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# Monitoring and Impact Assessment of Land Use Change on Environment in Burewala, Punjab through Geo-Informatics

**Isma Younes[1*], Rabiah Naseem[2] Rakhshanda Sadaf[3], Muhammad Shafiq [4], Haris Zafar[5], Amara Shahid[6]**

[1]Department of Geography, University of Punjab, Lahore, Pakistan
[2,5,6] Department of Geography, University of Punjab, Lahore, Pakistan
[3]Department of Geology, Federal Urdu University of Science and Technology, Karachi, Pakistan
[4]Earth Sciences Directorate, Space and Upper Atmosphere Research Commission, Karachi, Pakistan

*Email: Ismayounes2004@hotmail.com

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**Abstract:** Urbanization, migration and growth of commercial centers across the world have made global environment vulnerable to harmful noise levels. The worst impacts of land use change on environment are manifold in Pakistan as there is no proper implementation of environmental laws. The present research focused on the impact of land use on environment of Burewala, which is one of the badly affected cities of Pakistan due to growth of new colonies that are resulting in unchecked noise levels. The land use change of Tehsil Burewala between 1999, 2009 and 2014 was examined with the help of satellite imageries from Landsat TM, ETM+ and OLI sensors. Land use change detection based on remote sensing data is an efficient way of obtaining information for several decision making and support systems and works meaningfully as a research and analysis tool. It gives comprehensive information about the urban development of an area. Four major land use classes are identified including agricultural land, built up, bare soil and water bodies. A method of post classification comparison for change detection is used to detect the changes in land use. The results show a significant change in agricultural land and built-up area. Agricultural land has depleted by almost 14%, mainly owing to increase in built up area. It is concluded that study area is under development phase due to which it is experiencing a gradual increase in built up land through different years including infrastructure as well. Noise pollution in general has increased over the years.

**Keywords:** Land use, change detection, environment, noise pollution, satellite images, urban expansion.

## Introduction

The process of urbanization has been prompt and uncontrollable especially in developing countries (Kumar and Pathan, 2007). The areas in the world, which face such over powering economic developments, experience a rapid change in their land scape (Deka and Tripathi, 2010 and Wu, 2013). Deprivation of environmental processes, damage to green spaces, reduction in productive areas and noise pollution are the major consequences of such wild alteration in land (David, 2015; Pathan and Jothimahi, 1989; Salvati and Sateriano, 2013; Sarvestani and Ibrahim, 2011; Xu and Wang, 2000). The process of urban sprawl is very substantial in terms of driving change in land use and it is outcome of continuous population growth (Barredo and Demicheli, 2003 and Weng, 2001). Urban sprawl can be defined as the portion of built-up land and its level of dispersion in an area (Jieli et al., 2010). Urban sprawl can be referred as a pattern, which is viewed in a specific area at a specific time and it can be described as a process, when it is observed in different time intervals (Bhatta and Sarswati, 2010). Land use is getting high pressure on it due to increasing population and growing socio-economic needs. Due to such pressure, dramatic changes occur in land use (Seto et al., 2002).

Most of the agricultural and vegetation areas are converting into urban areas. The conversion of agricultural land into urban areas invites more population towards it, resulting in multiple issues. Higher the population in an area, the more is the land consumption demand and so is for food. These changes in land use usually result, when management fails in handling agricultural and urban fields and resources, which in turn result in the form of critical environmental anomalies. Every patch on surface of earth possesses a unique cover. Despite of being diverse in its nature, land use is quite closely linked with the characteristics of the surface of earth. Any alteration in the land use directly affects the land. It is not imperative that this change always occurs in the form of land degradation. Nevertheless, this change is result of large number of social causes, somehow affects the climatic conditions and biosphere too (Ahmad et al., 2013; Dewan and Yamaguchi, 2009 and Riebsame et al., 1994).

Today, forests occupy 30% of the earth's land area-

while 8000 years ago it was 50% of the total land area. The reason behind this reduction is that agriculture has wiped out much of forested area. To meet the demand of food, it has expanded into savannas and steppes throughout the world (Lambin et al., 2003). Global Forest Resources Assessment, 2000 assessed that during 1990s world's natural forests on average reduced by 16.1 million hectares per year indicating the loss of 4.2% of the forest area, which subsisted in 1990 (Lambin et al., 2003).

