanath Mangeshkar hospital, Naik Island, Mula Road, Patil Estate, Khadki Cantonment right bank of the Mula river, near Baner, Band garden and Retired Army officer Colony Mundhwa.

Land use in 1995 – Land use map of 1995 shows the rapid growth of urban built-up area in the study area. Compares to land use of 1980; built-up area in 1995 had grownup twofold times. Built-up area along Mhatre Bridge-Sangam Bridge zone and Sangam Bridge- Aagakhan Bridge zone has remained more or less same but density has grown tremendously.

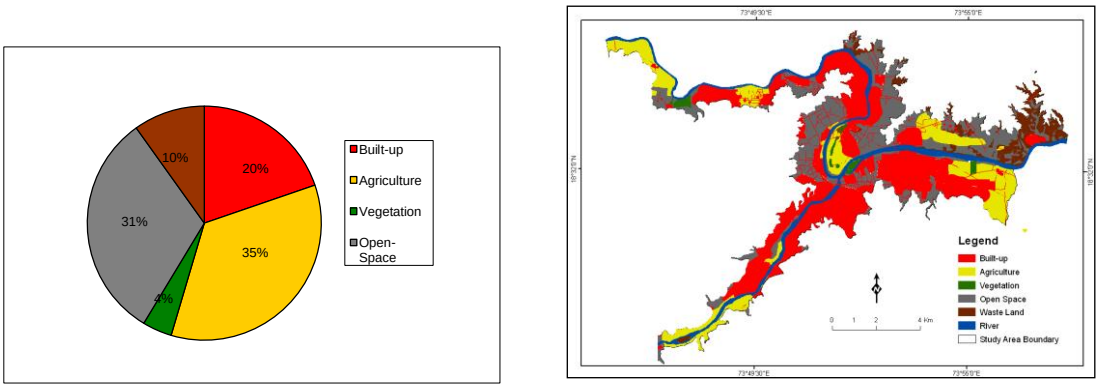

Figure 4: Land use in 1995

Along Shivane - Duttwadi, Balewadi, Sangamwadi, Aagakhan Palace, Mundhwa, Yerawada agriculture area has decreased. Vegetation cover is found in patches, at Sambhaji Garden, Naik Island, Bund Garden, Orchards near Baner. Agricultural fields are observed near Varje on the right bank of Muth River, near Dapodi, upstream to Holkar Bridge and in Sangamwadi area. In these areas, both terraces are used for agriculture. The soil is generally reddish-brown on the lower terrace. The appropriate and aesthetic use belongs to the bungalow, colonies, at Ganeshnagar, Koregaon Park, Karvenagar, Multistory housing of moderate height and government buildings like Engineering College and Bharati Vidhyapith Bhavan with sufficient open space in their surroundings. Temples near the river with trees, clean compounds and pleasing architecture also are beautiful sights along the rivers. Trees grow easily on river terraces. They improve the look of the area, along the river.

Along the Mula and Mutha River stretches of waste land can be observed. Some places are barren and some have grasses and shrubs and palm trees. These waste lands are considered as no-man's property by the people living in that area. Therefore, they misuse the area by throwing garbage there or using the site as public toilets. This spoils the scenic beauty of river banks of Mula near Holkar Bridge or Harris Bridge. Overlay analysis of land use of 1980 and 1995 gives clear picture of land use change from 1980 to 1995.

