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## IMPACTS OF LAND USE/COVER DYNAMICS ON PASTORALISM IN MELELA, MVOMERO DISTRICT, TANZANIA

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### ABSTRACT

#### Context and Background

Studies which have been conducted so far have focused on the processes of land use/cover changes in different areas at regional and global scale. Little is known about factors that influence land use/ cover dynamics at finer scales such as Melela ward in Mvomero district, Morogoro, Tanzania.

#### Goals and Objectives

The overall objective of the study therefore was to evaluate the land use land cover dynamics and their impacts on pastoralism in Melela. Specifically, the study intended to examine land use/cover dynamics from 1991 to 2016, to identify socio-economic factors that influence land use/cover dynamics and to determine the effects of land use/ cover dynamics on pastoral communities and agricultural production.

#### Methodology

Remote sensed satellite data were used for change detection analysis to assess the spatial and temporal land use/ cover change for the study area. Satellite images were processed and analysed to detect changes in land use/ cover at the site by using change detection analysis technique to evaluate transition in land use/ cover and to estimate changes in the area. A geographical positioning system (GPS) receiver was used for georeferencing the points for supervised classification and accuracy assessment. Change detection analysis and post classification comparison was used for the analysis of data. The analyses involved the application of an algorithm used to detect changes in spectral signature of the image. The products were the matrices and the categories of land use/ cover changes at the site. Descriptive statistics was employed to analyse the social economic data.

#### Results and Discussion

The study findings indicated a significant change in LULC as evidenced by an increase in agriculture and a loss of woodland within the plain. The period 2000-2016 has shown gains of agriculture and losses of woodland areas. Changes in the crops grown, increased immigrants of pastoralists, population growth, charcoal burning and livestock keeping contributed to an overuse of the existing land resources, which resulted in significant variations in the spatiotemporal patterns of land use changes with respect to specific socio-economic drivers. The assessment of changes in grazing land in Melela has shown that the current patterns are going to increase the existence of pastoralists in the region. Farmers on the other hand feel the grazing pressure brought about by the pastoral immigrants on their farms. The results of this study quantify the dynamics of land use/cover and its drivers on sustainable use of land. In the face of increasing population, pastoralism, and charcoal burning, there is a need for sustainable utilization of land resources.

#### Keywords:

*Land use; land cover; land use land cover change, pastoralism.*

## 1. INTRODUCTION

Long-term changes in rangeland ecosystems of the world have impacted on the livestock production, a key livelihood strategy in these areas (Kimiti *et al.*, 2018). The rapidly increasing change in land use/cover can have adverse impacts and implications on local land resources (Lambin, 2003). Studies have indicated that approximately 10-20% of drylands and around 24% of arable lands globally have been degraded (Aquino *et al.*, 2008; MEA, 2005). The land use/cover pattern of a particular area is an outcome of natural and socio-economic factors and their utilization in time and space (Olson, 2004). Land use/cover changes either modify habitat or change it completely and this has implications on the entire ecological systems such as climate, soils, vegetation, water resources, and biodiversity (Turner II *et al.*, 2007; Lambin, 2003). A Land use/cover change is seen as one of the threats to mobility and flexibility of livestock. For example, Msoffe *et al.* (2010) reported that agricultural land increased fivefold in Maasai Steppe while human population increased exponentially from 3.3% pa in 1988 to 3.4% pa in 2002, and this has restricted livestock movements by blocking their migratory routes. A similar trend has been observed in other parts of the country, notably Idodi and Pawaga wards in Iringa region, and Kilosa and Wami Sokoine wards in Morogoro region (Coppolillo, 2004; Tsoxo, 2006 and Wassena *et al.*, 2013). This has increased stocking pressure in the grazing areas and land use conflicts at the margins (Nzunda *et al.*, 2013).