Moreover, increase in urban areas generally increases the urban problems, which are generated mainly through abnormal increase in population (Aljoufie and Zuidgeest, 2013 and Maktav and Erbek, 2005). The processes of economic growth, mechanization and urban sprawl are responsible for such drastic increase in population and intensify pressure on land use. Socio-economic conditions are also linked with the process of urbanization. Unintended developmental strategies lead towards population growth at a high rate and consequently unrestrained urban sprawl with deprived infrastructure results (Jieli et al., 2010; Kiran and Joshi, 2012). Higher percentage of growth in urban area than the percentage of growth in population depicts the unexpected development that is resulting in unchecked noise pollution (Soffianian and Nadoushan, 2010). Rate of population growth determines the rate of urban sprawl. The ratio between the percentages of entire urban area to the percentage of entire population is one of the simplest means to measure urban sprawl (Sharma and Pandey, 2012; Sudhira and Ramachandra, 2003). The process of urbanization is inevitable. However, it can be controlled by analyzing land use processes and with the help of proper planning. Consequently, precise analysis and planning can be done by mapping urban areas. Such mapping helps in monitoring urban growth as well (Al-shalabi and Pradhan, 2012). Noise pollution has devastating human health effects (Agarwal and Swami, 2011). The road traffic noise in urban areas reduces the quality of the residential environment, which results in many physiological and psychological disorders (Kurakula, 2007).

## Study Area

Burewala is a Tehsil of Vehari district located in southern Punjab, Pakistan. It is known as an administrative subdivision of Vehari district. It was officially announced as Mandi Burewala in 1925. According to estimation during 2000, it is the 31$^{st}$ biggest city of Pakistan in terms of its population. The Tehsil lies between 30°10' and 31°22' north latitude and 72°39' and 73°55' east longitude (Fig. 1).

The total area of Tehsil Burewala is 1,318 square kilometers. There are 32 Union Councils, which are subdivided administratively. Total current estimated population of Burewala is 974,800 which was 725,633 in 1998 (Table 1). Urban population was 152,097 as per 1998 census, whereas annual average growth rate at that time was 3.39 %.

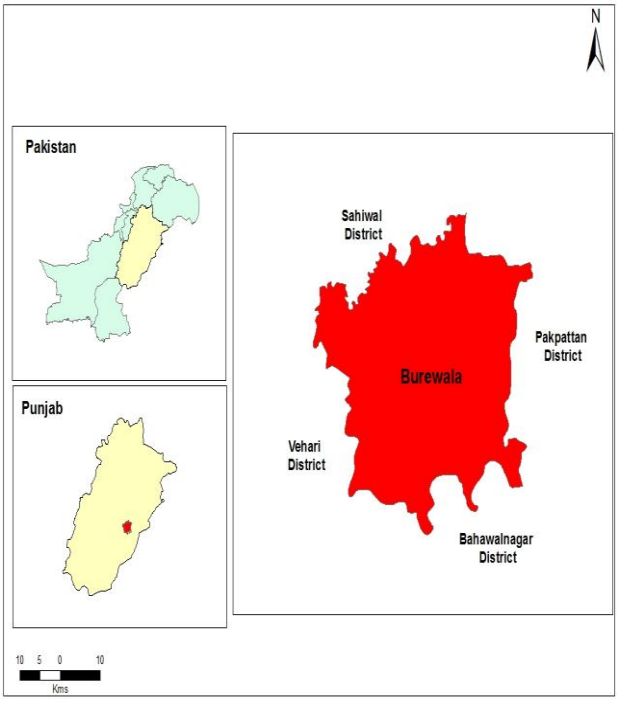


Fig. 1 Location map of the study area.

Table 1 Demographic details of Burewala.

| Year | Population |
|---|---|
| **1999** | 730,000 |
| **2003** | 790,050 |
| **2009** | 909,339 |
| **2014** | 986,000 |

Source: Punjab Development Statistics (2000, 2010, 2014).

## Data Acquisition and Sources

As remote sensing has become an essential tool for estimation of land use changes in last few decades, four sets of remotely sensed data have been used to analyze land use changes in the study area. In order to find out LU changes in Tehsil Burewala, four Landsat images (1999, 2003, 2009, 2014) with the resolution of 30 meters (Bands 1, 2,3,4,5,6,7,8 Path and Row 150-39) of the study area were acquired. These images were obtained from USGS an earth observatory website. All images have been used as a basic data source and to prepare land use change maps and classification categories were developed for this purpose. Population data has been acquired from Tehsil Municipal Administration (TMA), Burewala. Data of noise was collected using Sound Level Meter from sample locations.

