Assessing the Impact of Urban Growth on Agricultural Land in Gasabo District a Case Study of Ndera Sector

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ABSTRACT

Urbanization resulted into changes in the landscape, specifically the proliferation of concrete and impervious surfaces, and the displacement of agriculture and forestland. This study aimed to quantify urban growth and the changes of land use/land cover from 2005-2015 and to assess the impact of urban growth on agricultural land in Ndera sector of Gasabo district. To achieve the objectives, data have been collected such as shapefiles of Rwanda Administrative boundaries, Quick bird of 2005 and World View II of 2015 were acquired and processed by ERDAS IMAGINE Software to obtain Land use/Land cover and change detection maps, the various land cover classes that were interpreted in the study area include, built-up land, agricultural land, vegetation, water bodies and bare soil were visually analyzed and finally the maps were produced in Arc GIS Software.

The result of the study indicated that; in 2015, there was a significant rise in built-up areas where built-up raised from 2.07% in 2005 to7.14% in 2015; this means that the built-areas have increased by 5.07% between those spoken above periods while agricultural land was decreased with regard to the results by 19.64%. So, referring to those impacts followed by urban growth on agricultural land in Ndera sector of Gasabo district the city has to improve the land management knowledge and skills of the city planners to balance the increase of urban land demand and the loss of agricultural land.

Key Words: Urban Growth, Land Use/Land Cover, Urbanization, Change Detection

Introduction

Urban growth is the result of rapid urbanization and also it is one of the realities of our times; the world's population is getting more urbanized as people migrate from the rural to the towns and cities. Towns are perceived to offer improved living conditions, job opportunities and other opportunities including infrastructure such as good roads, schools, hospitals, markets, better communication network and electricity (Buhaug & Urdal, 2013). Urban growth in Africa both in spatial and economic terms is mainly due to natural population increase and migration (Felicia et al, 2012).

Agriculture is a way of life and provides scenic benefits, jobs, and income for many rural community but rapid urbanization continually threatens the livelihood of farming population and the social amenity benefit (Ogidi et al; 2014). Urbanization changes also the nature of the adjacent farms into idle, unused land, waiting to be converted to be urban uses. Even though farm ownership and farmer control of agricultural land is the rule and losing control of the resource that is basic to the livelihood becomes a greater concern. In view of this fact, it is important to evaluate the effect of urbanization, population decentralization, and economic growth upon the conversion of land from rural to urban uses (Rosenberger et al, 2002).

Urban growth on agricultural land use has become a global phenomenon plaguing all countries of the world; this phenomenon formed a challenge to most countries of the world, especially developing ones, because of the increasing of population at high rates, consequent the depletion of resources, especially agricultural lands around cities (Madallah, 2014).

Kigali city is one of the fastest growing cities in Africa. From its inception since 1907, the city has witnessed the remarkable spatial expansion, population growth and development activities such as building, road construction, deforestation and many other anthropogenic activities.In 1991, Kigali city only covered an area of 112 km^2 with 140,000 inhabitants. In 2012 the city expanded to a total population of 1,135,428 living in an area of 730 km^2. This has resulted in increased land consumption and a modification and alterations in the status of land cover/use. Nowadays, Kigali city has witnessed a tremendous rapid urbanization whereby agricultural and forest lands in urban fringes zones have been occupied by city dwellers (Nduwayezu, 2015).

The main purpose of this paper was to assess the impact of urban growth on agricultural land in Ndera sector by identifying the Land use/Land cover

(LULC) types in Ndera sector in 2005 and 2015 also by quantifying urban growth and land use/land cover (LULC) changes in Ndera sector from 2005-2015 and finally by analyzing the impact of expansion of Ndera urban areas on agricultural land from 2005 up to 2015.

Materials and Methods

The study area description

Ndera Sector shares its boundary with the following Sectors: In north: Gikomero, in south: Nyarugunga, in West: Bumbogo and Kimironko, and finally in East: Rusororo. Its geographic location is between 1°56'00"and 1°59'00" South and between 30°09'00" and 30°13'00" East. The sector of Ndera has 6 cells which are Mukuyu, Kibenga, Cyaruzinge, Bwiza, Rudashya and Masoro (GASABO, 2008). It is bound by steep undulating terrain to the north and west. Wetlands bind Ndera Sector in the south. Approximately 76% of the land area is suitable for development.

