Monitoring Land Use and Land Cover Change Using GIS and Remote Sensing in the Mizewa Watershed, Upper Blue Nile Basin

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ABSTRACT

The objective of this study is to evaluate the land use and land cover dynamics over 41 years (1973 to 2013) and to identify the major causes of changes in land use and land cover in the Mizewa watershed. The study used an integration of Remote Sensing (RS) and Geographic Information System (GIS) approach for analyzing the direction, magnitude, and spatial pattern of land use and land cover change in the study watershed. Results of this study showed that there were changes in land use and land cover patterns. Cultivated lands increased by 16.42% and 8.46% between 1973 to 1985 and 1986 to 1999 respectively. Furthermore, from 2000 to 2013, there were 1040.214, 984.028 and 111.02 hectares of settlement and plantation, bush lands and grasslands had been changed to cultivated land. The expansion of cultivated lands between 1973 and 2013 in the watershed could be directly related to rapid population growth and the clearing of bush lands and grass lands for such increasing agricultural land demand. On the contrary, the size of shrub or bush lands and grass lands coverage had decreased from 1973 to 1985 with -17.18% and -39.79% with an annual rate of change of -1.32% and -3.07% respectively. In addition, settlement and plantation increased from 1985 to 1999 with a rate of 6.18% per year. However, grass lands and bush lands decreased from 1985 to 1999 with annual rate of change -0.78 and -2.11% respectively. The change was induced by the transformation of bush lands and grass lands to cultivated lands. The massive reduction of shrub or bush lands particularly between 1973 and 1985 occurred due to lack of administration especially during the transition period and land redistribution as well as drought. Shortage of land has forced farmers to cultivate steep slopes and shallow soils that are vulnerable to degradation, and to increasingly rely on selling firewood and charcoal for supplementary income which has also contributed to the extensive destruction of the woody biomass and shrub lands. The cumulative effect of these had resulted in environmental degradation. Hence, it is recommended that there should be appropriate land use planning that identifies the proper land for specific purpose so that the marginal lands will not be put into agricultural use.

Keywords*: Land Use, Land Cover, Watershed, Mezewan, Ethiopia*

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Background of The Study

The The UN's Food and Agricultural Organization (FAO) defines land as "an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man (FAO, 1976)".

The term/concept of Land cover encompasses the biophysical state of the earth's surface and immediate subsurface, thus embracing the soil material, vegetation, and water status (ibd). Originally, the term had a narrower meaning, and referred only to the type of vegetation that covered the land surface, but this concept was later broadened to include soils and biodiversity as well (ibd).

Land is a dynamic canvas through which human and natural systems interact. Understanding the many factors influencing Land Use and Land Cover (LUCC) has been the focus of scientific study across multiple disciplines, locations, and scales. But direct measurements alone are not sufficient to provide an understanding of the forces driving change. Linking observations at a range of spatial and temporal scales to empirical models provides a comprehensive approach to understanding land use and land cover change (Turner *et al.* 1995).

A change in land use/land cover (LULC) is increasingly rapid, and can have adverse impacts and implications at local, regional and global environments (Brandon, 1998). As succinctly noted by Reid et al. (2000), LULC is an endlessly changing process taking place on the surface of the earth. Furthermore, Richards (1990) argues that the modern world has been facing massive changes in its land use patterns in the past few centuries. Williams (1990) indicated that in the last few decades' conversion of grassland, woodland and forest into cropland and pasture has risen dramatically in the tropics. This has been regraded as a serious problem adversly affecting the environment. The change is due to human activities and/or natural processes (Meyer and Turner, 1994). Moreover, this change could be the result of complicated interactions of socioeconomic and biophysical factors like economic diversification, technological advancement, demographic pressure and many other related conditions (Reid *et al*., 2000). These findings also assist in monitoring the dynamics of land use resulting out of changing demands of increasing population (Moshen, 1999). Studies of rates, extents, patterns, causes and implications of land use/land cover dynamics at local level can help to design more effecient land management strategies and policies. However, evaluation of land use and land cover changes in Ethiopia varies in spatial and temporal perspectives ; as a result, this study attempts to bridge such evaluation gaps in the case of Mezewan watershed in the upper Blue Nile Base of Tana Watershed.

1.1 Materials and Methods

1.2 Description of the study area

The study was conducted in the Mezewan Watershed situated in the Lake Tana basin about 65 kms from Bahir Dar, the capital city of the Amhara Region, along the road to Weji and Debretabor towns. The total area of the catchment is about 13676.62 hectares. It is part of the Upper Blue Nile river basin and its altitude ranges from 1482 to 2200 meters above sea level (masl). Subsistence agriculture is the major means of livelihood in the area with an average farm size of about one hectare.

Rainfall follows a unimodal distribution with an average annual rainfall of about 1600 mm. The average temperature is about 21.7 ^{o}C with a maximum yearly variation of 4^{o}C. There are two temperature peaks: one from May to June at the start of the rainy season and the other at

the start of the dry winter season from October to November. The color of the soil varies from dark brown to red. The study area is dominated by a crop-livestock mixed farming system.