## Methodology

Layer stack is an important operation done in this research after acquiring the required images. Satellite image is always acquired in separate bands. The process of combining these images of different bands is known as Layer stacking. Layer stack of each image was done in Erdas Imagine software. Image sub-setting was performed after the process of layer stacking. In this process, the imageries were clipped to extract only the study area by converting digitized boundaries into AOI. The process of image enhancement includes different techniques to enhance the graphical dissimilarity of different feature classes present in the particular image. The step of image enhancement is done in order to change the value of pixels present in the image and that's why after the completion of pre-processing, the step of image enhancement is performed. Brightness/contrast method has been found most suitable one for this study after testing several methods on dataset. Landsat images of 1999, 2005, 2009 and 2014 go through the process of image enhancement with the help of brightness/contrast technique in order to get better results in the process of image classification. In the process of image classification, image pixels are generalized and combined into different groups, each referring to a specific land use class. After pre-processing and image enhancement, satellite imageries were classified with object oriented approach. To create meaningful objects in imageries process of segmentation was performed with the help of multi-resolution method. After segmentation, process of classification is carried out. The process of nearest neighbor was used in the current study. This process involves the selection of samples based on the least distance measured among them. While making a new class, related samples were selected based on their spectral response. The classification categories included soil, water bodies, agricultural land and built up area (Table 2).

Table 2. Land use classification through Landsat images.

| LU classes | General Description |
|---|---|
| Bare Soil | All the vacant areas, abandoned fields and patches of bare soils are included in this class. |
| Water bodies | Areas that are covered by water are denoted as water bodies such as rivers and streams. |
| Agricultural land | This class includes all the cultivated and arable land |
| Built-up area | All the buildings, roads and sealed surfaces found are included in this class. |

The changes in the LU on temporal basis from 1999 to 2014 were evaluated with the help of Nearest Neighbor classification method in Erdas imagine. Primary data of noise was collected by field survey. The tool used for primary data collection was Sound Level Meter, (an instrument, which can measure noise range from 35 to 130 dB). Data were collected from different sites using dBA. Measurements were kept as slow response and A weighted sound level was preferred for road traffic noise. The instrument read A grade weight values directly and the microphone was kept 1.2 meter above the ground at a distance of 1.5-5 meter. The noise level was measured thrice a day. First readings were taken from 6 A.M. to 8 A.M and second readings from 12 P.M. to 2 P.M. While, third readings were taken from 8 P.M. to 10 P.M. and then averages were calculated to show the spatial patterns of noise during different time periods.

## Results and Discussion

### Change in Land use

After classification and analysis of the images, it has been found that two classes experience a major change. Agricultural land experiences a decrease in its area. On the other hand, built up is showing an increase (Table 3).

Table 3. Land use distribution in Tehsil Burewala for 1999, 2009, 2014.

| Landuse Catagories | 1999 | 2009 | 2014 |
|---|---|---|---|
| | Area(sq.km) | Area(sq.km) | Area(sq.km) |
| Builtup | 250.82 | 344.51 | 430.87 |
| Agricultural land | 870.55 | 784.68 | 690.8 |
| Bare Soil | 191.24 | 182.1 | 188.96 |
| Water | 6.31 | 7.61 | 9.29 |
| Total | 1318.9 | 1318.9 | 1318.9 |

Built up area had a share of 250.82 $km^2$ among all classes during 1999. It reaches to 344 $km^2$ in 2009 and in 2014 it goes up to 430.87 $km^2$ showing an increase of almost 14% from 1999 to 2014. On the other hand, agriculture shows a declining trend. It had a share of 870.55$km^2$ in 1999, which has decreased to 784.68 $km^2$ in 2009 and 690.8 $km^2$ in 2014, showing a decline of almost 14% during 1999 to 2014 (Fig. 2).