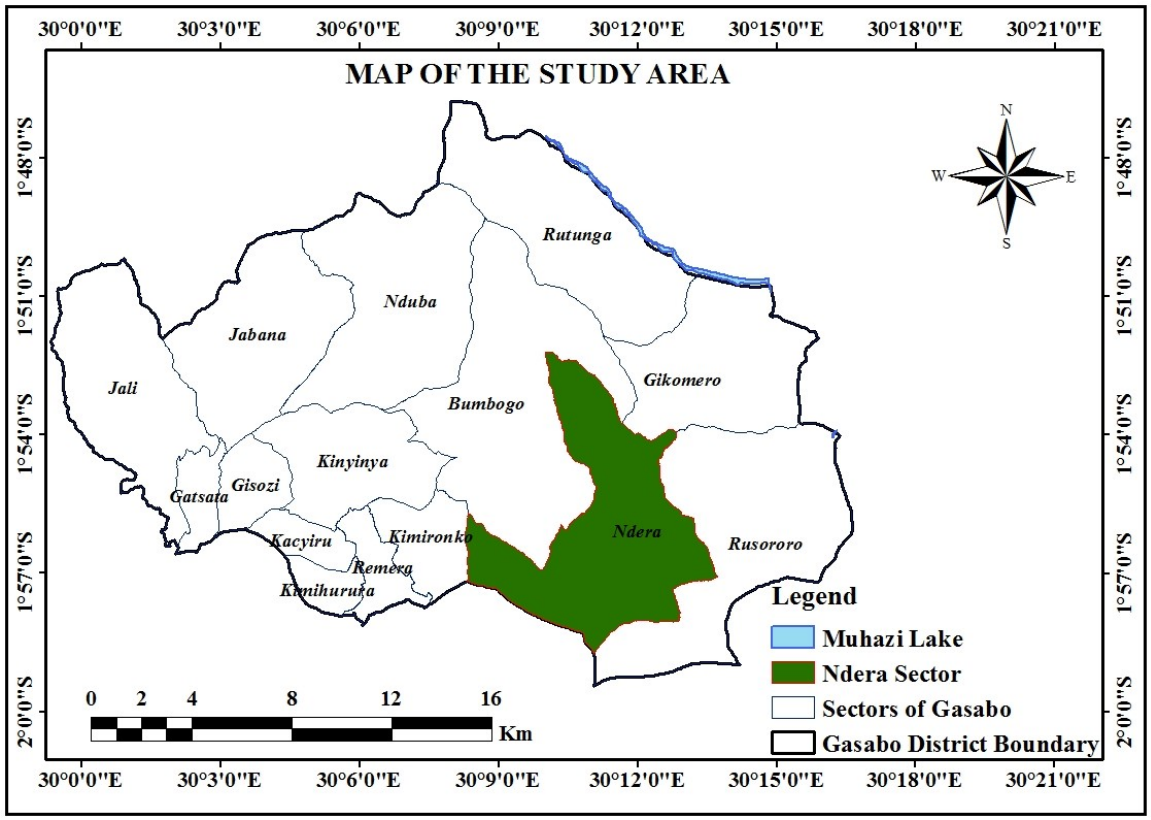

Figure 1: Map of the study area

The vast wetland network results in fragmented land parcels in this region. The areas along these wetlands are generally steep slopes. Around 22% of the area falls under steep slopes (slope gradient above 20%) and 1.2 % of the area is covered by forests. The steeps slopes, forests, wetlands and natural drain channels need to be protected. And its surface is 5025 ha with total population of 37,00inhabitants and

population density of 15p/ha (Gasabo,2013).