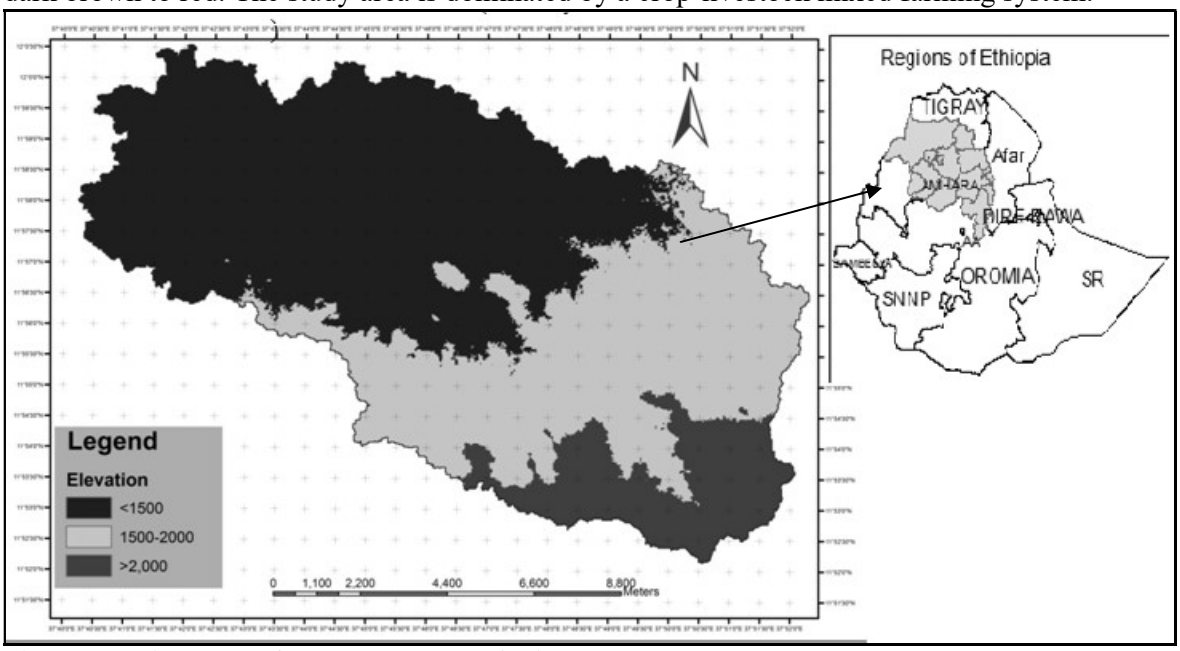


Fig.1: Location map of Mezewan Watershed

2.1 Data Sources

The data for this study was obtained from both primary and secondary sources. The primary sources include climatic and hydrological data collected from stations of the study area available in National Meteorological Agency (NMA) and Ministry of Water Resources (MoWR), site and topographic information of *Shuttle Radar Topography Mission* (SRTM data), Remote sensing data from satellite images and socio-economic data collected through socio-economic surveys. Review of maps, technical reports, published and unpublished documents relevant to the study were used as secondary sources of data.

No	Data (image)	Sensor	Resolution	Path/row	Date of acquisition	Source
1	Landsat1	MSS	57x57m	169/052	12/12/1973	GLCF
2	Landsat5	TM	30x30m	169/052 &170/052	1/1/1986	GLCF
3	Landsat7	ETM +	28.5x28.5m	169/052 & 170/052	12/09/1999	GLCF***
4	LANDSAT8	LDCM *	30m x 30m	169/052 &170/052	12/04/2013	USGS**
5	SRTM Data	-	20m	-	-	GLCF
6	Climatic Data	-	-	-	1970-2013	NMA

Table 1: Data and data sources

* Landsat Data Continuity Mission **United States Geological Survey ***Global Land Cover Facility

2.2 Methods of Data Collection and Analysis

To evaluate the land use/land cover changes in the Mezewan Watershed the following data sources, data collection methods and analysis were utilized. Remotely Sensed data namely, Landsat1, Landsat5, Landsat7 and Landsat8 images were the main sources of data for this objective as these sources allow generating quantitative data for changes in land use and land cover over time.

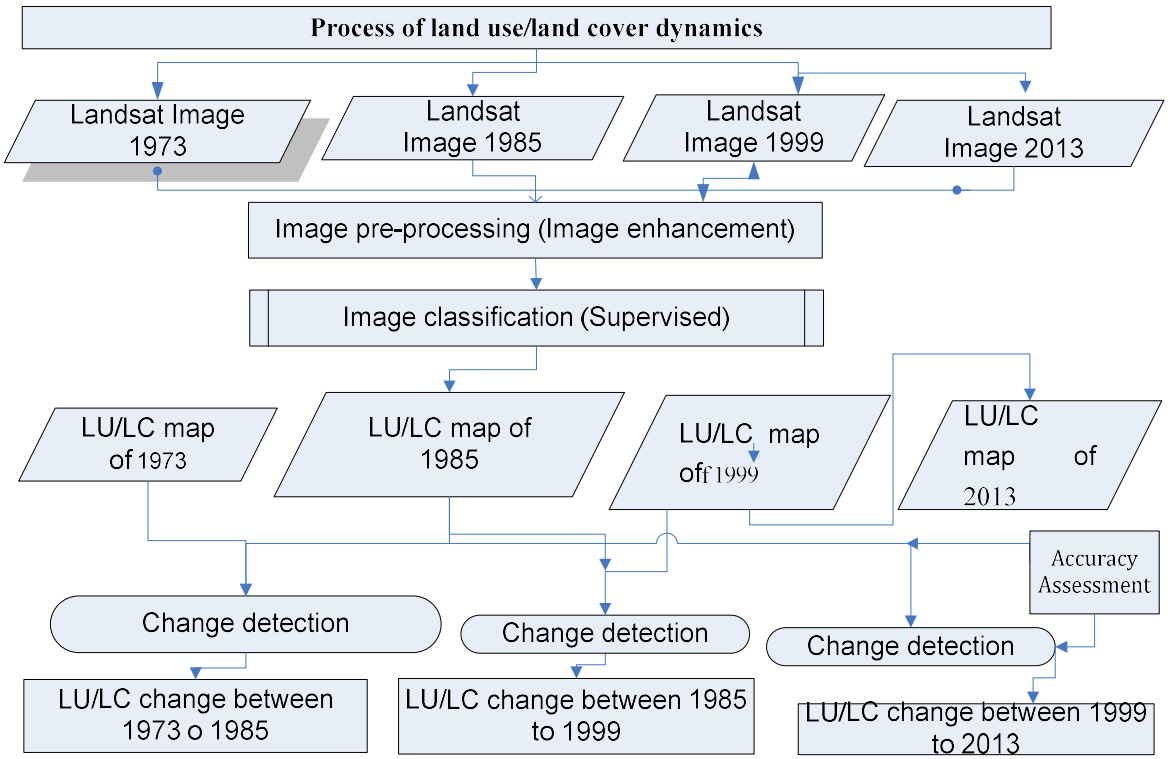


Figure 2: The Schematized flow diagram of land use and land cover evaluation

GIS and remote sensing methods allow for spatial monitoring and for integrating the expertise of stakeholders in the analysis. As a result to analyze and quantify the spatial-temporal Land Use and Land Cover changes GIS and Remote sensing techniques were used. Data from Land sat imageries were processed using ERDAS EMAGINE 2010 software and spatial analysis, interpolation and other calculations using ArcGIS 10.2. In order to detect the change the ENVI 5 software was utilized for its ease to calculate change matrix. Supervised digital image classification techniques were employed, and complemented with field surveys that provided on-the-ground information about the types of land use and land-cover classes.