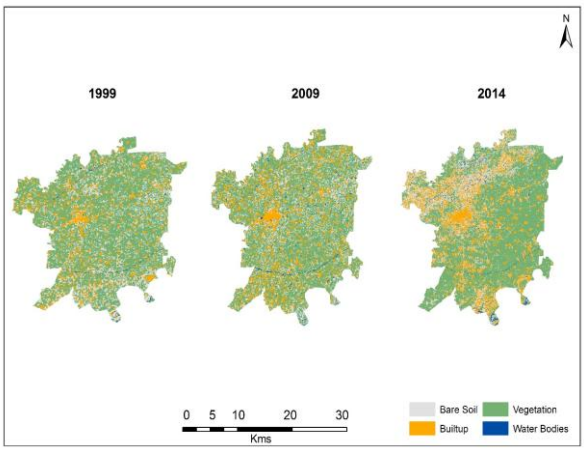


Fig. 2 Land use changes in Tehsil Burewala for year 1999, 2009 and 2014.

Built up has area grown in all directions but the growth can be clearly seen in directions of North, Northeast and South. Central part of Tehsil is also showing an increase in built up area because of the presence of Burewala (main city) here. Decrease in agricultural land has been taken up by the built-up area. The other two classes i.e. soil and water shows a negligible change. Share of both classes remained almost same during these years (Fig. 3).

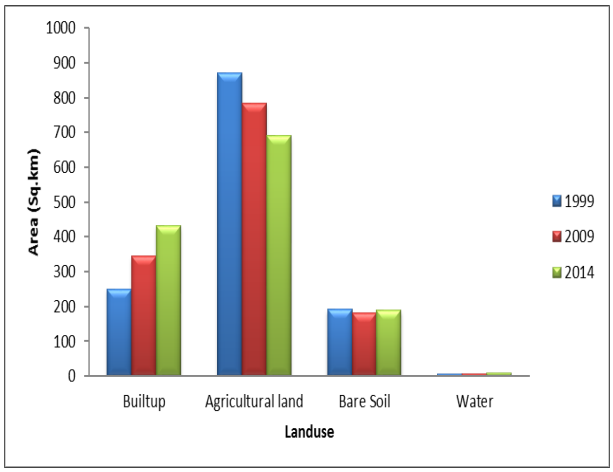


Fig. 3 Land use distribution for years 1999 and 2014.

## Urban Expansion

Expansion in urban area with time can be seen in Figure 4. Major growth has taken place in the north, north-east, and south as well as in the central part. Sahiwal and Pakpattan districts lie to the north and east of Tehsil. Built up area has been increased along the Pakapattan canal, which flows from Vehari to Pakpattan. The main city of Burewala lies in the center of the Tehsil, which has grown in almost all directions in last 15 years comprising a commercial as well as residential area. Moreover, a main road from Vehari to Pakpattan and a railway line also pass through the city. In south, built up area has grown along the River Sutlej, which passes through southern part of the Tehsil. Population data also indicate an increase in population. In 1999, total population was 725,633 which has increased up to 974,800 in 2014 showing a rise of more than 0.2 million inhabitants in Burewala that has resulted in urban expansion (Fig. 4).

During years 1999 to 2003, total five new colonies were built in Tehsil Burewala. From year 2003 to 2009, 16 new colonies were established contributing in urban growth. There was a built up of 23 new colonies during 2009 to 2014. Total 44 new colonies have been built in Burewala during these 15 years, which mainly contributed to urban expansion. Major construction of these colonies was done along Luddon road, Multan road, Masoom Shah road and Lahore road. Some colonies were also built along Sheikh Fazil road and Jamlera road. The purpose of change detection is to know that which land use has increased or decreased from 2009 to 2014 and which land use has been converted into other land use type. Change detection gives a clear indication about the rate at which area is changing in terms of land use. From the classification maps of Tehsil Burewala, it has been seen that Burewala has witnessed a change in terms of urban land use during the last 15 years.

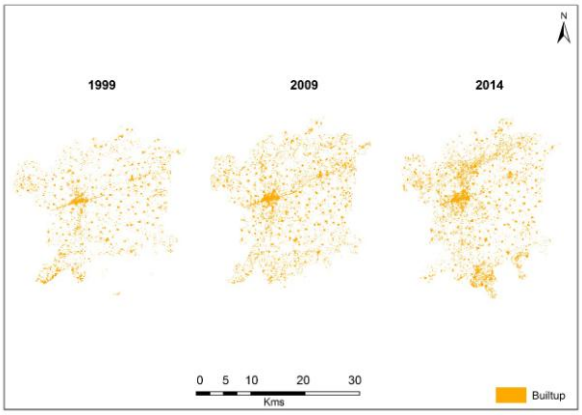


Fig. 4 Urban expansion in Tehsil Burewala during 1999-2009 and 2014.