Pastoralism remains the predominant land use system in most of the arid and semi-arid areas of sub-Saharan Africa. Studies show that there is land use conversion and an increasing exclusion of pastoralists from land with the highest potential (Campbell *et al.*, 2000), forcing major pastoral communities of Maasai and Barabaig of Tanzania to move large herds of livestock from traditional grazing areas to low livestock density areas such as Morogoro, Coast, Mbeya, Iringa, Rukwa and Ruvuma Regions. This has brought different ethnic groups into the same ecological ranges, with increased potential for environmental degradation and land use conflicts (URT, 1997). A growing number of agro-pastoralists including Kuria, Sukuma, Gogo and Nyamwezi are switching management systems and adopting extensive livestock production systems. For example, cattle herders have been practicing systems of transhumance for a long period (Kisoza, 2007). Interventions for increased food security through expansion of agriculture without sound land use planning can negatively affect pastoral land use, and in turn, food security, in ways that are not always noticed by policy makers (Flintan *et al.*, 2013; Flintan *et al.*, 2019). Land acquisition procedures have a great role in determining agricultural systems which finally influence the land use and land cover change. According to Olson *et al.* (2004), land tenure arrangements have been the driving force of land use change in Tanzania, Uganda, and Kenya. Land tenure dynamics in these countries have led to changes with regard to who is engaged in land management practices, who has the right to use land and the manner in which land should be used. Most of these changes influenced land use patterns in agricultural and pastoral lands. In Morogoro region, there have been recurring conflicts on land resources between crop cultivating farmers and livestock keepers (Kushoka, 2011; Msoffe *et al.*, 2019). For example, in Melela ward, the conversion of native land into settlement and agriculture is on the increase, at the expense of loss of pasture and water for livestock (Kushoka, 2011). Despite the huge efforts by the government and stakeholders of finding a lasting solution to land conflicts, the problem still appears to linger on. Thus, further assessment is required in order to achieve the long sought-after solution to the problem (Flintan *et al.*, 2019). Most available literature is focused on the impact of land use/cover change on climate change and on agriculture but the implications of these on pastoralism are less considered (Msoffe *et al.* (2010). Therefore, this study aimed at investigating the dynamics of land use/cover changes and their implication on livestock keeping. The

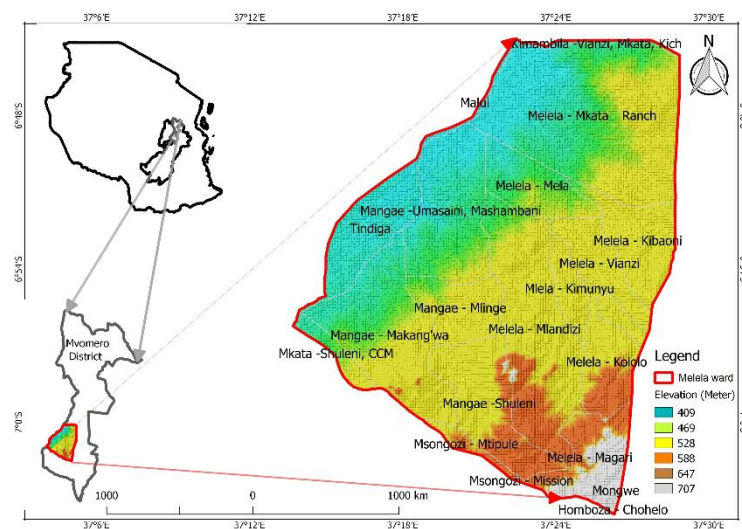
findings from this study would be vital for sustainable development and utilization of land resources in general. Specifically, the study intended to examine land use/cover dynamics from 1991 to 2016 and to determine the effects of land use/cover change on pastoral communities and agricultural production in Melela ward.

## 2. MATERIALS AND METHODS

### 2.1 Description and Location of the Study Area

#### 2.1.1 Location

Mvomero is one among seven districts of Morogoro region covering about 73,325 km<sup>2</sup>. Other districts include Kilosa, Ulanga, Gairo, Malinyi, Morogoro rural, Kilombero, and Morogoro municipality. Mvomero District was created in 2001. It is located between latitudes 06° 42`S and 7° 06`S and longitudes 37° 12` and 37° 27`E (Figure 1). Melela is one of the wards in Mvomero District. The ward is located along the Morogoro – Iringa main road about 50 km away from Morogoro municipality.



**Figure 1: Location of Melela Ward in Mvomero District, Morogoro Tanzania**

#### 2.1.2 Climate and land use

Melela Ward is characterized by moderate rainfall between March and May (long rains) and from October to December (short rains) with predominantly easterly trade winds which bring moisture from the Indian Ocean. The annual rainfall is between 600 mm and 750 mm and temperatures range from 18 – 30°C (Mbogoni and Ley, 2008). The farming system in the area is broadly described as agro-pastoral. The system of production is mainly low density, low rainfall, and utilizing extensive fallow systems. These semi humid farming systems have low population densities and variable rainfall. Major food crops include maize, sorghum, cassava, cowpeas, pigeon peas, lablab, pumpkins, sweet potatoes, and groundnuts. The major cash crops are sunflower, sesame, and cotton. However, cotton is no longer grown due to market constraints. Crops are normally grown in pure stands. Natural vegetation consists of wooded bushland of *Combretum spp.*, and bushland of *Acacia spp.* Some of the bushlands are newly cleared and planted with agricultural crops while some other land is under bush fallow covered by young bushes and grass. In Melela village, natural vegetation consists of open bushland of *Acacia spp.*, and various grasses. The land is used mainly for scattered smallholder rainfed cultivation of sesame, sorghum, and maize.