3. Result and Discussion

Land uses and land covers are dynamic. There are different reasons for land cover and land use changes. Land use changes can move in two directions: either, in the negative, leading to land degradation and loss of (production) potential etc, or, in the positive, resulting in a higher value or potential such as access to cultivated land, housing etc.

3.1 Land Use and Land Cover Types in the Mezewan Watershed

Based on the field observation and the characteristics of Landsat satellite images of the year 1973, 1985, 1999 and 2013 using the application of image classification methods, four major land use and land cover types were identified in the Mezewan Watershed. These include Bush lands, Grass lands, cultivated lands and Settlements and plantations (Table 2).

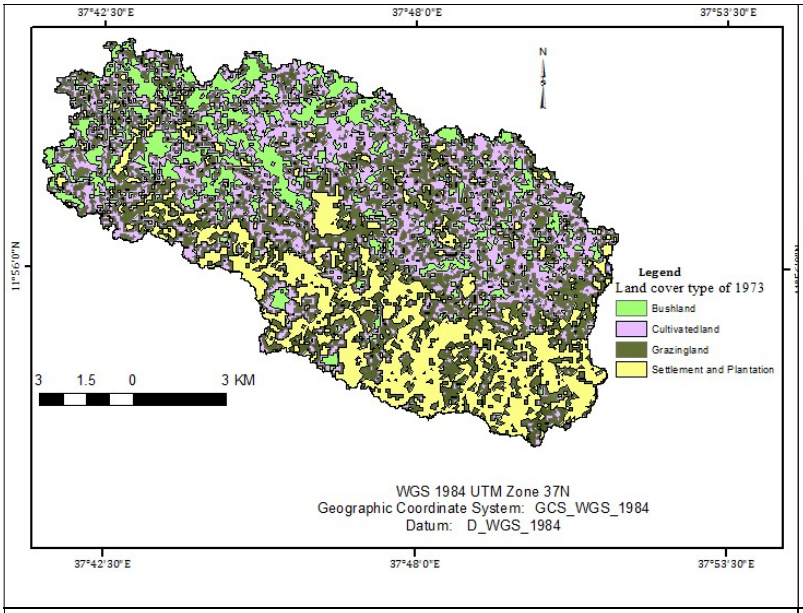
Table 2: Description of Land use and land cover classes identified .

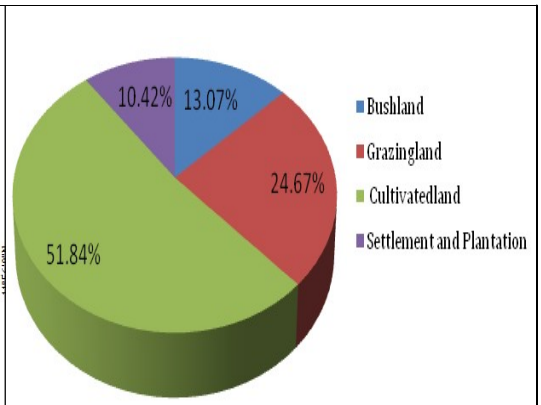
Types	Description
Bush lands	areascoved with shrub, some grasses and woody plants and those land surface features devoid of any type of growing crops but used for pasture, or bare lands which include those parts of the land surface mainly covered by bare soil and exposed rocks with scattered bushes. These belong to uncultivated lands covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests
Grass lands	areascoved with grasses; lands where small grasses are the predominant natural vegetation including lands with scattered or patches of trees andused for grazing and browsing
Cultivated lands	areas of land ploughed and/or prepared for growing crops. These are the areas currently allotted to rain fed crop cultivation both, annuals and perennials, mostly the cereals. Subsistent types of and the small scale irrigated lands.
Settlements and plantations	areas, permanently covered by the scattered rural settlements within the cultivated fields as well as the artificial forests around their homesteads, mostly eucalyptus trees.

3.2. Land Uses and Land Covers Classification of the Study Area

Land use land cover map of Mezewan watershed was generated for each of the four periods (1973, 1985, 1999 and 2013), separately and areal extent of each land category and transformation statistics were computed. The major land cover categories found in this study were Bush lands, Grass lands, cultivated lands and Settlements and plantations. Remarkable changes have been observed among the major land use categories during the periods investigated. The spatiotemporal and areal extent of the four major LULC changes of the watershed area between 1973 and 2013 are presented below (Figures 3, 4, 5 & 6).

As indicated in Figures 3 a & b, the greatest share of the area in Mezewan Watershed in 1973 was found in Cultivated lands category covering 7089.48ha (51.84%). Grazing Lands and Bush lands covered 3373.92 ha (24.67%) and 1788 ha (13.10%) respectively. Settlements and plantations covered about 1425.22ha (10.42%) of the total area of the watershed. This shows that 76.51% of the total area of the watershed was covered by Cultivated lands and Grazing lands in 1973 and the remaining 23.49% was covered by Bush lands and Settlements and plantations (Table 3).