Data collection and analysis

This study used the Microsoft word, Microsoft excel, ArcGIS and ERDAS software's and the data that have been collected have been obtained from MININFRA and RLMUA and have been used to be aware of the land use/land cover changes in Ndera sector; those data are from Quick bird of 2005, World view II of 2015 and shapefiles of Rwanda administrative maps which was helpful to extract land use and land cover in Ndera sector. Data of land cover have been interpreted and analysed and the ERDAS has been used to analyse the changes from agricultural land to urban area in Ndera sector. Firstly, the image has been pre-processed by image enhancement where Atmospheric correction has been performed to enhance the quality of Image by eliminating some cloud and Haze in the satellite image.

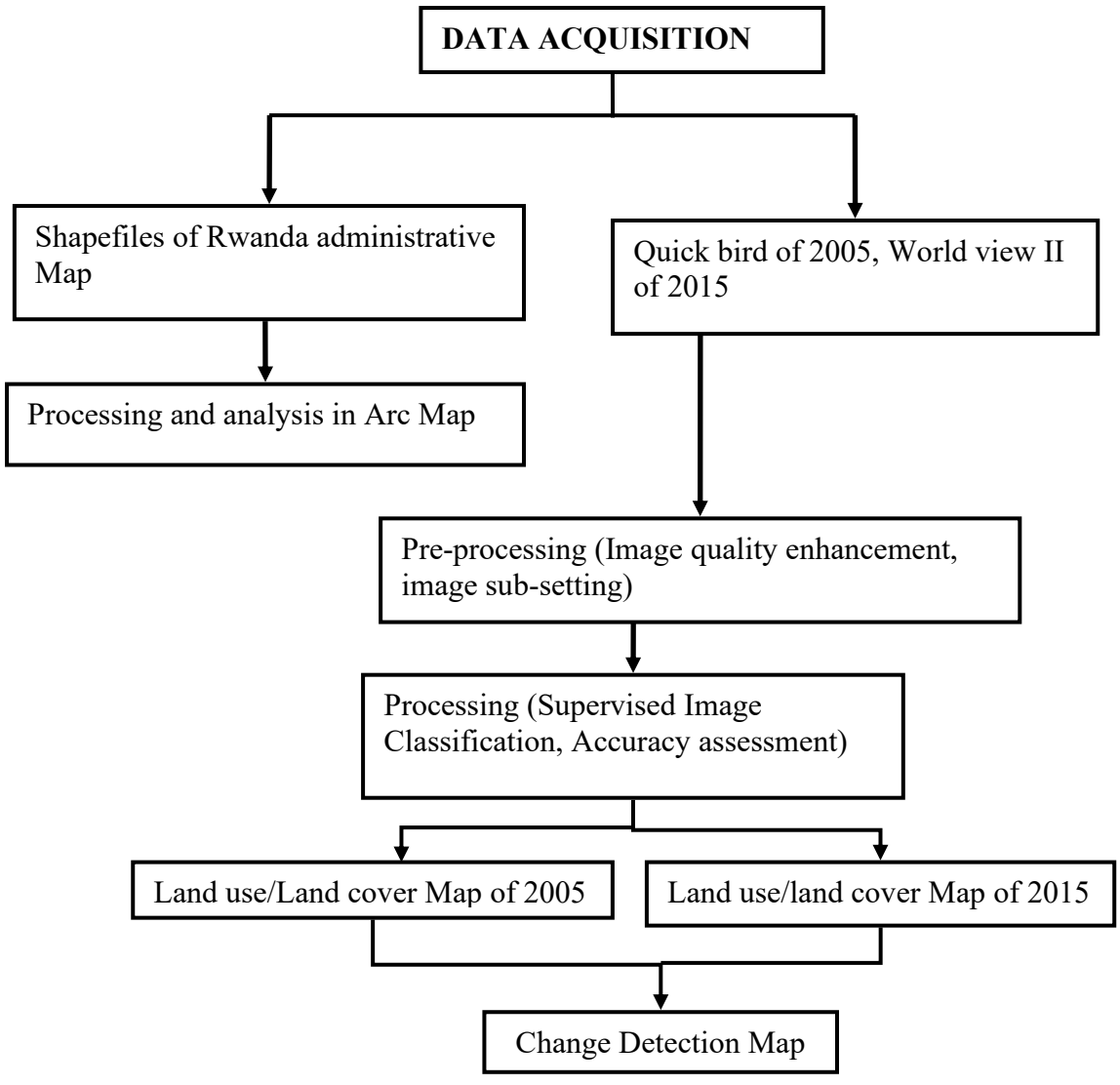

Figure 2: Flowchart of Data processing and analysis

Image classification has been used in classifying land cover change regarding the period of time in Ndera sector. The purpose of Image classification was to extract information classes from a raster image by creating the signature and digitizes a portion which has to be classified and then after each land cover will have a corresponding class. The resulting raster from image classification has been used to create classified maps.The supervised classification has been used by selecting representative samples for each land cover class in the digital image. These sample classes are called "training sites". The image classification software uses the training sites to identify the land cover classes in the entire image. The classification of land cover has been based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training site. The common supervised classification algorithms are maximum likelihood and minimum-distance classification. In this research each of the land use and land cover map has been compared to the reference data to assess the accuracy of the classification. The reference data has been prepared by considering random sample points, the field knowledge and google earth image. During this classification accuracy assessment, the random points have been used to identify