## **2.2 Data Collection and Analysis Procedure**

### **2.2.1 Analysis of land use and land cover change**

Remotely sensed satellite data were used for change detection analysis to assess the spatial and temporal land use/cover change for the study area. Landsat (OLI, TM and ETM+) data were downloaded from archives of the USGS Global Visualization Viewer (GloVis) for the time periods 1991–2000 and 2000–2016. Classification of remotely sensed data is done using an image processing software, and for this study, QGIS version 2.6 was employed. A geographical positioning system (GPS) receiver was used for georeferencing the points for supervised classification and accuracy assessment. Based on the high resolution and visual interpretation of remotely sensed data and the local knowledge of the area, four easily identifiable macro classes were identified. However, these macro classes give a general trend or dynamics of LULC at the scale of the study area. Different methods are available for classification and the choice of the method depends on the resolution of the image and availability of classification software, among other factors (Lu *et al.*, 2011). For this study, a supervised classification approach was used. Maximum likelihood algorithm was used for the classification of the images. Accuracy assessments measure how close an image of unknown quality is to a standard image which is assumed to be correct (Campbell, 2007). An error matrix was used to assess such elements as the overall accuracy, omission error, commission error, and kappa coefficient.

Change detection analysis technique was employed to evaluate transition in land use/cover and to estimate changes in the area. Change detection analysis entails finding the type, amount and location of land use changes over time. Among the change detection approaches, post classification comparison (PCC) was used for this study to identify changes in land use/cover. PCC is frequently employed for comparing data from different sources and dates (Csaplovics and Zewdie, 2015). This approach determines “from-to” changes in order to identify the transformations among the land cover classes. PCC identifies changes by comparing independently classified multi-date imagery on a pixel-by-pixel basis using a change detection matrix. In this study, the change detection assessment was applied to individual image classification outputs in order to identify the respective changes for the time periods 1991-2000 and 2000-2016. The products were the matrices and the categories of land use/cover changes at the site. The observed change detection matrices were then processed in an intensity analysis program (Pontius *et al.*, 2004). The product of the intensity analysis comprised loss, gain, net change and swap. The analysis also determined which categories are relatively dormant versus active in a given time interval, as well as landscape that showed persistence between the two time periods.

#### ***Loss, Gain, Net change and Swap of Categories and Intensity graphs***

Following Pontius *et al.* (2004) and Aldwaik and Pontius (2012), the subsequent definitions (also Table 1) were adopted:

The persistence ( $C_{ii}$ ) is the area which remained under the same land use/cover category over time and which, in a transition matrix is indicated on the diagonal as in Table 1.

The Gross loss of category ( $GL_i$ ) is the difference between its initial area ( $C_i, t_1$ ) and the persistence (equation 1):

$$GL_i = C_{i,t_1} - C_{ii} \leq 0 \quad (1)$$

This is given in the last column on the right whereas last row on the bottom indicates the gross gain of a category. The Gross gain of category ( $GG_i$ ) is:

$$GG_i = C_{i,t2} - C_{ii} \geq 0 \tag{2}$$

while the net quantity change is the absolute difference between the gross gain and the gross loss (equation 3), and the overall change for each category is given as a sum of the gross gain and gross loss (equation 4):

$$Net\ quantity\ change = |GG_i - GL_i| \tag{3}$$

$$Overall\ change = GG_i - GL_i \tag{4}$$

The difference between overall change and net quantity which occurs when a land use/cover category undergoes a simultaneous gain and loss is called Swap (equation 5).

$$Swap = Overall\ change - net\ quantity\ change \tag{5}$$

Table 1. Transition matrix for comparing land use/cover categories of two maps from different points in time

