Pakistan Geographical Review, Vol. 69, No.1, June 2014, PP 15-27

TEMPORAL ANALYSIS OF URBAN DEVELOPMENT IN SARGODHA: A GEOSPATIAL PERSPECTIVE USING LANDSAT TIME SERIES DATA

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ABSTRACT

The present research work reveals the utility and ability of new paradigm in historical urban development i.e., the use of Geographical Information System and Satellite Remote Sensing data in obtaining historical (temporal) change in landuse patterns of study area. The efforts were made to collect the reliable data from various sources including Global Land Cover Facility (GLCF), free web repository of satellite imageries. In addition to this secondary datawere also collected from various governmental and non-governmental organizations like Census Organization of Pakistan, Punjab Development Statistics, and Sargodha Municipal Corporation, a semi-structured questionnaire was used to obtain information about historical development of land use patterns prevalent in the city of Sargodha since 1992. The basic purpose of this was to have an insight into the perception of the local population about the land use patterns prevailing in the city. However, the result of this research work shows a rapid historical development in built-up land use between 1992 and 2010 while the same period witnessed a reduction in all other classes particularly the category under agricultural land use. It was also inferred that the future change by years to come may likely to follow the same trend as in the past since 1992.

KEY WORDS: Urban Development, Change Detection, LULC, Public Perception

INTRODUCTION

In present research we have identified and analyzed the historical transition of different landuse change patterns with the help of post classification technique applied on multi-temporal Landsat imageries of 1992, 2000, 2005 and 2010.The current research emphases on the process of landuse changes and consequent pattern change. The reclassification of the final four class maps in to built-up and non-built-up areas were executed and then combination of "past -to-present" change evidence was acquired about the built and un-built up class through maps.Rural-urban migration and industrialization are two known causes of haphazard and unplanned growth of urban centres all over the world. This issue has become more complex due the fact that it is associated with cities particularly within the built up area. This momentous growth of population results in overcrowding within urban centres which ultimately become burden to available civic amenities which forces the middle class as well as builders to move to outlying suburbs bringing about changes in existing land use of the city phenomenon (Saravanan and Ilangovan, 2010).

Lo & Noble (1990) produced maps for the urban area of Boston at level III of the Anderson, (1976) scheme. Curran and Pedley, (1990) in one of their pioneer studies mapped numerous cities/urban areas with the help of MSS digital data using the Anderson scheme of classification for upland England. Jensen (1996) achieved an accuracy of 64.6 percent for 11 land use types at the urban-rural fringe of Denver, Colorado, Charbonneau of Montreal, Canada. The results derived from unsupervised

classification of the Satellite Remote Sensing digital data were 5-30 percent additional correct than official data and statistic. In a similar study Haack *et al.* (1987) classified Miami's land use into water bodies, wetland, croplands, built-up/commercial areas, having done so he inferred that thematic mapper satellite remote sensing data do not always lead to precise findings. In yet another study Harris and Ventura (1995) by using Landsat thematic mapper imagery attained a classification accuracy of 77 % in a multitude of residential, commercial, industrial and open spaces classes after classification of Beaver Dam, Wisconsin. This overall accuracy was improved later by 8 % after such secondary source information like zoning and housing density was integrated in the classification.

Doi, (1991) used two Landsat TM images year (1989 and 1990) to create a land-use map of Vietnam at a scale of 1:1000,000 by visual interpretation. The area for each category was calculated from the result of land-use analysis through simple percentage method. Sunar, (1998) collected two images of Landsat TM (1992) and Landsat pan (1993) to assess merged multi resolution data sets and to carry out comparative measurement of image quality. In the same year Sunar, (1998) also studied to detect land use land change changes by using multi-temporal Landsat TM imagery for Istanbul, Turkey, employing various methods like image overlay, image differencing, principal component analysis (PCA) and classification compositions. Kwarteng, *et al*. (1998) used and analysed Landsat Thematic Mapper (TM) images to determine their utility for both spatial and spectral mapping as well as temporal change detection in Kuwait city and found Satellite Remote Sensing (SRS)data appropriate for urban land use changes.In order to identify urban land use changes with high resolution TM &Landsat XS date sets, both the normalized difference vegetation index (NDVI) and principal component analysis (PCA) were used to infer the results.