the exact position of the place under consideration with latitude and longitude and its type by visual observation. The total numbers of random points that have been used are 228 points which have been used for Quick Bird of 2005 and 130 points which have been used for World View II of 2015. With the help of ERDAS Imagine software change detection analysis has been carried out in this study to observe land cover change, specifically changes of agricultural land and built-up areas as well as overall change of other Land covers from the time frame of 2005 to 2015 in the 5 cells of Ndera sector.

Results and Discussions

Land Use/Land Cover classification in 2005

Accuracy assessment

Table 1: Accuracy assessment of Quick Bird 2005

Class Name	Reference Total	Classified total	Number Correct	Producer's Accuracy (%)	User's Accuracy (%)
Bare Soil	37	38	33	89.19	86.84
Vegetation	73	77	67	91.78	87.01
Water Bodies	1	1	1	100.00	100.00
Buildings	5	4	4	80.00	100.00

Agricultural Land	114	110	104	91.23	94.55
Total	230	230	209		
Overall Classification Accuracy = 90.87%, Overall Kappa Statistics = 0.8550					

The accuracy of Quick Bird of 2005 has been assessed where the points were randomly selected to assess that classification accuracy. The overall classification Accuracy is 90.87% and overall kappa statistics is 0.8550. This were different to (Everitt et al., 2008) where in his research done on site of the Rio grande near del Rio, Texas showed that Overall classification accuracy were 83.2% and the Overall kappa statistics were 0.769.

Extent of Land use/Land cover classes in 2005

Table 2: Land cover of Ndera sector in 2005

LU/LC	Area (Ha)	Percentage (%)
Vegetation	1051.77	35.45
Water Bodies	18.7212	0.63
Agricultural Land	1379.7	46.5
Bare Soil	455.67	15.35
Buildings	61.4148	2.07
Total	**2967.276**	**100**

The data obtained from Quick Bird 2005 showed that five land use/land cover classes have been taken for the purpose of the research which are: Agricultural Land, Buildings, Bare Soil, Water Bodies and Vegetation cover which covers an area of 1379.7 ha, 61.4148 ha, 455.67 ha, 18.7212 ha, and 1051.77 ha respectively which is calculated/ quantified by using ERDAS IMAGINE Software.