	Time2				Total time1	Gross Loss
	Category 1	Category 2	Category 3	Category 4		
Time 1						
Category 1	<b>C<sub>11</sub></b>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>1,t1</sub>	C <sub>1,t1</sub> - <b>C<sub>11</sub></b>
Category 2	C <sub>21</sub>	<b>C<sub>22</sub></b>	C <sub>23</sub>	C <sub>24</sub>	C <sub>2,t1</sub>	C <sub>2,t1</sub> - <b>C<sub>22</sub></b>
Category 3	C <sub>31</sub>	C <sub>32</sub>	<b>C<sub>33</sub></b>	C <sub>34</sub>	C <sub>3,t1</sub>	C <sub>3,t1</sub> - <b>C<sub>33</sub></b>
Category 4	C <sub>41</sub>	C <sub>42</sub>	C <sub>43</sub>	<b>C<sub>44</sub></b>	C <sub>4,t1</sub>	C <sub>4,t1</sub> - <b>C<sub>44</sub></b>
Total time 2	C <sub>1,t2</sub>	C <sub>2,t2</sub>	C <sub>3,t2</sub>	C <sub>4,t2</sub>	C <sub>1,t2</sub>	
Gross Gain	C <sub>1,t2</sub> - <b>C<sub>11</sub></b>	C <sub>2,t2</sub> - <b>C<sub>22</sub></b>	C <sub>3,t2</sub> - <b>C<sub>33</sub></b>	C <sub>4,t2</sub> - <b>C<sub>44</sub></b>	∑C <sub>i</sub>	

Source: Adapted from Pontius *et al.* (2004)

NOTE: The persistence of a category is indicated on the diagonal (bolded); the gross gain and gross loss of a category are given on the last row and column respectively.

The intensity graphs were also generated. This helps to measure how the size and intensity of both gross losses and gains vary across space (Aldawaik and Pontius, 2012).

### 2.2.2 Determination of effects of land use/cover change on pastoral communities and agricultural production

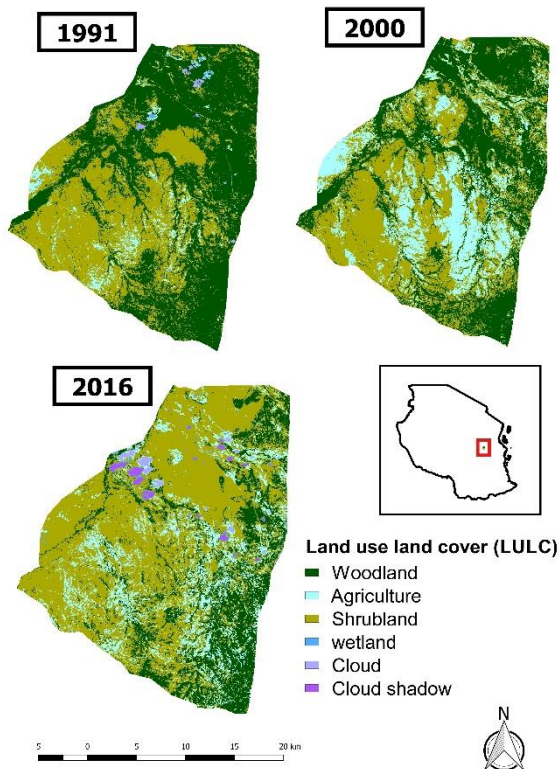
Focus group discussions and scheduled interviews were used to collect information on how land use/cover dynamics impact on pastoral communities and agricultural production. Each participant was asked to indicate the following: Livestock ownership, farm size, migration patterns, migratory routes, proximity of farm plots and grazing area, proximity to water sources, and incidence of livestock diseases. Four land use/cover types were investigated namely woodland, agriculture, wetland, grassland/shrub land. These were envisaged to show how land use/cover changes affect livestock production system in terms of grazing resources, water resources, migratory routes, and incidence of livestock diseases. The analysis of the effect of land use and land cover dynamics on pastoral communities and agricultural production was done using quantitative methods. The collected data were sorted, coded and entered into the Statistical Package for Social Sciences (SPSS).

Descriptive statistical analysis was carried out which included frequency distribution. A table of percentages was used to summarize the results from the households' questionnaires.

### 3. RESULTS

#### 3.1 Land Use/Cover Changes during the Period 1991-2016

Variation of different land use/cover changes resulting from human activities and other drivers in Melela Ward was studied. The analysis involved land use/cover classes for the years 1991, 2000, and 2016. Four land use/cover classes namely woodland, agriculture, wetland, grassland/shrubland were identified. The identified land use/cover categories revealed the changes in land use/cover that had taken place during the study period (Figure 2).