DESIGN AND METHODS

An apparent rapid temporal expansion and growth of the urban agglomeration of Sargodha city has been presented through the change detection techniques. The urban growth has taken place in all urban features in the whole of city. Similarly extended residential area, commercial and industrial development, extended road facilities and other city's infrastructure construction occupied the un-built up space and transformed it into built up zones all over Sargodha city. The most prominent transformation as evident through maps is in agricultural land in to built-up areas. Fig. 4 shows the process of overlay to the built-up land to reveal the place of change during 1992 to 2010.Fig.1 and 2, delineate the two major types of landuse that is built-up land and non-built up and these figures specifically have shown the transformation of valuable agricultural land of the city to built-up area.

Table-1 reveals the change statistics and answers to study questions regarding "how" and "where" these dynamic and historical changes have taken place. In short, after preparing the change detection maps of the study area for various years (Fig.1 and 2) it can be deduced that Satellite Remote Sensing (SRS) data has been proved to be very

effective and productive in finding and interpretation of spatial and single entity through time and space is fruitful in comparison, change detection and comprehensive pictorial presentation of these variations depicted on paper maps. After analyzing extensive approaches in change detection, a multi-date post-classification assessment system algorithm was used to find out changes (Jenson, 2004). The post-classification comparison method requires a change information "past-to-present" and it help in calculating and mapping the phenomena of change in the historical urban landscapes since past.

Table 1: Area Change in Hectare and Percentage of Land use Classes

Land Use	Area change in Hectare				Area change in %			
	1992-2000	2000-05	2005-10	1992-2010	1992-00	2000-05	2005-10	1992-2010
Built-up land	+14696	+6953.2	+6280.3	+27929.5	+10	+5	+4	+19
Barren land	-13751.3	-5119.3	-1951.3	-6680.7	-9	-4	-1	-5
Agriculture	-18275	-2664.9	-5993	-26932.9	-13	-2	-4	-18
Water Bodies	-10172.33	-830.91	-1664.02	-7677.4	-7	-1	-1	-5

RESULTS

Fig. 4 depicts the temporal landuse classification dynamics changes since 1992 to 2010 and portrays an overall relative change in the Sargodha city. Moreover, while looking at Fig. 1,2 and 3 it is apparent that the spatial patterns and trends in the urban landuse category actually initiated by the urban development and growth which is following a definite direction along all the main arterial roads of the city. This in turn suggest that the future growth and related landuse plans, type and management should follow the directions of growth corridors by developing highways viz-a- viz, population growth.

Built-up areas demonstrate remarkable increase in its magnitude and extent while un-built-up surfaces have recorded an appreciable decrease since 1992 to 2010. A steady and consistent spatial development of built up areas has been observed from 1992 to 2010 (Fig. 5 and 6). It is also apparent from the temporal mapping of the city that there has been a continuous transformation from non-built up land to urban built-up areas.