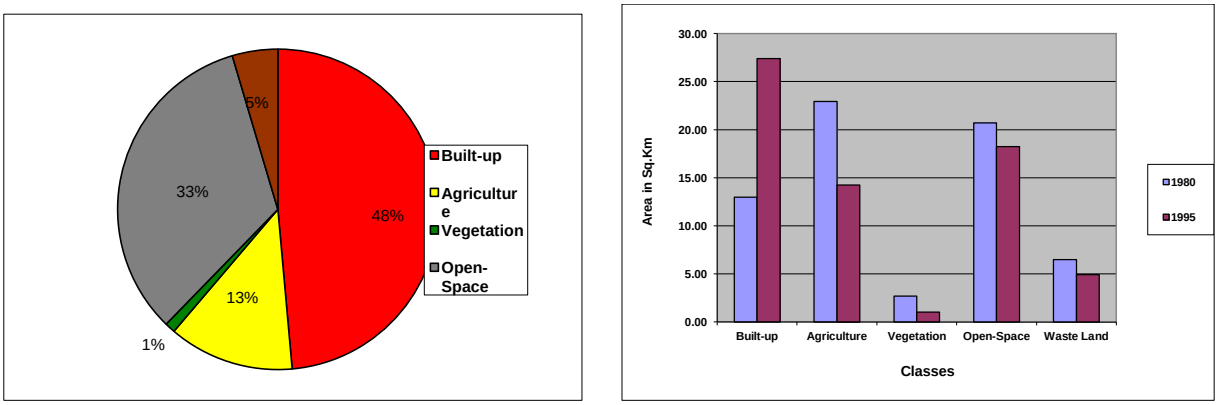

Figure 5: Land use Change Distribution in 1980 and 1995

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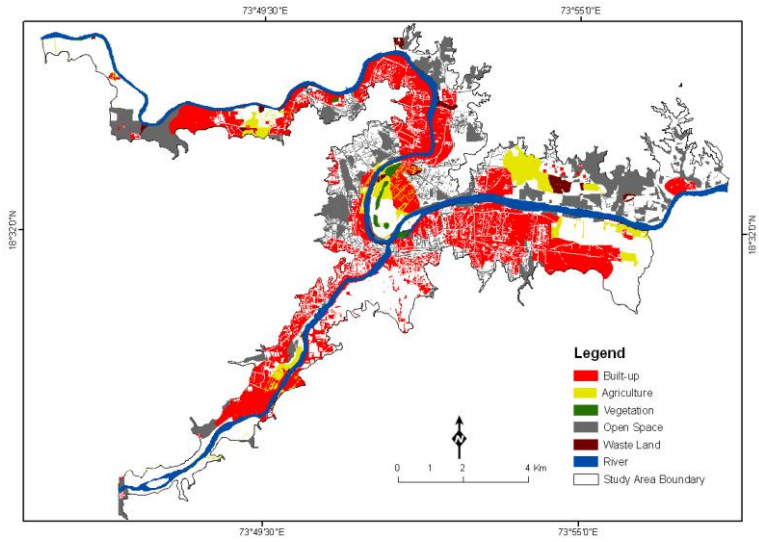

Figure 6: Land use Change in 1980 and 1995

The map shows dominance of built-up area between Varje to Mhatre Bridge, Karvenagar and Erandwana. Similar situation observed in Deccan, Koregaon Park, Wadiya College, Aagakhan Palace, Yerawada and Aundh. The land under agriculture and open space is transformed into built-up area almost every place. It is regrettable that the area under agriculture is deceased and those areas goes under built-up and open space landuse e.g. Baner, Aundh, Bopodi, Mundhwa, Vadgaonsheri, Kharadi Info Tech Park, Ramwadi, Aagakhan Palace, Varje-Karvenagar and some part of Shivane-Nanded villages. On the other hand agriculture in Shivane to Varje, Sangamwadi, west and south part of Mundhwa, vine yard near Bopodi and Balewadi between new Shivaji Maharaj Bridge to Wakad Bridge. Most of the open space in 1980 is converted into built-up area.

Land use in 2008 - The Landuse Map of 2008 (Figure 7) shows the effects of urbanization. Growing population increases the demand of land, therefore the agriculture, vegetation, open space or waste land is transformed into built-up area.

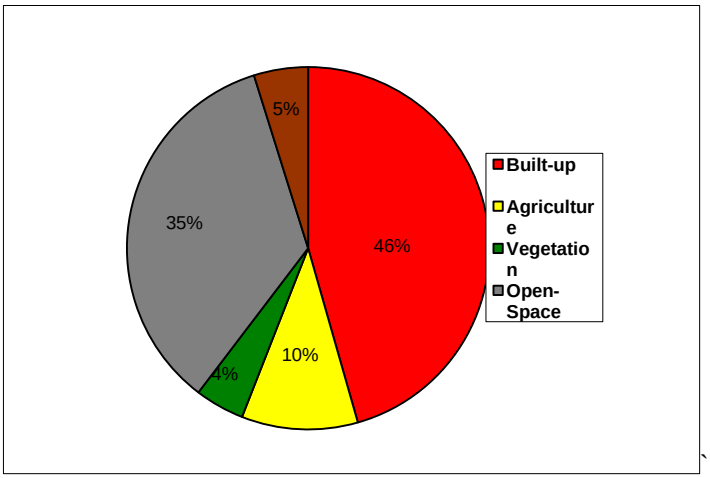

Figure 7: Land use Distribution of 2008

Maximum area is under built-up class i.e. 46 % (29.99 sq. km.), open space i.e. 35 % (22.90 sq. km.) followed by agriculture 10 % (6.82 sq. km.), waste land 5 % (3.18 sq. km.) and vegetation 4 % (2.90 sq. km.). Agricultural land is found in patches. Vegetation cover has grown up from 1995 to 2008 as a result of increase in number of gardens, parks, golf ground, lawns.