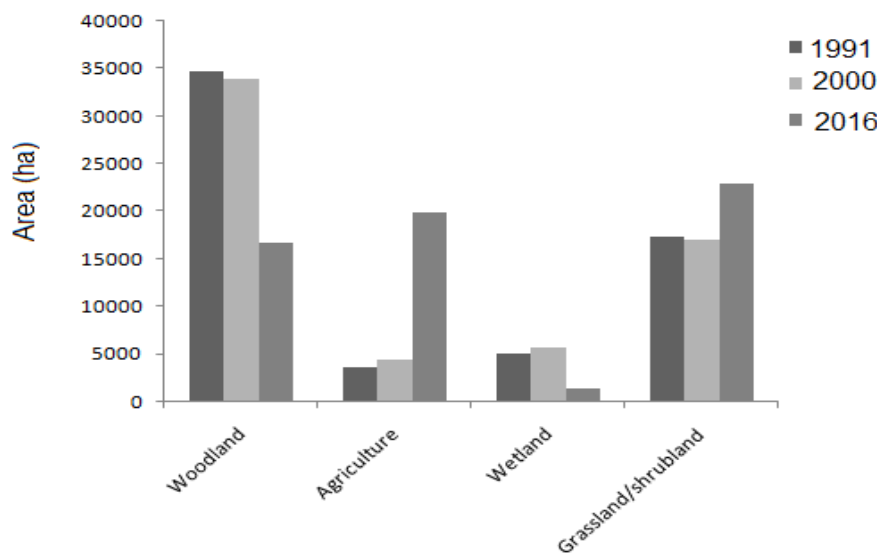


**Figure 2: Trends of Land use land cover (LULC)**

Table 2 and Fig. 2 show the total area in hectares as well as percentage covered by each land use/cover classes in 1991, 2000 and 2016. Tables 3 and 4 show land use/cover classes coverage and a changing trend across the two epochs (1991-2000 and 2000-2016) in terms of land use/cover classes loss and gain. In 1991, the largest area is shown to have been covered by woodland followed by grassland/shrubland. Agriculture had the least land use cover followed by wetland. A similar trend was recorded for 2000 but with minor variation. In 2016, the largest area is shown to have been covered by grassland/shrubland followed by agriculture, woodland, and lastly wetland. Woodland appears to have been cleared by the year 2016.

**Table 2: Land Use Land Cover 1991, 2000, and 2016**

Land use/Land Cover classes	1991		2000		2016	
	ha	%	ha	%	ha	%
Woodland	34800	57.0	33900	55.6	16700	27.4
Agriculture	3700	6.1	4400	7.2	20000	32.8
Wetland	5100	8.4	5700	9.3	1400	2.3
Grassland/shrubland	17400	28.5	17000	27.9	22900	37.5
<b>Total</b>	<b>61000</b>	<b>100</b>	<b>61000</b>	<b>100</b>	<b>61000</b>	<b>100</b>



**Figure 2: Distribution of land use/cover for 1991, 2000 and 2016**

Table 3 shows that the largest gross loss in 1991–2000 was experienced by woodland (12133.71 ha), followed by grassland/shrubland (8635.05 ha), wetland (4012.11 ha) and agriculture (2975.13 ha).

**Table 3: Cross tabulation matrix showing observed persistence (on the main diagonal) and observed Land Use/ Cover Changes (off the main diagonal) for Melela from 1991 - 2000**

		Woodland	Agriculture	2000 Wetland	Grassland/ Shrubland	Total 1991	Gross loss
1991	Woodland	20859.93	2377.98	3387.78	6367.95	32993.64	12133.71
	Agriculture	2124.9	355.14	461.61	388.62	3330.27	2975.13
	Water/Wetland	3157.74	290.52	788.13	563.85	4800.24	4012.11
	Grassland/Shrubland	6728.4	1196.19	710.46	9441.27	18076.32	8635.05

<b>Total 2000</b>	<b>32870.97</b>	<b>4219.83</b>	<b>5347.98</b>	<b>16761.69</b>	<b>59200.47</b>	<b>27756</b>
<b>Gross gain</b>	<b>12011.04</b>	<b>3864.69</b>	<b>4559.85</b>	<b>7320.42</b>	<b>27756</b>	

Woodland and grassland/shrubland had a gross loss of 22767.48 ha and 11934.54 ha respectively during the period 2000-2016 (Table 4).