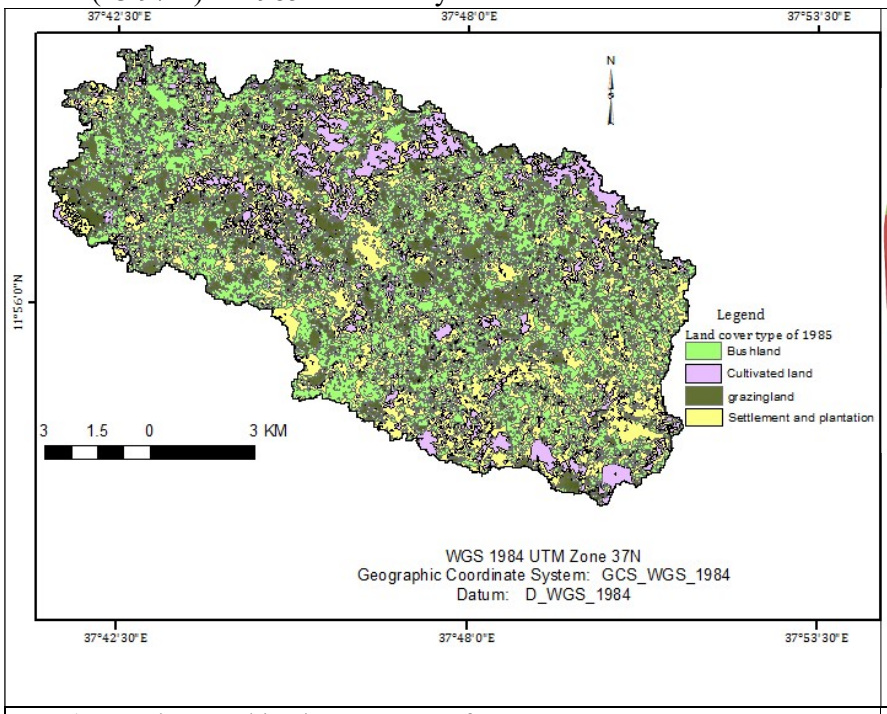


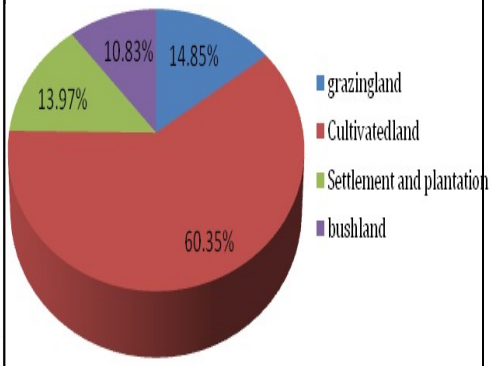


a) Land use and land cover types of 1973 | b) Areal coverage (%) in 1973

Figure 3 a&b**:** Land use/ land cover map & areal coverage of Mezewan Watershed in 1973.

As depicted in (Figures 4 a & b), the greatest share of land in 1985 was - cultivated land, which covered an area of 8253.76ha (60.35%). Grazing lands and Settlements and plantation occupied 2031.47ha (14.85%) and 1910.58ha (13.97%) respectively. The smallest area of the watershed was covered by Bush lands, which accounted for only 1480.81ha (10.83%). The swift expansion of cultivated land was due to the conversion of grass lands and shrub lands into agricultural land due to the rapid population growth in the study area. In addition to this, there was expansion of Settlements and plantation from 1425.22ha (10.42%) in 1973 to 1910.576ha (13.97%) in 1985 in the study watershed.

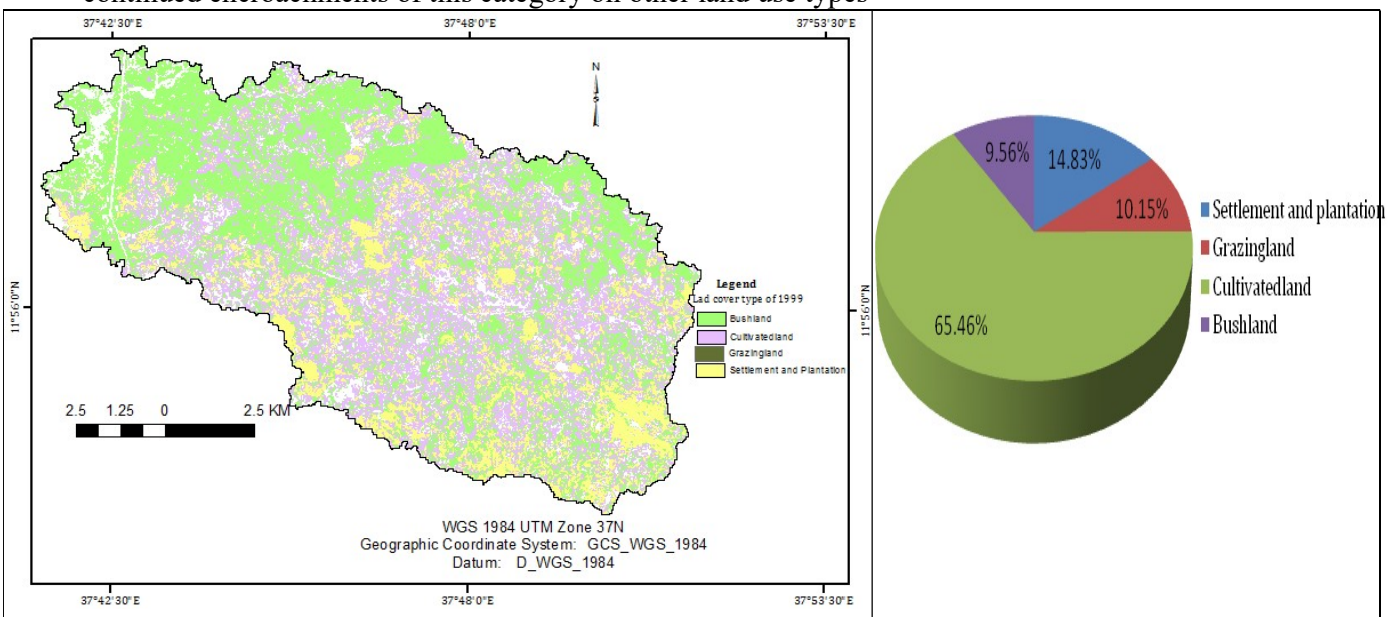




a) Land use and land cover types of 1985 | b) Areal coverage (%) in 1985

Figure 4 a & b: Land use/ land cover map & areal coverage of Mezewan Watershed in 1985