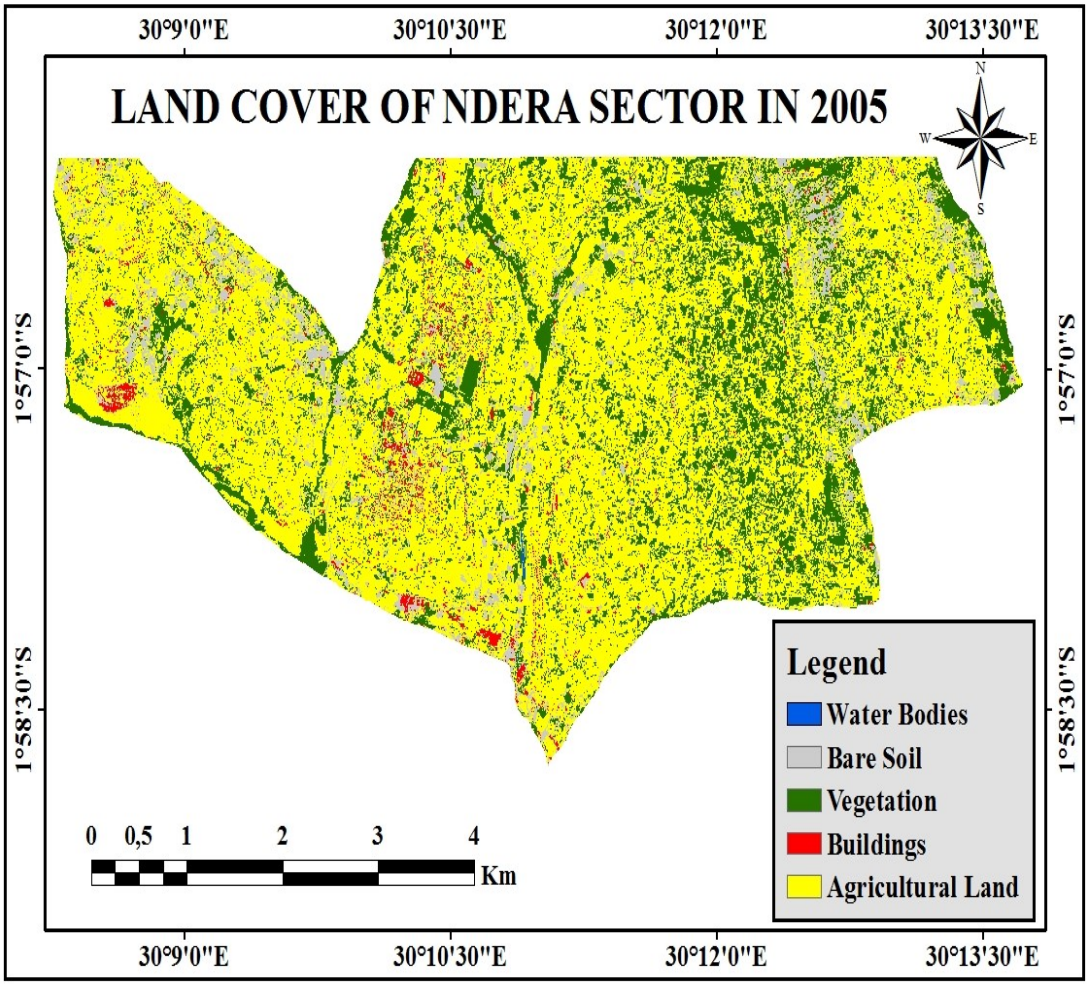

Figure 3: Map of Land Cover of Ndera in 2005

The figure number 3 shows the map of land use/land cover in Ndera sector in 2005 where it mentions different land cover including water bodies, Bare soil, vegetation, Built-up and agricultural land which occupied a very large part in the study area.

Land Use/Land Cover classification in 2015

Accuracy assessment

Table 3: Accuracy assessment of Worldview II 2015

Class Name	Reference Total	Classified total	Number Correct	Producer's Accuracy (%)	User's Accuracy (%)
Bare Soil	78	76	75	96.15	98.68
Vegetation	1	1	1	100.00	100.00
Water Bodies	28	36	27	96.43	75.00
Buildings	10	8	5	50.00	62.50

Agricultural Land	13	9	9	69.23	100.00
Total	130	130	117		
Overall Classification Accuracy = 90.00%, Overall Kappa Statistics = 0.8270					

The overall accuracy of classification image dated 2015 with worldview II was 90.00% and the Kappa coefficient was 0.8270 which were different to shahi et al. (2015) where in his research done in University Putra Malaysia (UPM) in Serdang, Selangor showed that Overall classification accuracy in the main area were 88.18% and the Overall kappa statistics were 0.7636 and it showed also that the Overall classification accuracy in the validation area were 86.40 % and the Overall kappa statistics were 0.7318%.