**Table 4: Cross tabulation matrix showing observed persistence (on the main diagonal) and observed Land Use/ Cover Changes (off the main diagonal) for Melela from 2000 - 2016**

	2016				Total 2000	Gross Loss
	Woodland	Agriculture	Wetland	Grassland/ Shrub land		
Woodland	<b>11072.34</b>	7877.97	795.06	14094.45	33839.82	<b>22767.48</b>
Agriculture	843.66	<b>2135.43</b>	76.68	1314.54	4370.31	<b>2234.88</b>
Wetland	1851.75	993.87	<b>479.16</b>	2326.41	5651.19	<b>5172.03</b>
Grassland/Shrub land	2949.03	8946.9	38.61	<b>5132.07</b>	17066.61	<b>11934.54</b>
Total 2016	16716.78	19954.17	1389.51	22867.47	60927.93	<b>42108.93</b>
<b>Gross Gain</b>	<b>5644.44</b>	<b>17818.74</b>	<b>910.35</b>	<b>17735.4</b>	<b>42108.93</b>	

Results in Table 5 indicate woodland as having the greatest gross gain and the greatest gross loss with a net quantity change of 122.67 ha. This is followed by grassland/shrubland which shows a net quantity change of 1314.63 ha. Agriculture had the least gross gain and the least gross loss with a net quantity change of 889.56 ha. This is followed by wetland with a net quantity change of 547.74 ha.

**Table 5: Quantitative changes for Melela between 1991 and 2000**

Years	LULC classes	Gross Gain	Gross Loss	Sum	Net quantity change	Swap
<b>1991 -2000</b>	<b>Woodland</b>	12011.04	12133.71	24144.75	-122.67	24267.42
	<b>Agriculture</b>	3864.69	2975.13	6839.82	889.56	5950.26
	<b>Wetland</b>	4559.85	4012.11	8571.96	547.74	8024.22
	<b>Grassland/Shrubland</b>	7320.42	8635.05	15955.47	-1314.63	17270.1

In 2000–2016, the largest gross gain was for agriculture (17818.74 ha), followed by grassland/shrubland (17735.4 ha), woodland (5644.44 ha) and wetland (910.35 ha) (Table 6).

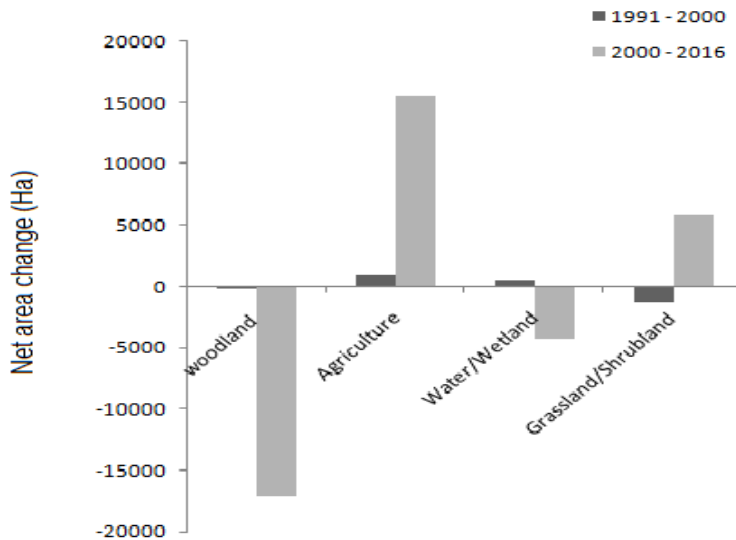


Figure 3: Net quantity change of land use land cover for Melela during 1991-2016

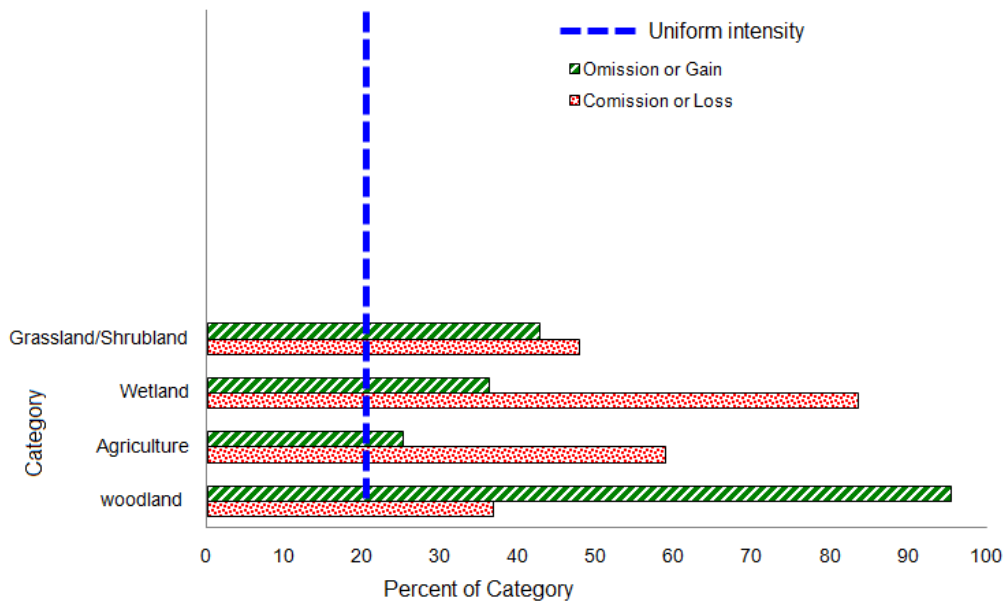
Table 6: Quantitative changes for Melela between 2000 and 2016