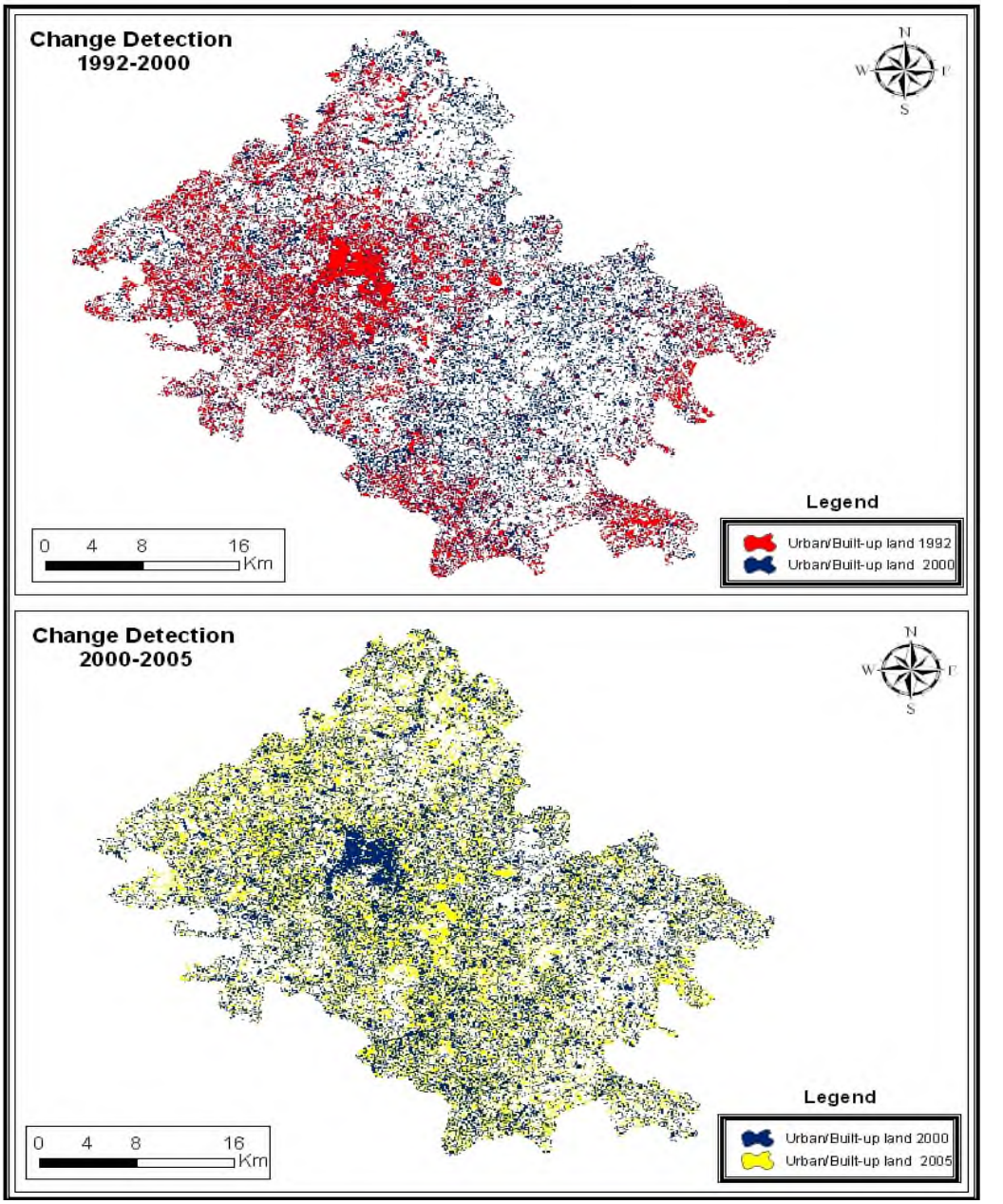

Figure.1 and 2: Change Detection Pattern of Sargodha City 1992-2005

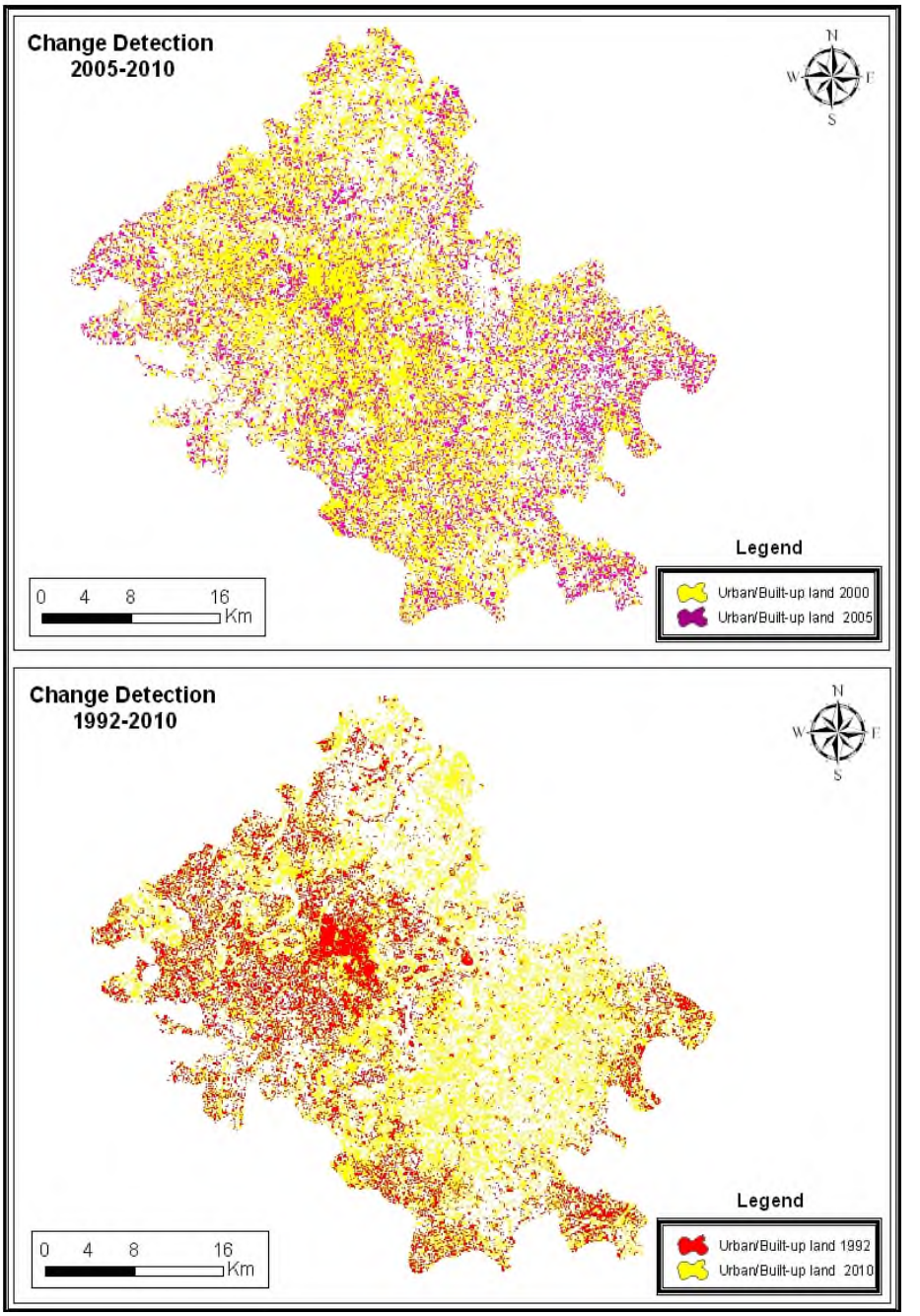

Figure.3 and 4: Change Detection Pattern of Sargodha City 2005-2010

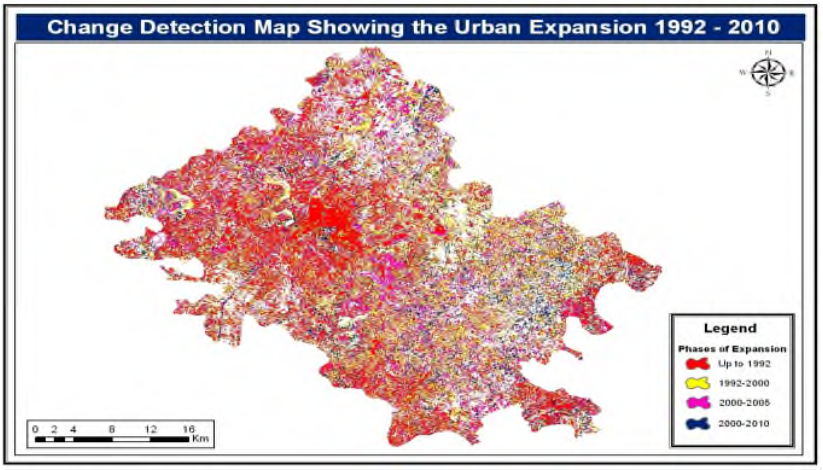

Figure 5: Map Showing Change Detection and Urban Growth in Sargodha 1992- 2010

Table1 reveals the landuse change in the area (both in percentage and in hectares) regarding all the classes and landuse re-classes. It is apparent from the data that there has been a general decrease in non-built up area and a substantial increase of 51% for the built up area during the study period have been observed.

Table2: Area change in hectare and percentage of land use re-classes

Land Use	Area In hectare				Area change In %			
	1992-2000	2000-2005	2005-2010	1992-2010	1992-2000	2000-2005	2005-2010	1992-2010
Built Up	14696	6953.2	6280.3	27929.5	55	17	13	51
Non- built Up	-14696.03	-6953.29	-6280.28	-27929.6	-12	-7	-6	-31