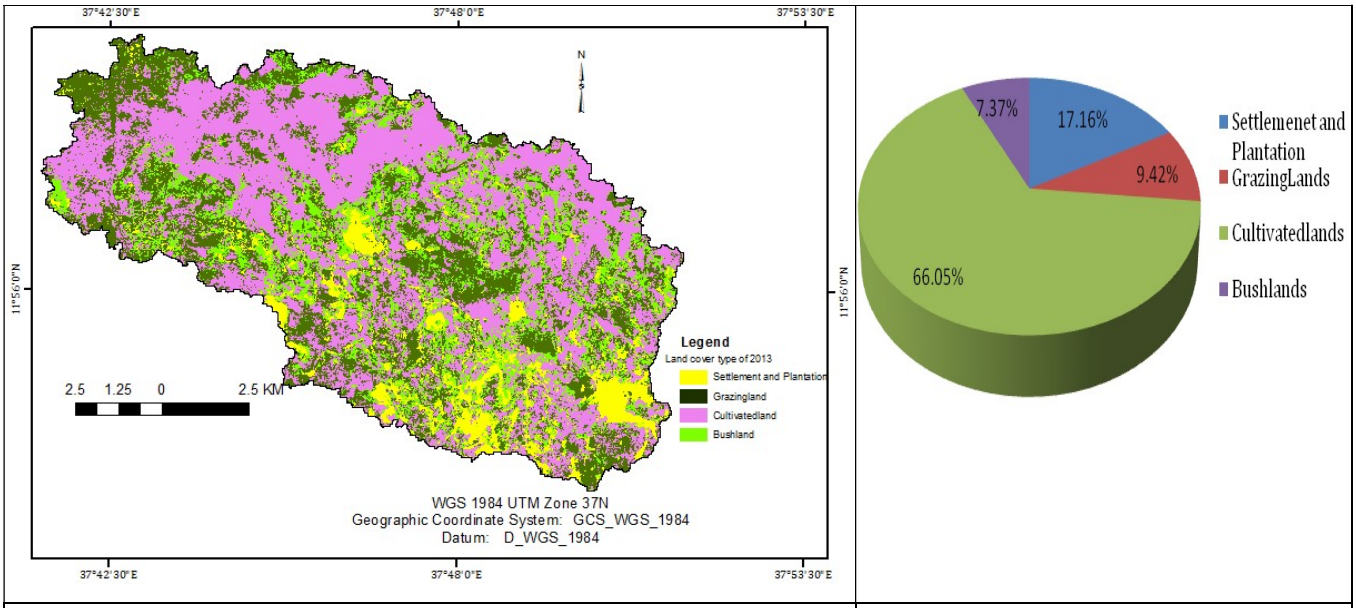
An analysis of the 1999 land use and land cover shows that cultivated land takingthe largest share from all land use type in the watershed. It accounts for about 8952.31ha (65.46%) followed by Settlements and plantation 2028.62ha (14.83%) and Grazing land 1388.48ha (10.15%), respectively. Bush land is the least land cover type in the watershed with a total area of 1307.21 ha (9.56%) (Figure 5). The trend in cultivated land substantiates the continued encroachments of this category on other land use types



a) Land use and land cover types of 1999 | b) Areal coverage (%) in 1999

Figure 5 a& b**:** Land use/ land cover map and areal coverage of Mezewan Watershed in 1999

As clear It can be understood from (Figures 5.4a and b) that the largest share of land use in 2013 is under cultivated lands, which covers an area of 9033.03ha (66.05%). Settlements and plantation and Grazing lands cover of 2347.32ha (17.16%) and 1288.48ha (9.42%), respectively. The least areal coverage was of Bush lands, which accounts for only 1007.79ha (7.37%) from the total area of the Watershed. The increase in cultivated land was due to the conversion of shrub and grass lands into agricultural land as a result of the rapid population growth in the study area. In addition, there was expansion of Settlements and plantation because of the high demand for land for housing from the rapidly growing population in the study watershed.



a)Land use and land cover types of 2013 | b) Areal coverage (%) in 2013

Figure 6 a&b: Land use/ land cover map & areal coverage of Mezewan Watershed in 2013

As Table 3 and Figure 6 depict, in the study area, from 1973 to 2013, cultivated land and Settlement and plantation were continuously increasing whereas bush lands and grazing lands were continuously decreasing.

Table 3: Area of the land use and land cover units at different periods

Land use/ Land Cover type	1973		1985		1999		2013	
	Area(ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Settlement and plantation	1425.22	10.42	1910.58	13.97	2028.62	14.83	2347.32	17.16
Grazing lands	3373.92	24.67	2031.47	14.85	1388.48	10.15	1288.48	9.42
Cultivated lands	7089.48	51.84	8253.76	60.35	8952.31	65.46	9033.03	66.05
Bush lands	1788	13.07	1480.81	10.83	1307.21	9.56	1007.79	7.37
Total	13676.62	100	13676.62	100	13676.62	100	13676.62	100

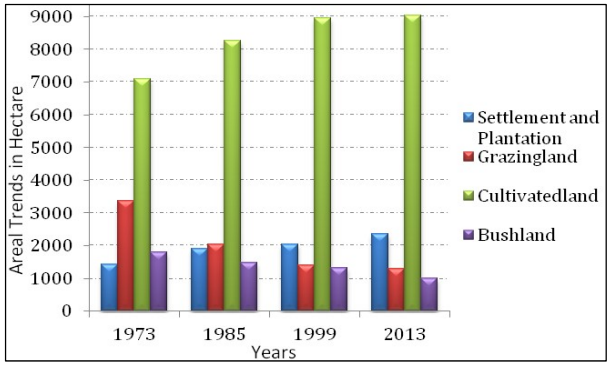


Figure 7: Land use /cover classes in1973, 1985, 1999 and 2013

3.3 Land Use and Land Cover Change

An important aspect of change detection is to determine what is actually changing to what i.e. which land use and cover class is changing to the other land use and land cover. In this study,

the process involves a pixel to pixel comparison of the study area by using images of different years through overlay analysis.

The land use and land cover change matrix depicts the direction of change and the land use type that remains as it is at the end of the day, in hectares. In the land use and land cover change matrix shown in Table 4 and 5, the rows represent the earlier land use and land cover categories and the columns represent the recent land use categories. From 1973 to 1985, a total of 966.9 hectares of bush lands, 1901.00 hectares of grass lands and 441.76 hectares of settlement and plantation had been changed to cultivated lands (Table 4). About 4709.8 hectares of the cultivated lands remained in the same category until 1985, while 2379.651hectares changed to other categories (Table 4). Transformation was largely into bush land, grass land, and settlement and plantation land use types. However, the loss of agricultural land to these three categories was compensated by a gain from other land use categories.

Table 4: Inter-category Land use and land cover change matrix of Mezewan Watershed (1973 to 1985)

		Land use and land cover type of 1985				
Land use and land cover type of 1973		Bush Lands(1)	Grass Lands (2)	Cultivated lands (3)	Settlement and Plantation (4)	Total
	Bush Lands (1)	394.37	11.53	966.9	415.24	1788.04
	Grass Lands (2)	130.88	909.59	1901.00	432.40	3373.87
	Cultivated lands (3)	600.32	958.13	4944.1	586.54	7089.09
	Settlement and Plantation (4)	355.26	152.22	441.76	476.40	1425.64
	Total	1480.82	2031.47	8253.76	1910.58	13676.63

As shown in (Figure 8) between 1973 and 1985, there was a dramatic expansion of cultivated land followed by settlement and plantation, where as grass land and bush land use types showed a reduction in areal coverage.