Years	LULC classes	Gross gain	Gross loss	Sum	Net quantity change	Swap
2000-2016	woodland	5644.44	22767.48	28411.92	-17123.04	45534.96
	Agriculture	17818.74	2234.88	20053.62	15583.86	4469.76
	Wetland	910.35	5172.03	6082.38	-4261.68	10344.06
	Grassland/Shrubland and	17735.4	11934.54	29669.94	5800.86	23869.08

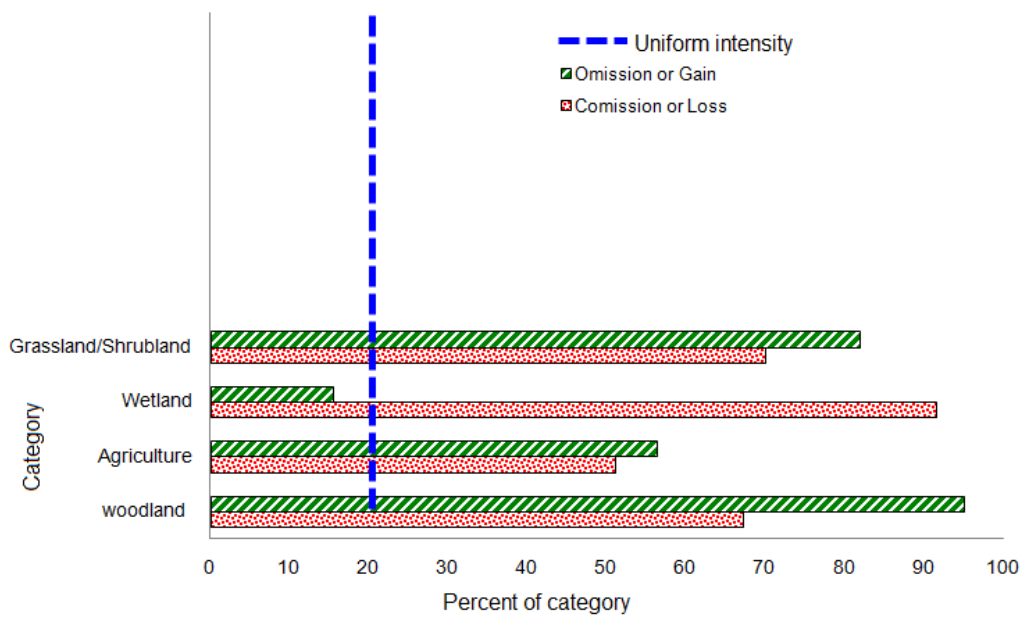
### 3.2 Category Level Analysis

Category level intensity analysis compares the intensity of gain and loss for a particular class in a given time interval (Figs. 5 - 6). The analysis provides a graphical approach of intensity analysis at category (class) level whereby the dashed vertical line indicates a uniform rate of change. The rate of change on the left of the uniform line (i.e., rate of change less than uniform) indicates dormant class change and on the right of the line (i.e., rate of change greater than uniform) indicates active class change. Similarly, category analysis identifies whether or not the pattern of category is stable across time intervals in terms of gains and losses. If the intensity of a category's gain/loss is greater (changing at a rate faster) or less (changing at a rate slower) than the uniform line for both time intervals, that particular category is said to be stationary, otherwise it is dynamic.