## Change Detection in Built Up Area

During 1999, total built up area was 250.82 square kilometers, which increased up to 430.87 square kilometers in 2014 showing a growth of 71%. Agricultural area has been reduced to 52.32% in 2014 while it was 60% in 1999. It can clearly be seen that the built-up area has expanded at the cost of agricultural land (Table 5).

Table 5 Land use change detection statistics.

| Land use categories | 1999 | 2014 | Area change | Growth (%) |
|---|---|---|---|---|
| | Area (sq.km) | Area (sq.km) | | |
| Agricultural land | 870.55 | 690.8001 | -179.74 | -20.64 |
| Built-up | 250.82 | 430.8727 | 180.05 | 71.78 |
| Bare soil | 191.24 | 188.9646 | -2.28 | -1.19 |
| Water bodies | 6.319056 | 9.2924 | 2.98 | 47.22 |
| Total | 1318.92 | 1318.92 | -- | -- |

The increase in population was a major factor behind such a rapid urban expansion. Major expansion has been done in north, north eastern and southern directions, where open spaces are easily available with less cost. The central part of main city (Burewala) has also expanded remarkably. Several housing schemes have been built within the city area as well as in the north eastern and southern directions.

Construction of more than 40 colonies along different roads increased urban area by wiping out agricultural land. Luddon road, Masoom Shah road, Multan road, Sheikh Fazal and Jamlera roads experienced urban expansion along them. Many agricultural areas have

turned into residential colonies. Commercial area is also growing with the densification of residential area. Growth of residential areas along major routes shows the ribbon development in study area (Fig. 5).

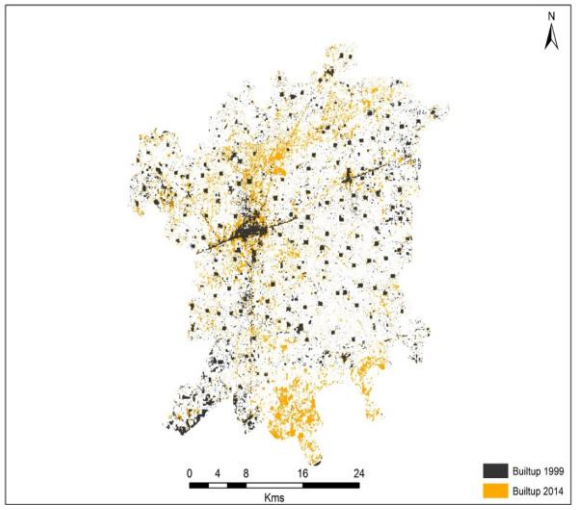


Fig. 5 Change detection in built-up area from 1999 to 2014.

The levels of noise are also increasing in Burewala as indicated in Table 6. The levels of noise were 85db, 90db and 88db along main road at sample sites near Shadman colony, Ghulam Muhammad colony and Habib colony respectively. Mang Sharif was also experiencing high noise levels than permissible limit. Rests of all sample sites were having noise levels within the permissible limit of WHO.

Table 6. Noise levels in 2009 and 2014 at different locations.

| Sample Sites | Noise (dB)_2009 | Noise (dB) _2014 |
|---|---|---|
| Shadman colony | 73 | 85 |
| Ghulam Muhammad colony | 90 | 90 |
| Habib colony | 74 | 88 |
| Shah Faisal colony | 66 | 76 |
| Gulshan Ghani colony | 76 | 80 |
| Awan town | 62 | 69 |
| Sabzazar town | 65 | 71 |
| Warraich town | 67 | 74 |
| Chak 257/EB | 50 | 52 |
| Chak 487/EB | 53 | 59 |
| Chak 495/EB | 54 | 57 |
| Chak 301/EB | 51 | 53 |
| Chak 299/EB | 59 | 60 |
| Chak 299/EB | 57 | 62 |
| Chak 281/EB | 52 | 55 |
| Chak 291/EB | 53 | 56 |
| Chak 541/EB | 50 | 52 |
| Chishtian Sharif | 69 | 78 |
| Chak 11/G | 66 | 69 |
| MangSharif | 77 | 80 |
| Madressa | 71 | 77 |
| Chak 166 | 66 | 78 |
| Chak 158 | 63 | 74 |
| Chak 367 | 59 | 68 |

Source: Field Data (June, 2009, 2014).