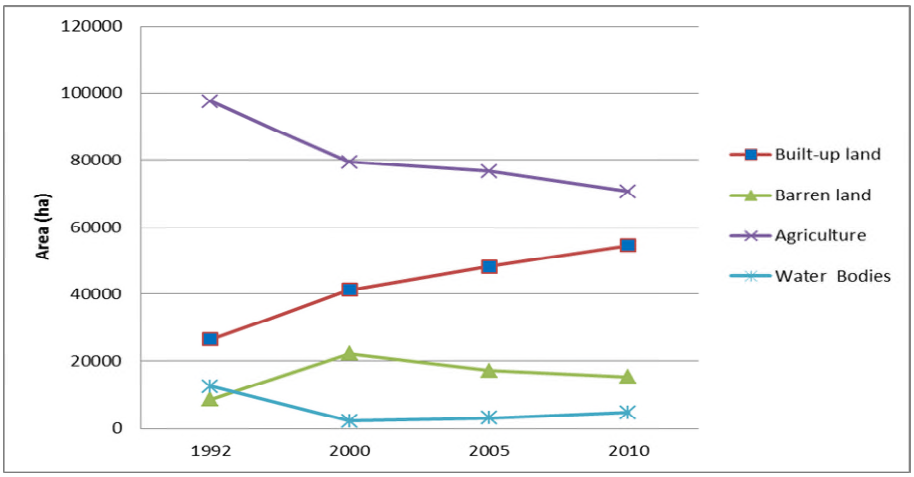

Figure6: Historical patterns of land use changes in the study area (1992-2010)

DISCUSSION

This section of analysis is concerned with landuse changes in Sargodha and the major driver of this change which is anthropogenic in nature therefore, a public perception survey was conducted during the months of March-April 2012 in various localities. The survey carried out in the following steps.

First of all we collected the map of Sargodha and identified the sample localities of research area. We decided to cover all those areas where Landuse changes are visible on ground as well change detestation maps were prepared after image analysis in GIS environment. The geographical orientation of the sample areas were also taken into consideration as to cover all along major roads linking of the city of Sargodha with other cities of Punjab.

Muradabad, Kachery Baazar, Block 8, 19 and 22 were the sample localities selected as the survey areas for this research work. These areas included the old neighborhood, newly constructed colonies and development taking place along major arterial roads of the city .The administrations of these areas are controlled by union *Nazims*, who are performing their duties efficiently.

The on screen findings revealed that most of the landuse changes have taken place in old city and along major road network. Taking into consideration this, it was then decided to carry out a general survey of research area on the basis of a random sample chosen with the consultation of research supervisor. The objective of this survey was to have an insight into what kind of landuse changes have taken place and what are the factors responsible for this change, the likely effects of Landuse changes were also been observed. A self-administrated questionnaire was devised and a pre-test was carried out in the 10 % sample population and questionnaire was later modified a little therefore the final questionnaire consisted of 19 questions.

The gender composition of the total sample of 1125 respondents revealed that out of total 90.6% were males while remaining 9.4 were female respondents. More or less same proportion found in all the surveyed zones of Sargodha. Literacy and education has fundamental importance of any in depth study of the present nature. The level of education is an indicator of socio-economic development and prosperity of a society. As far as educational characteristics of the sample population is concerned we found that most of the respondents were bachelors (37.5 %) followed by teachers, engineers and doctors etc.; with a percentage of 20.9.There were only 22.7 % respondents were uneducated. The proportion of others category was 18.7%.

Out of 19 questions, the response of the following 6 questions has been give below:

What type of landuse is usually found around your living place?

In response to this question 40.6 percent of the respondents replied that residential is a common landuse around them, followed by commercial 32.7 %, 13.6 Agriculture, 10.8 % open while only 3.3 percent revealed that they have open landuse around them.

2. Do you think that the area you are living now has changed during the last 20-25 years?

The overwhelming response (87.0 percent of total) to this question was that the areas where they are living now has changed dying the past 20-25 years while 10.7 % said No while remaining replied as they do not know.

It was further revealed that most of them think that this change is being caused by commercialization in the city, followed by population increase and development by the government

3. Do you think the pollution is a gift of the landuse changes in Sargodha?

This question was actually related to the overall environment of the city of Sargodha and majority of the people was replied in positive to this question. This also revealed that the people are aware of the environmental issues.

4. How would you rate the overall quality of Sargodha's landscape green character?

The majority of the respondents (87.9 %) were not happy with the overall quality of the landscape and green character of the city. They think that landscape of Sargodha is in a miserably condition and needs to be improved in near future. Remaining 12.1 percent were indifferent with the situation and did not show any concern about this condition.