Land use Changes from 1995 to 2008 – Built-up area (27.40 sq. km.) has increased by 4% from 1995 to 2008, whereas agriculture land has declined considerably by 11.25%. On the contrary there is gradual increase in land under vegetation by 3%. This can be attributed to increase in area under gardens, lawns, plantation along the river bank,

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aesthetic reclamation of land along the river terraces etc. Land use change from 1995 to 2008 (Figure 8) shows that area under agriculture is totally converted into urban built up. Built-up area is increased in Duttwadi, Magarpatta, Mundhwa, Phulenagar, Yerawada, Baner, Balewadi, Pune and Khadki Cantonment area, Aagakhan Palace, Ramwadi, Vadgaonsheri and Kharadi. Agricultural land is seen only in small patches at some outer peripheral boundary of Municipal limits, i.e. Mundhwa, Aagakhan palace, Kalas, Aundh etc. Vegetation is increased as a result of beutification, gardening, developing jogging parks, golf courses, lawns etc. As far as open space is considered it has also increased by 4%. Due to increase in PMC limits. Many villages outside PMC limits has been included under PMC jurisdiction. But at the same time the land under agriculture of these villages doesn't contributes to increase in agriculture land due to haphazard growth of residential zone that have been already taken in these villages.

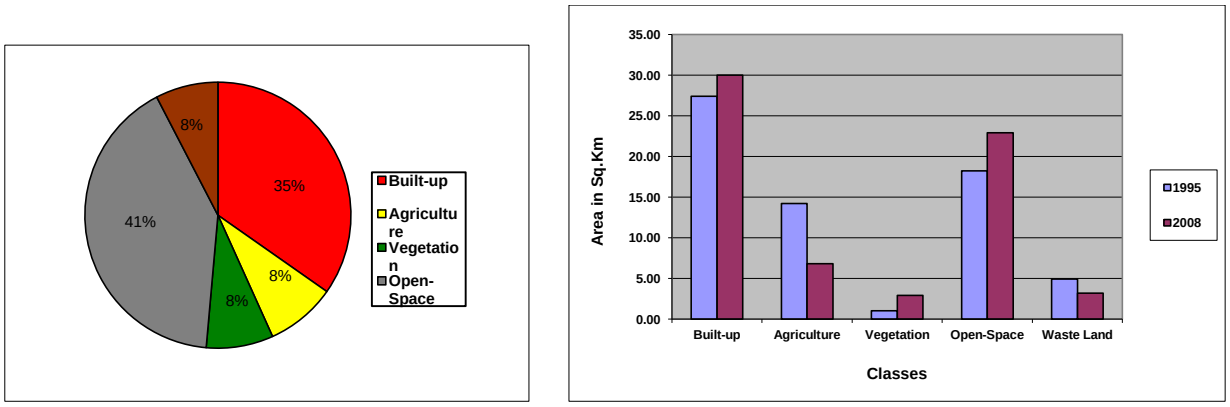

Figure 8: Land use Change in 1995 and 2008

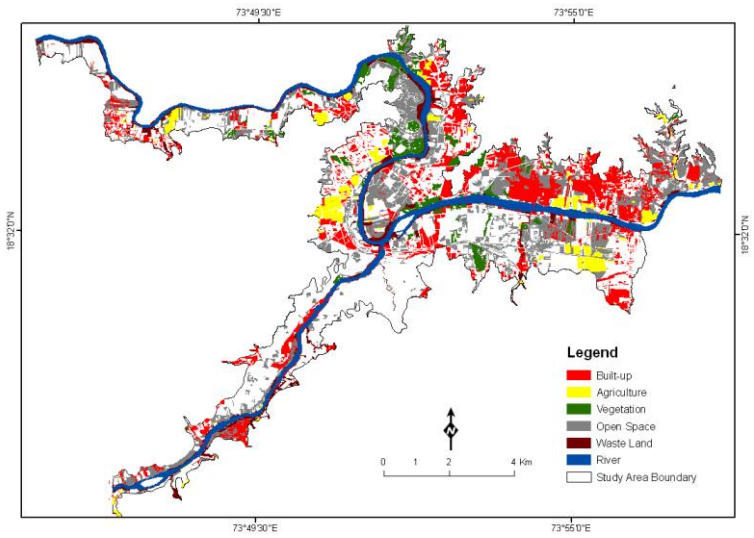

Figure 9: Land use Change 1995 and 2008

V. OBSERVATIONS AND CONCLUSIONS

Pune city had witnessed fast growth during 1980, 1995 and 2008. Urban growth has transformed most of the agricultural land into industrial, commercial and residential areas. Built-up area has increased from 12.99 sq. km (1980) to 29.99 sq. km (2008). Agriculture area has decreased from 22.93 sq. km. in 1980 to 6.62 sq. km. in 2008. Built-up area increased along Deccan Gymkhana, Erandwana, Aundh and Khadki Cantonment Area in 1995 and in 2008. It also

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increased in Duttwadi, Aagakhan Palace, Ramwadi and Kharadi. If landuse of 2008 is compared with that of 1980 and 1995 there is a less increase during these years core area of city was already occupied both banks. In 2008 built-up area increased particularly along the terraces of Duttwadi and Kharadi, etc. Mula-Mutha River terraces are used for variety of purposes like garden, residential buildings, roads, shopping complex, recreation grounds, cremation grounds, brick kiln, boat clubs, temple etc.