Figure 6 shows the spatial patterns of noise in Burewala. Noise levels of only two years have been compared due to unavailability of noise data of 1999. The dark green color highlights the areas, which have noise levels within permissible limits. Yellow color indicates the medium range of noise levels in study area. Red color shows the areas facing maximum noise levels. It is noteworthy that noise levels have increased in areas, where new colonies have been built. The maximum noise levels were measured at Shadman colony, Ghulam Muhammad colony and Habib colony (Table 6). The noise levels at these locations can cause induced hearing loss to local inhabitants. It is due to the unchecked growth of new colonies that have led to such an increase in noise levels in the study area.

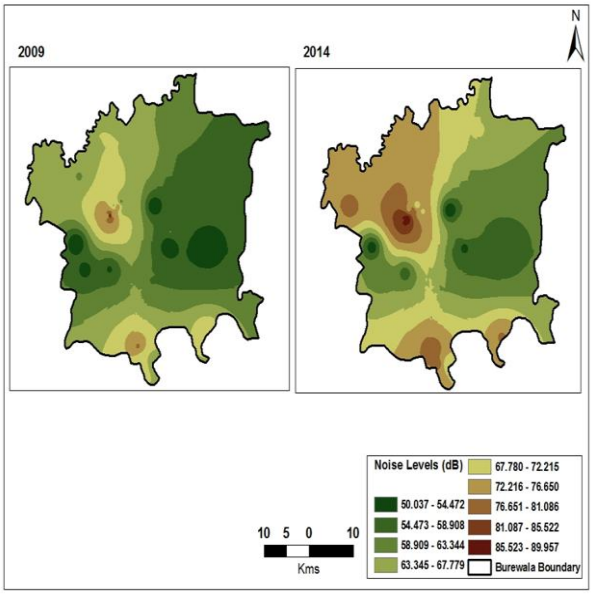


Fig. 6 Spatial pattern of noise levels in 2009, 2014.

**Variations of noise level along the road**

The variations in noise levels along the road for 2014 were analyzed. Figure 7 shows the sample locations along primary roads where noise levels were measured. Land use based noise distribution in 2014 reveals that averages of noise levels along primary roads of Shadman colony (SC) and Water Works colony (WWC) were maximum that were 85 dB (A) and 95dB (A) respectively. The average noise levels were lower at sample locations along secondary roads in same colonies than along primary roads and that were 69 dB (A) at Shadman colony and 80 dB (A) at Water Works colony. Tertiary roads were having even lower average noise levels than secondary roads. The noise levels along tertiary roads were 60dB (A) at Shadman colony and 63dB (A) at Water Works colony.

The analysis of noise levels shows that the residential places along primary roads were the noisiest places to live at both locations. A little decrease in noise levels at both locations can be observed along secondary

roads, but noise levels were even very high along secondary road of Water Works colony. The major reason of such a high volume of noise along secondary road is the presence of general bus station along primary road. The noise levels have made the area, a very high risk zone for workers of bus station as well as for the inhabitants of adjacent area. The noise levels along tertiary road at WWC were within the permissible limits set by WHO for residential areas.

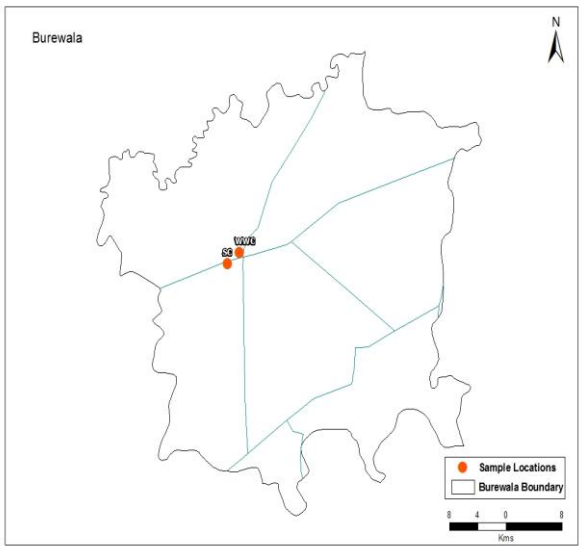


Fig. 7 Sample locations along roads.