Extent of Land use/Land cover classes in 2015

Table 4: Land use/Land cover of the study area in 2015

LU/LC	Area (Ha)	Percentage (%)
Vegetation	1765.36	59,50
Water Bodies	2.6532	0,09
Agricultural Land	797.036	26,86
Bare Soil	190.138	6,41
Buildings	211.897	7,14
Total	**2967.0842**	**100**

Data in the table 4 were obtained from World view-II of 2015 five land use/land cover classes have been taken to see how much area is covered by each of these classes. Therefore, agricultural land covers 797.036 ha, urban covers 211.897 ha**,** vegetation covers 1765.36 ha**,** bare soil covers190.138 ha and Water Bodies cover 2.6532 ha.

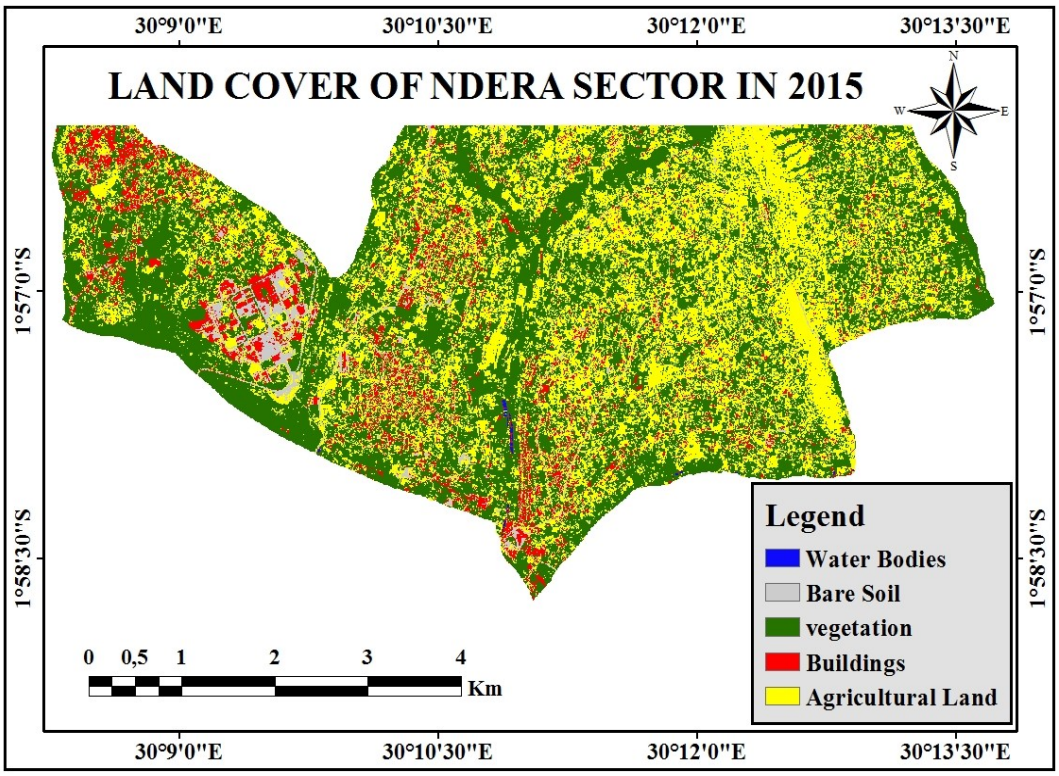

Figure 4: Map of Land Cover of Ndera in 2015

The figure 4 showed the land cover that located in Ndera sector. The study mentioned that they were five land covers which were: Water Bodies in blue, bare soil in gray, Vegetation in green, Built-up area in red and agricultural land in yellow.