5. Do you expect the present Landuse (state of the city) to look the same 15-20 years from now as it does today?

Most of the respondents were of the view that the present landuse of the city shall no longer remain the same as it will deteriorate further with the passage of time. They thought that with the rapid increase in population and rural to urban migration the landuse will change.

6. As per your observation Sargodha is developing/expanding towards/along which road?

The most important question of our field work was related to rapid landuse changes along the major roads which are connecting Sargodha with rest of Punjab. The response to this question was that the city was expanding towards Lahore (56.7%), followed by towards Bhalwal (32.6%) and Jhang road (11.7%). This is because of the fact that all these three roads are leading towards three major cities of the province. All the above questions and their responses were in good agreement with remotely sensed data and maps created in GIS environment.

Since our primary aim was to study and investigate land use changes taking place in Sargodha Tehsil during the period of 1992-2010 We classified images in four classes which is Agriculture, Built up land Barren land and Water bodies. It was concluded from the study area that the population increased and built up land area increased 51% and agricultural areas decreased to 31%, after classifying all the images of the study area we have come to know that in 1992 agriculture area was 67% (97527.8 ha), Built up area was 18% (26511.4 ha), water body 9% (12371.9 ha) and barren land was 6% (8566.8 ha).While analyzing 1992 image, a major proportion of the study(9% of the total) was found under water or wet. This was a puzzling aspect during our analysis, however after

ground truthing and studying the history of floods in the study area it was revealed that it was due to 1992 floods of Pakistan. Floods of 1992 were regarded as 5th worst in the history of the Country. Jhelum and Chenab was in high flood during September 1992.Many districts of the Punjab including Sargodha was under flood water and standing crops were destroyed. While in year 2000 image results were different and agricultural area was reduced from 67% to 55% (79252.8 ha) and Built up area was more increased (41207.4 ha). Barren land was 15% and water bodies reduced to 2% which was 9%.In 2005 results were little bit changed built up area occupy more space and agriculture area more reduced and water body remain same which was in 2000 image. The last image of year 2010 of Sargodha (tehsil) was entirely different, built up area was 38% (54440.9 ha), Agriculture more reduced from 53% to 49% and barren land also reduced to 10% water body increased from 2% to 3%.Over all we have found variation between agriculture and built up area which is clearly visible in all the images as well people's perception.

All the land use classes for pattern recognitions were distinctly produced for each study are but with more importance were given to built-up land as it is most likely to be because of anthropogenic activities which make up this class; and hence indeed, it is one land use which affects the other classes/categories. In order to do so we have made use of various statistical techniques and formulas. However, the result of this research work shows a rapid progression in built-up land use between 1990 and 2010 while the same period witnessed a reduction in all other classes particularly the category under agricultural land use. It was also inferred that the future change by years to come may likely to follow the same trend as in the past since 1990.

RECOMMENDATIONS:

Following are few recommendations for the future urban change directions and growth corridors in the city of Sargodha.

Keeping in view of the findings of this research it is more likely that the city will grow in the years ahead creating crowdedness and haphazard growth along with the main roads leading towards other cities. This situation will have adverse consequences in the area because of the associated problems like overcrowding, congestion, traffic burden, lack of civic facilities and crimes. It is therefore recommended that people should be encouraged to build towards the outskirts of city and along major roads through the provision of incentives and forces of attraction that are available at the city center.

Agricultural land use is diminishing with the passage of time as evident through Satellite Remote Sensing data during the study period from 1990 and 2010, while there has been a growth in the spatial expansion of Sargodha as against its agriculture land use. There is a possibility of continual reduction in this category over next few decades. It is anticipated that the city might reduce in producing its agricultural products, for which it is famous in the country i.e; citrus fruits. This in turn will attract the surplus labor from surrounding villages which will result in-migration into the area. Although, presently there have been a number of industrial units in study area and many of those are

already defunct during our study period. It is therefore suggested that Punjab government should encourage investors both local and foreign which in turn may help region to come up again.

Open land seems to be reducing between 1990 and 2010 which again indicating that the urban built up land is occupying these open land areas hence signifying a desirable change.

As revealed by the people perception survey of the sample localities that major land use changes have been observed along roads which connects Sargodha with other neighboring cities therefore it is recommended that new residential areas and allied enterprises may be built along the roads i.e.; along Lahore road ,Faisalabad and Jhang.

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