The noise levels were also above the threshold set by WHO along primary roads at Shadman colony but noise levels were low along secondary and tertiary roads at Shadman colony and they were within the permissible limits for residential areas. It is noteworthy that residential areas start along primary road at Shadman colony.

Table 7. Noise levels along roads in 2014.

| Sample location | WWC (Noise db) | SC (Noise db) |
|---|---|---|
| Primary roads | 95 | 85 |
| Secondary roads | 80 | 69 |
| Tertiary roads | 63 | 60 |

Source: Field data (2014).

## Conclusion

Present study reveals the impacts of land use change and urban expansion on environment of Tehsil Burewala from 1999 to 2009 and 2014. Demolition of agricultural land for the sake of urban expansion is a major ongoing practice now a days. This practice has been observed both locally and globally. Study has highlighted the remarkable change in land use in Tehsil Burewala in a time span of 15 years. The major change has been witnessed in built up area and agriculture. Built up area, which was 250.82 square kilometers, increases up to 430.87 square kilometers in 2014. It shows that 180.05 square kilometer of built up land has increased during above stated time period (Table 3).

Increase in built up area is mainly due to increase in population, which has risen up to 974,800 sq km in 2014 from 725,633 sq km in 1999. This growth in population requires more residential area to inhabit people. Furthermore, commercial, economic and industrial growth is also contributing to land use change and urban growth, thus resulting in diminishing agricultural area in Tehsil Burewala. Major growth occurred along Pakpattan canal, which flows from Vehari to Pakpattan, in south along River Sutlej and in central part of the Tehsil, where main city lies. It can be clearly seen that urban expansion is done mainly along water bodies and central city. Availability of open spaces has also contributed in urban growth. Total 23 new residential colonies have been built from 1999 to 2014 and 44 colonies in last five years in Tehsil Burewala.

Increased built up area has also resulted in an increase in noise pollution especially in major junction points of roads in the city. The levels of noise were 85 db, 90 db and 88db along main road near Shadman colony, Ghulam Muhammad colony and Habib colony respectively. These higher noise levels show that continuous exposure to these levels can cause permanent noise induced hearing loss among local workers.

## References

Agarwal, S., Swami, B. L. (2011). Road traffic noise, annoyance and community health survey- A case study for an Indian city. *Journal of noise and health*, **13** (53), 272-276.

Ahmad, F., Shafique, K., Ahmad, S. R. (2013). The utilization of MODIS and landsat TM/ETM+ for cotton fractional yield estimation in Burewala. *Global Journal of Human-Social Science*, **13** (7), 21-42.

Aljoufie, M., Zuidgeest, M. (2013). Spatial-temporal analysis of urban growth and transportation in Jeddah City, Saudi Arabia. *Cities*, **31**, 57–68.

Al-shalabi, M., Pradhan, B. (2012). Manifestation of remote sensing data in modeling urban sprawl using the SLEUTH model and brute force calibration: a case study of Sana'a city, Yemen. *Journal of the Indian Society of Remote Sensing*, **41** (2), 1–12.

Barredo, J. I., Demicheli, L. (2003). Urban sustainability in developing countries megacities: modelling and predicting future urban growth in Lagos. *Cities*, **20** (5), 297–310.

Bhatta, B., Saraswati, S. (2010). Quantifying the degree of freedom, degree of sprawl, and degree of goodness of urban growth from remote sensing data. *Applied Geography*, **30** (1), 96–111.

Bisht, B. S., Kothyari, B. P. (2001). Land cover change analysis of Garurm Ganga watershed using GIS/ remote sensing technique. *Indian Soc. Remote Sensing*, **29** (3), 165-174.

Codjoe, S. N. (2004). Population and land-use and land-cover dynamics in the Volta River Basin of Ghana, 1960-2010. Ecology and Development Series No. 15, PhD thesis, Cuvillier Verlag Gottingen.

Dale, P. E. R., Chandica, A. L., Evans, M. (1996). Using image subtraction and classification to evaluate change in sub-tropical intertidal wetlands. *International Journal of Remote Sensing*, **17** (4), 703–719.

Deka, J., Tripathi, O. P. (2010). Urban growth trend analysis using Shannon Entropy approach: A case study in North-East India. *International Journal of Geomatics and Geosciences*, **2** (4), 1072–1078.

Dewan, A. M., Yamaguchi, Y. (2009). Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. *Environmental Monitoring and Assessment*, **150** (1-4), 237-249.