Table 5: Changes of LULC in study area from 2005-2015

LU/LC	Area in Hectares (Ha)		Area in Percentages (%)		Changes in Hectares (Ha)	Changes in Percentages (%)
	2005	**2015**	**2005**	**2015**	**2015-2005**	**2015-2005**
Built-up area	61.41	211.9	2.07	7,14	150.49	5.07
Agricultural land	1379.7	797.04	46.5	26,86	-582.66	-19.64
Vegetation	1051.77	1765.36	35.45	59,50	713.59	24.05
Water	18.72	2.65	0.63	0,09	-16.07	-0.54
Bare land	455.67	190.14	15.35	6,41	-265.53	-8.95

LU/LC changes between 2005 and 2015

As it is illustrated in the table above; the built-up area as well as agriculture area has been changed drastically from 2005 to 2015.

Area of Land Use/Land Cover and their Percentages

Table 6: Change and no change Matrix table

Changed and no changed area (Ha)	**2015**				
2005	**Water Bodies (1)**	**Bare Soil (2)**	**Vegetation (3)**	**Buildings (4)**	**Agricultural land (5)**
Water Bodies (1)	0.19 **(No Change)**	1.64	11.01	1.7	4.11
Bare Soil (2)	0.28	38.12 **(No Change)**	253.13	40.97	123.02
Vegetation (3)	0.96	54.54	648.16 **(No Change)**	62.44	284.65
Buildings (4)	0	8.08	30.26	9.846 **(No Change)**	13.14
Agricultural land (5)	1.51	87.7	822.05	96.89	371.7 **(No Change)**

The table 6 illustrate the areas that have changed and the areas that have not changed in the study area from 2005-2015.