With the same pattern, in the years between 1985 and 1999, cultivated land as well as settlement and plantation continued their dramatic expansion while grass land and shrub land kept on showing reduction following their conversion to the cultivated and settlement and plantation land use types (Fig 9)

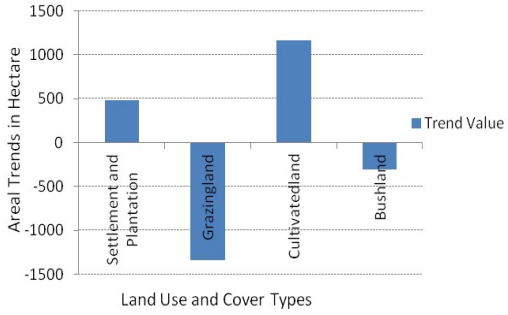


Figure 8: Land Use and Land Cover change between 1973 and 1985 in the Mezewan Watershed

As a result, 1179, 528.64 and 133.23 hectares of grasslands, bush lands as well as settlement and plantation had been changed to cultivated land (Table 5). This shows that there was a dramatic expansion of cultivated land within the specified time period because of population pressure and an increased demand for housing.

Table 5: Inter -category LU/LC change matrix of Mezewan Watershed (1985 to 1999)

		Land use and land cover type of 1999 **(ha)**				
Land use and land cover type of 1985		Bush Lands (1)	Grass Lands (2)	Cultivated lands (3)	Settlement and Plantation (4)	Total
	Bush Lands (1)	398.43	473.62	528.64	80.13	1480.82
	Grass Lands (2)	156.64	313.782.555	1179.00	375.14	1710.78
	Cultivated lands (3)	686.38	869.37	7111.5	868.95	9536.2
	Settlement and Plantation (4)	65.345	45.486	133.23	704.4	948.461
	Total	1306.794	1388.479	8952.31	2028.619	13676.62

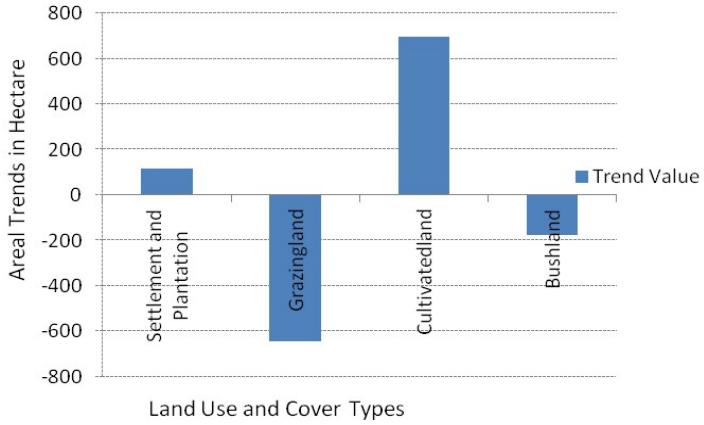


Figure 9: Land Use and Land Cover change between 1985 and 1999 in the Mezewan Watershed

The same trend prevailed, from 1999 to 2013 for cultivated land as well as settlement and plantation expansion due to the conversion of shrub lands and grass lands to these land use categories. As a result as shown in (Figure 10) bush land showed a reduction in areal coverage.

Table 6: Inter-category Land use/ land cover change matrix of Mezewan Watershed (1999 to 2013)

		Land use and land cover type of 2013 **(ha)**				
Land use and land cover type of 1999		Bush Lands(1)	Grass Lands (2)	Cultivated lands (3)	Settlement and Plantation (4)	Total
	Bush Lands (1)	49.99	40.99	984.03	231.78	1306.79
	Grass Lands (2)	293.69	44.31	111.02	939.46	1388.48
	Cultivated lands(3)	274.99	1132.77	6897.77	647.20	8952.31
	Settlement and Plantation (4)	389.12	70.40	1040.21	528.88	2028.62
	Total	1007.79	1288.48	9033.03	2347.32	13676.20

Furthermore, from 1999 to 2013, 1040.214; 984.028 and 111.02 hectares of settlement and plantation, bush lands and grasslands had been changed to cultivated land (Table 6). This shows that there was a dramatic expansion of cultivated land within the specified time period because of population pressure and an increased demand for housing.

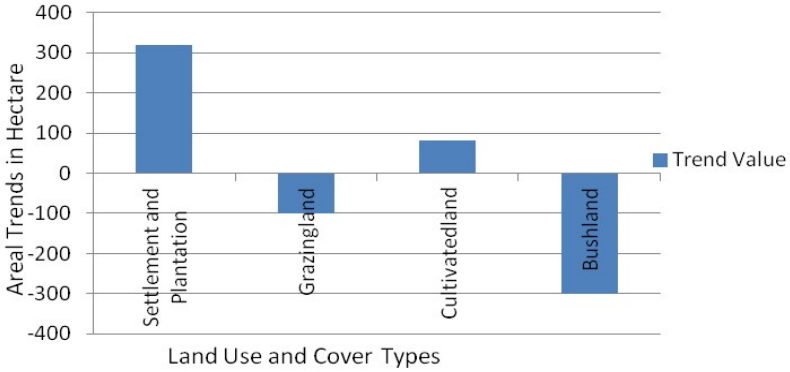


Figure 10: Land Use and Land Cover change between 1999 and 2013 in the Mezewan Watershed

3.4. Accuracy Assessment

To assess the accuracy of the classification, confusion matrix was used. Accuracy assessment allows for evaluating a classified image file (thematic raster layer). The Cell Array for this utility lists two sets of class values for the randomly selected points (random points) in the classified image file. One set of class values is automatically assigned to these random points as they are selected, and the other set of class values (reference values) serve as an input. These reference values were based on ground truth data of Eighty Eight points. The Accuracy Assessment Cell Array is an organized way of comparing the classification with ground truth data (Tables 7, 8, 9 & 10).