David, O., Lobina, G. P. (2015). A comparative land use-based analysis of noise pollution levels in selected urban centers of Nigeria, *International Journal of Environmental Research and Public Health*, **12**, 12225-12246.

Jieli, C., Manchun, L., Yongxue, L., Chenglei, S., Wei, H. (2010). Extract residential areas automatically by new built-up index. *18th International Conference on Geoinformatics. IEEE Xplore digital Library, 1–5.*

Karteris, M. A. (1990). The utility of digital thematic mapper data for natural resources classification. *International Journal of Remote Sensing*, **11** (9), 1589-1598.

Kumar, J. A. V., Pathan, S. (2007). Spatio-temporal analysis for monitoring urban growth: A case study of Indore city. *Journal of the Indian Society of Remote Sensing*, **35** (1), 11–20.

Kiran, G. S., Joshi, U. B. (2012). Estimation of variables explaining urbanization concomitant with land-use change: a spatial approach. *International Journal of Remote Sensing*, **34** (3), 824–847.

Kurakula, V. (2007). A GIS based approach for 3 D noise modeling using 3D City Model. M.Sc. Thesis (unpublished), 113 pages.

Lambin, E. F., Geist, H. J., Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, **28**, 205-241.

Lu, D, Mausel, P., Brondizios, E., Moran, E. (2004). Change detection techniques. *Int. J. Remote Sensing*, **25** (12), 2365-2407.

Maktav, D., Erbek, F. (2005). Analysis of urban growth using multi-temporal satellite data in Istanbul, Turkey. *International Journal of Remote Sensing*, **26** (4), 797–810.

Nasr, A. H., Helmy, A. K. (2009). Integration of Misrsat-1 and SPOT-2 data for quantitative change detection applications. *ICGST-GVIP J.* **9** (5), 53-59.

Pathan, S. K., Jothimahi, P. (1989). Urban land use mapping and zoning of Bombay Metropolitan Region using remote sensing data. *Journal of the Indian Society of Remote Sensing*, **17** (3), 11–22.

Pathan, S., Shukla, V. (1991). Urban land use mapping: a case study of Ahmedabad city and its environs. *Journal of the Indian Society of Remote Sensing*, **19** (2), 95–112.

Riebsame, W. E., Meyer, W. B., Turner, B. L. (1994). Modeling land-use and cover as part of global environmental change. *Climate Change*, **28** (1), 45-64.

Salvati, L., Sateriano, A. (2013). To grow or to sprawl? Land cover relationships in a Mediterranean city region and implications for land use management. *Cities*, **30**, 113–121.

Sarvestani, M. S., Ibrahim, A. L. (2011). Three decades of urban growth in the city of Shiraz, Iran: a remote sensing and geographic information systems application. *Cities*, **28** (4), 320–329.

Selcuk, R., Nisanci, R., Uzun, B., Yalcin, A., Inan, H., Yomralioglu, T. (2003). Monitoring land-use changes by GIS and remote sensing techniques: case study of Trabzon. *Proceedings of 2nd FIG Regional Conference, Morocco.*

Seto, K. C., woodcock, C. E., Song, C., Huang, X., Lu and Kaufmann, R. K. (2002). Monitoring land use change in the Pearl River delta using Landsat TM. *International Journal of Remote Sensing*. **23** (10) 1985–2004.

Sharma, L., Pandey, P. C. (2012). Assessment of land consumption rate with urban dynamics change using geospatial techniques. *Journal of Land Use Science*, **7** (2), 135–148.

Soffianian, A., Nadoushan, M. A. (2010). Mapping and analyzing urban expansion using remotely sensed imagery in Isfahan, Iran. *World Applied Sciences Journal*, **9** (12), 1370–1378.

Sudhira, H., Ramachandra, T. (2003). Urban growth analysis using spatial and temporal data. *Journal of the Indian Society of Remote Sensing*, **31**(4), 299–311.

Weng, Q. A. (2001). Remote sensing, GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. *International Journal of Remote Sensing*, **22** (10), 1999–2014.

Wu, J. (2013). Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. *Landscape Ecology*, **20**, 1-11.

Xu, H., Wang, X. (2000). A remote sensing and GIS integrated study on urbanization with its impact on arable lands: Fuqing City, Fujian Province, China. *Land Degradation and Development.* **11** (4), 301–314.