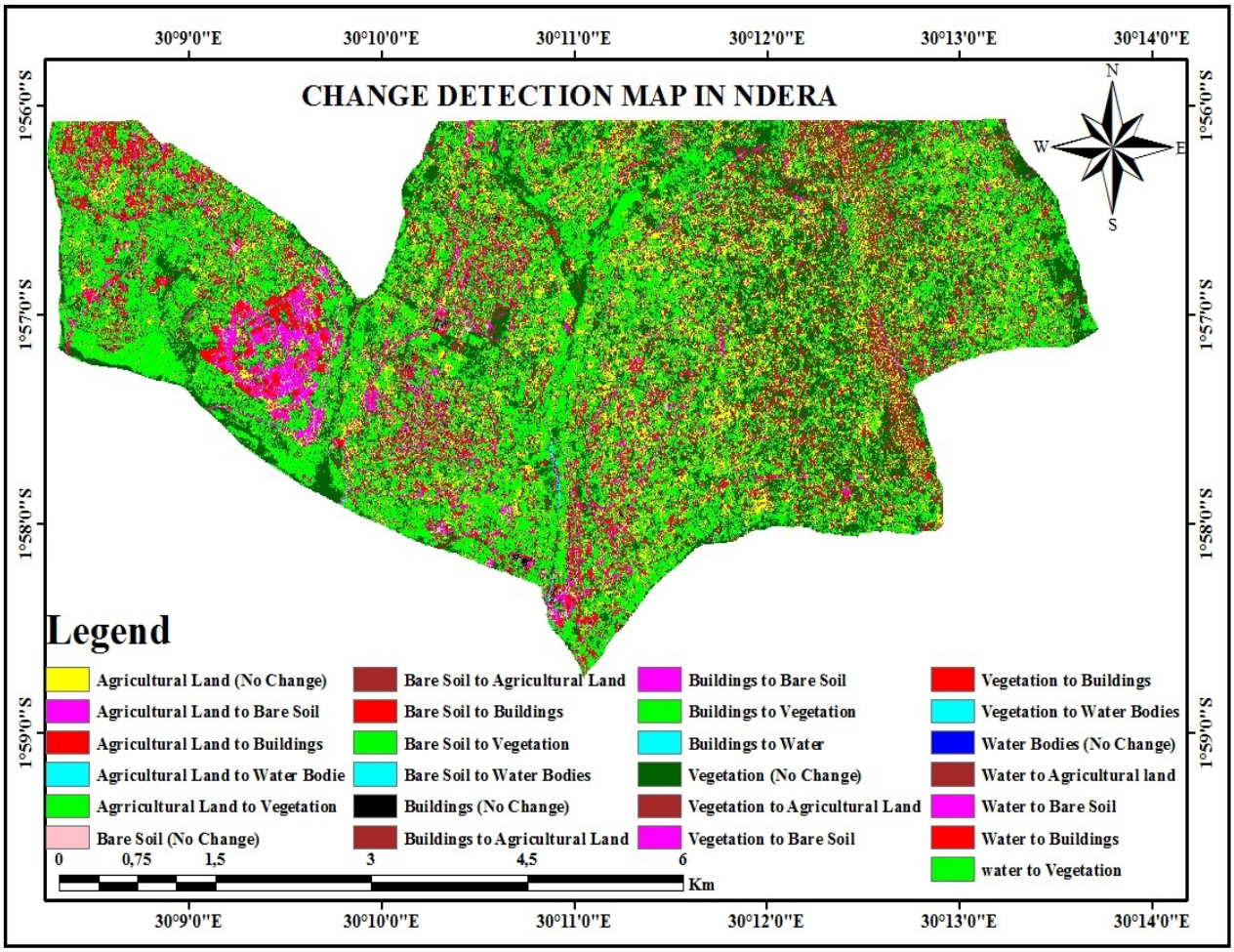

Figure 5: Map of Change detection in the study area from 2005-2015

The increase in built-up area from 2.07% up to 7.14% has many reasons. Ndera sector has experienced a great increase in Built-up area based on the results obtained where large numbers of buildings have come in to existence and corresponding infrastructure development leads to the increase of built-up area and that increase has contributed to the loss of agriculture area (GASABO, 2013).

There is an increase in vegetation or shrubs by 24.05 %over the study period; this increase is contributed to the grass grown on land and some trees that have been planted within the study period according to the government policy of planting trees.

Impact of urban growth on agricultural land and other land uses.

Loss of agricultural land and bare land.

A remote sensing technique was used to assess the spatial growth of built-up area for the given period of 10 years. All the two

LULC maps of Ndera are predominantly covered with built-up area. During 2005 built-up area has increased to 7.14%, with a sharp decrease in bare land and agricultural land areas. Between the year 2005 and 2015 there was a slight increase in built-up class with only 5.07 % of changes, agricultural land has been changed into other land covers including built-up area by 19.64%. However, urban growth has occurred during 2005-2015. And, when the two LULC maps of 2005 and 2015 were compared, one observed a marked difference in the western part of Ndera. During the course of 10 years, an area of around 888.18 ha of agricultural lands was lost to built-up areas and vegetation. These agricultural lands were prominently spread in the south and western part of Ndera up to 2015. Bare land losses were also accounted in the course of urbanization. Approximately 150.865 ha of bare lands were lost during the study period.

Conclusion

This study focus was to assess the expansion of urban areas and associated impacts on agricultural land in Ndera sector. Regarding to the socio-economic impacts exerted, it could be seen from two basic dimensions. The first one is the impact of urban expansion on the agricultural land because land is the most important economic base for the rural residents; but as urban expansion consumes agricultural land, farm lands become smaller and smaller. Small farm lands cannot produce enough to feed themselves and their families and provide for the market. The other social problems are the displacement of the people to urban areas which in turn highly affects urban population conditions. Accordingly, decreasing in agricultural land holding and food production ranks at the top of the problem imposed on rural societies. According to the major findings of the study, which was obtained from the changes of 2005 and 2015 High Resolution images; table 9 shows that the extent of urban expansion over all land uses is 202Ha, and 96.89 Ha over agricultural land only within 10 years interval. This shows that still the rate of urban expansion has increased rapidly from time to time. This resulted in the reduction of agricultural land. Generally, the higher rate of urban expansion, leads to the higher loss of agricultural land.

As recommendations, the Governments have a range policy of urban policy and agricultural policy. Practically the following mechanisms are recommended; (1) To improve the land management knowledge and skills of the city planners to balance the increasing land demand and the loss of agricultural land. (2) One of the causes of horizontal expansion of the city is

rapid population growth resulted from natural increase and rural urban and urban-urban migrations; therefore, improvements in the spatial planning and urban planning should get considerable attention.

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