Table 7**:** Confusion matrix of 1973 land use and land cover classification in percent

Land use and cover type	Bush lands	Grass lands	Cultivated lands	Settlement and Plantation
Bush lands	89.59	7.69	6.61	0
Grass lands	4.13	79.19	4.5	7.46
Cultivated lands	5.57	2.26	75.8	13.43
Settlement and Plantation	0.72	10.86	13.09	79.1
Total	100	100	100	100

Table 8: Confusion matrix of 1985 land use and land cover classification in percent

Land use and cover type	Bush lands	Grass lands	Cultivated lands	Settlement and Plantation
Bush lands	92.59	4.69	5.61	2
Grass lands	1.13	80.19	7.5	6.46
Cultivated lands	3.57	5.26	77.8	14.43
Settlement and Plantation	2.72	9.86	9.09	78.1
Total	100	100	100	100

Table 9: Confusion matrix of 1999 land use and land cover classification in percent

Land use and cover type	Bush lands	Grass lands	Cultivated lands	Settlement and Plantation
Bush lands	95.9	2.05	4	6.24
Grass lands	0.57	80.43	8.09	6.55
Cultivated lands	1.4	8.11	80.22	8.12
Settlement and Plantation	3.58	3.45	7	79.09
Total	100	100	100	100

Table 10: Confusion matrix of 2013 land use and land cover classification in percent

Land use and cover type	Bush lands	Grass lands	Cultivated lands	Settlement and Plantation
Bush lands	94.9	1.05	3.0	7.24
Grass lands	1.57	81.43	9.09	5.55
Cultivated lands	2.4	7.11	81.22	7.12
Settlement and Plantation	2.58	4.45	6.0	80.09
Total	100	100	100	100

Confusion matrix indicates the nature of the classification error and is used in many other research works. As shown above (Table 10) the overall accuracy and Kappa coefficient was 86.11% and 0.8312, respectively. This indicates that 86.11% of the land use and land cover classes are correctly classified. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification (Congalton, 1991). For instance, a value of 0.8312 implies that the classification process is avoiding 83 percent of the errors that a completely random classification generates.

3.5 The land use and land cover changes in temporal perspective

The change from the base year to the next reference year was calculated for each land use and land cover using the following formula:

Change from base year = (A-B)/B Where A = Recent year area under concerned land use/ cover in ha. B = base year area under concerned land use/ cover in ha.

Table 11: Extent and trends in Land use land cover classes and fraction of change in between 1973 to 2013 in the Mezewan Watershed from the base year

Land use and cover type	**1985-1973**			**-1985-1999**			**2013-1999**			**2013-1973**		
	Change in ha.	% of base year*	Annual rate of change (%/yr)	Change in ha	% of base year *	Annual rate of change (%/yr)	Change in ha	% of base year*	annual rate of change (%/yr)	Change in ha	% of base year*	annual rate of change (%/yr)
Settlement &Plant	485.36	+34.1	+2.62	118.04	6.18	0.412	318.7	+ 15.71	+ 1.05	922.1	64.7	1.58

ation												
Grass lands	-1342.5	-39.79	-3.07	-642.99	-31.65	-2.11	-100	-7.20	-0.48	-2085.44	-61.81	-1.51
Cultivated lands	1164.3	16.42	+1.26	698.55	8.46	0.56	80.72	0.90	0.06	1943.6	27.4	0.67
Bush lands	-307.2	-17.18	-1.32	-173.6	-11.72	-0.78	-299.42	-22.91	-1.53	-780.21	-43.64	-1.06

* percent of base year is calculated as change in recent year area of land use and cover in ha minus previous year area of land use and land cover in ha divided by the previous year area of land use/ cover in ha times 100

The total change of cultivated lands in between 1973 to 1985 was 16.42% whereas in between 1985 to 1999 it increased by 8.46% (Table 11). The expansions of cultivated lands were by the outflow of bush or shrub lands and grass lands as explained in the change matrix of (Table 4 and 5). The expansion of cultivated lands between 1973 and 2013 in the watershed could be directly related to rapid population growth.

On the contrary, shrub or bush lands and grass lands had decreased from 1973 to 1985 by -17.18% and -39.79% with an annual rate of change of -1.32% and -3.07% respectively. Furthermore, grass lands and bush lands decreased from 1985 to 1999 with an annual rate change -0.78 and -2.11% respectively. The change was induced by the transfer of bush lands and grass lands to cultivated lands (Table 11). The massive reduction of shrub or bush lands particularly in between 1973 and 1985 occurred due to lack of administration especially during the transition period and land redistribution as well as drought. Shortage of cultivated land has also forced farmers to increasingly rely on selling firewood and charcoal for supplementary income, and this has also contributed to the extensive destruction of the woody biomass and shrub lands. Shortage of land has forced farmers to cultivate steep slopes and shallow soils that are vulnerable to degradation.

However, settlement and plantation increased from 1985 to 1999 with a rate of 6.178% per year. This is because of the degradation of bush lands, especially due to the 1985/86 drought,which claimed the lives of thousnads of humans and animals and caused a huge loss of vigitation biomass in the hilands of Ethiopia.

3.6 Causes of Land use and Land Cover Changes in the Mezewan Watershed

Understanding the complexity of landuse and landcover (LULC) changes and their driving forces and impacts on human and environmental security is important for the planning and the management of natural resources and for associated decision making. Hence, land use and land cover change is modeled as a function of selected socio-economic and biophysical variables that act as 'driving forces' of land use change (Turner II *et al.* 1993). Accordingly, the land use and land cove change indicators in the study area are modeled as follows (Figure 11). Land use and land cover dynamics are prevalent, speed up and driven by human actions (Agarwal et al., 2002). Various types of human activities may lead to soil degradation. The following classification of causative factors is slightly modified from the GLASOD guidelines (Oldeman *et.al*, 1991) and is based on interview and observation, and are summarized as key cause-effect.