One of the major polluting activities and repulsive sites are associated with the slums observed along the Mula-Mutha Rivers and around adjoining nalas. The slums along the river are of poor standard than slums in other areas. Some of the slums are built on the sloping land of the river banks e.g. Harris Bridge, Tadiwala Road slum (Naik Island). High densities of slums/ huts are found along and inside nalas, e.g. Duttwadi slum, Shivaji stadium area. All the effluents and the garbage is directly discharged into these nalas and from there it reaches to main river channel. Mid stream bars Naik Island has been distracted due to pollution activities of slum. On the other hand, slums away from the river like Yerwada are much cleaner. They have better layout, better structure with proper hygiene facilities. Brick kiln constitute another polluting activity. They emanate smoke, dust accompanied by waste dumps. River Terraces are best suited sites for making bricks as there manufacturing requires large quantity of water. Open space along the river is used to dump construction material waste, solid waste etc.

Increasing population due to immigration, the demand of the land forced to convert agricultural land and open space into urban built-up. The people from other states migrated to Pune in search of jobs in public and private sector. Afterward they used to settle in Pune. Most of migration occurred in lower income group. These migrant found their place along the river bank, or on the open space adjacent to river wherever it is available to them. It has created burden on the land mostly on the upper terrace.

Area adjacent to Wakad. Baner, Aundh, Sangavi, Pimple Nilakh, Pimple Saudagar, Pavana River stretch along Dapodi has been greatly altered by new residential complexes, fencing walls, slums, open illegal parking for heavy vehicles (trucks, Company buses, Travel and Tour Buses), Brick kilns etc. Some of the slums are built on the sloping land of river banks e.g. slum between Shivaji Bridge and Sangam (Railway) Bridge. High density of slums are found along and inside of nalas e.g. Duttwadi slum, Shivaji Stadium slum etc.

The area around bridges have been artificially elevated/ raised by dumping murum/ dubber and or soil e.g. a stretch from Rajaram Bridge to Mhatre Bridge. The area along the shunting line of railway has also been artificially raised. Walls have been built on both sides of river and also within river channel to protection the adjacent area from flooding. Recently, a long stretch of embankment along the right bank of Mutha River has been constructed downstream from Varje Bridge to Manikbaug – Vitthalwadi in order to protect nearby residential zone from flooding.

Most of the years, the discharge within the river channel is controlled by three dams located at 20– 40 km. west of Pune City. Therefore water is present only in the narrow channel nearly all around the year, and for sometime during the monsoon period. Larger water bodies are only found behind the bunds like Kalas, Kaspatewadi and Wakad.

Agriculture is more affected due to urbanization on upper and lower terraces as compare to vegetation which has increased because of beautification at many places along the river banks and along terraces. Numbers of bridges across both rivers have increased the accessibility of both banks. This has also amplified the conversion of agricultural land to built-up land.

The best use of river terraces is for gardens, public buildings, boat club, agriculture, colleges and so on. Because of the fertile soil use of river terraces for agriculture and gardens or plantation is best. But the industrialization on river bank, slums, dumping ground, sewage treatment plant are some of the misuses of terraces. Temples and Ghats nears the river with trees, clean compound and pleasing architecture also are beautiful sight along the rivers e.g. Vriddheshwar Siddheshwar Temple (Congrss Bhavan), Duttmandir, Ahilyadevi Holkar Ghat (Sangam Bridge) etc. Tree has been planted on river terraces. They improve the look of terraces along the river area.

The appropriate landuse includes cultivation, better housing, boat club, gardens, roads, etc. and the undesired landuse included brick kilns, slums, industrial area, waste land/ barren land, etc. the unwanted and polluting landuse of the river terraces occupies a relatively high percentage of area. Valuable open area within Pune City along the river and in fringe areas should be put under good and beneficial landuse, for the inhabitants of the town. It could be done by increasing the number of parks along the rivers providing proper landscaping and benches for the people, to rest. The sanitation and rehabilitation of slums along the river is of great importance, waste land, gullied nalas, irregular slopes could be changed by planting trees, good landscaping and proper surveillance. It is suggested that wherever possible, the green belt should be preserved and enlarged.

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