Land use and land cover change causes are direct agents that promote changes resulting in a given pattern of land use and land cover. They are direct pressures exerted on land resource

under which the onset of degradation or deterioration processes occur. These pressures are, in turn, caused by driving forces of a variety of origins (i.e. economic, social, political, environmental, etc.), which can be understood as indirect causes of land use and land cover change. The problem of land degradation in Ethiopia, especially in the highlands, stems largely from poor land-use practices and population pressure (UNCCD, 2008). Added to these are the droughts, soil moisture change, competition for common land resources, over grazing, demand for agricultural lands, over cultivation, increased demands for forest products, decline in primary productivity of ecosystems, increased exposure of land to soil erosion and poor or negligible land management practices (Figure 11). Inappropriate farming practices, overgrazing, deforestation and the use of crop residues and dung for fuel by rural households are among the main causes. Very high population pressure, particularly in the highland farming areas has, led to a decline in arable area. Combined with increasing land degradation and recurrent droughts, this has contributed to declining crop productivity. Increased human and livestock populations have led extension of agricultural practices on to marginal lands, significantly reducing the already dwindling bush lands of the highlands.

The important current conditions (the state of land**)** observed in the study area include annual rainfall variability, land deformation by gullies and rills, increased soil erosion, reduced water holding capacity of soils, greater soil moisture deficit for plant growth, declining biodiversity and loss of productive land. According to FAO (2004), Land Degradation Assessment in Drylands (LADA) framework impacts refer to impacts land use and land cover changes on the different aspects of people's livelihoods, imposed by the state of land degradation and its causes. Examples of impacts of land degradation, which is caused by land use and land cover changes in the study area have increased poverty and migration, land productivity decline, loss of biodiversity, changing water cycle and carbon storage capacity, change in population size and spatial distribution (Figure 11).
Responses are understood in the LADA framework of FAO (2004) as the direct or indirect actions taken by land users and managers to the impacts on their livelihood caused by the state of land degradation, the pressures on the land causing such state, and the driving forces causing such pressures. Therefore, there is a need for land use policies considerations, conservation and rehabilitation of land resources, use of monitoring and early warning system, commitment to international convections on land use, investments in land and water resources and applying appropriate land use planning (Figure 11).

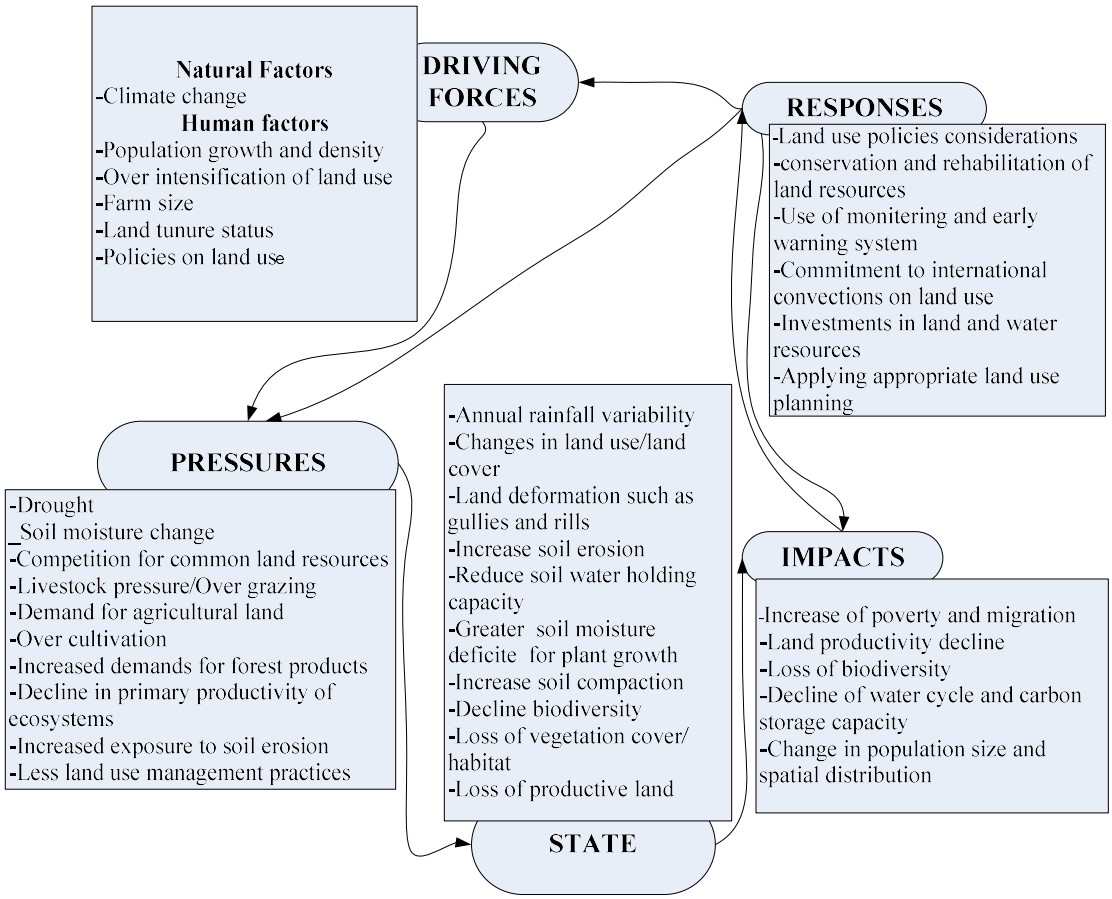


Figure 11: Major types of DPSIR indicators with their description in the Mezewan Watershed (Model modified from FAO, 2004)

4. Conclusion and policy implications

This study detected that the Mizewa watershed has undergone numerous land use cover changes in recent decades. Cultivated lands use increased markedly between 1973 and 1985 by 1164.28 hectares (16.42%), and this situation has continually increased between 1985 and 20113 by 698.55 hectares (8.46%); in total, from 1973 to 2013 it increased by 1943.55hectares (27.42%) in the watershed. However, the distribution of the bush lands, and grass lands areas has decreased (Table 11). The result was indicative that such areas were converted to cultivated lands with very fast and continuoually declining trends.

In general, this study examines the land use and land cover dynamics that occurred in *Mizewa Watershed* for the last 41 years under discussion. It describes different components for the prevailed change and the related implications such as increase biodiversity loss and soil erosion. Hence, this study identifies the following under-mentioned policy implications:

- ✓ Changes in land use and land cover affect land-based ecosystems and biodiversity
- ✓ Changes in land use and land cover affect soil health and have flow-on effects for water quality in rivers, lakes, and increase the risk of erosion and flooding
- ✓ Insufficient government attention to land degradation, agricultural development and to family planning
- ✓ Inappropriate development strategies and lack of land use planning.

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