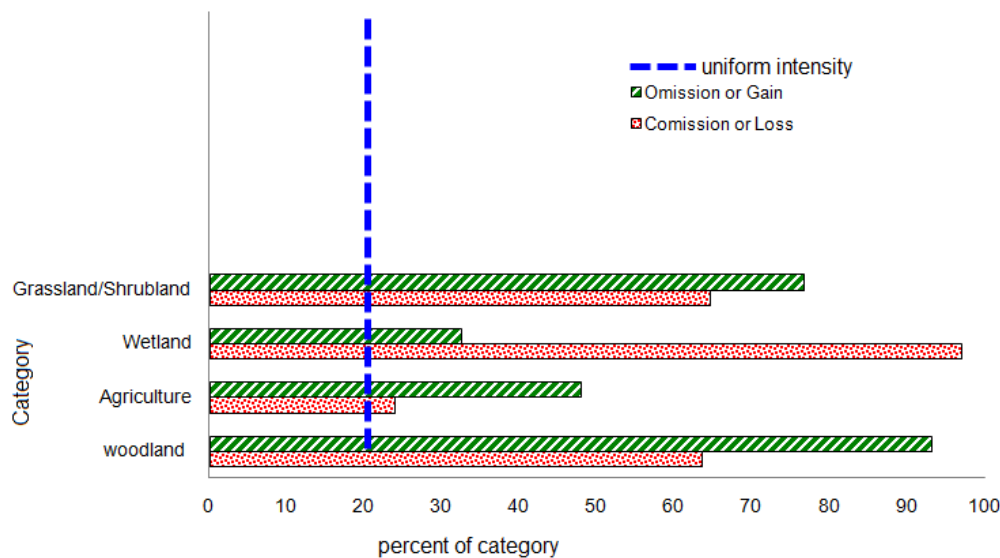
The results of intensity analysis at category level for 1991–2000 and 2000–2016 respectively are given in Figures 5 and 6. During 1991–2000, the classes showed significant activeness in both gains and losses. Woodland was most active in gaining, followed by grassland/shrubland. Wetland and agriculture changed more actively in losing. During the period 2000–2016 (Fig. 6), agriculture and grassland/shrubland were dormant in losing but active in gaining especially in agriculture



**Figure 4: Category intensity analysis for Melela 1991–2000**



**Figure 5: Category intensity analysis for Melela 2000–2016**



**Figure 6: Overall Category intensity of Melela 1991-2016**

### 3.3 Impact of Land Use/Cover Change on Pastoral Production

In order to establish whether the observed land use/cover dynamics have impacted pastoralism, household interviews were conducted on the perception of pastoralists on feeding system, availability of pasture, distance covered to grazing land, area of grazing land, water source, incidence of diseases, access to grazing land, access to residue from farmers’ lands and livelihood over the historical periods of 1991, 2000 and 2015.

Table 7 shows responses on feeding system among livestock keeping communities, with the results indicating that about 90% of the pastoralists depend on communal land for grazing. The impact of LULC dynamics on pastoral production in Melela ward was observed using satellite imagery. As for gains in agriculture and grassland/shrubland, the respondents reported to feed more in communal land (Table 7) by 83.3% in the year 1991 and by 90% in the year 2015 while private pasture featured only marginally. Pasture availability has declined over the years (Table 8) due to increased pressure from various land use types in the area.

**Table 7: Responses of respondents on feeding system**

Feeding system	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
private pastures	4	4.4	0	0	2	2.2
Communal	75	83.3	83	92.2	81	90.0
Mixed	11	12.2	7	7.8	7	7.8
<b>Total</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>

**Table 8: Responses of respondents on availability of pasture**

Availability of pasture	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
Adequate	70	77.8	22	24.4	14	15.6
Inadequate	20	22.2	68	75.6	76	84.4
<b>Total</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>

The distance covered by herders looking for pasture has been increasing over the years from less than 1 km in 1991 (27.8%) to over 6 km in 2015 (93.3%) (Table 9). Majority (77.8%) of pastoralists' perception shows that pasture was adequate before year 2000 (Table 8) and inadequate thereafter (84.4%). Grazing area seems to have been consistently reduced after 1991 (Table 10) as observed by majority of respondents thus resulting in increased stoking pressure. With regard to water source, there appears to be a decreasing trend in the use of permanent streams and an increasing trend in the use of ponds/dams (Table 11).

**Table 9: Responses of respondents on distance covered to grazing land**

Distance covered to grazing land	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
Less than 1km	25	27.8	0	0	0	0
2-5 km	50	55.6	23	25.6	6	6.7
6 - above	15	16.7	67	74.4	84	93.3
<b>Total</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>

**Table 10: Responses of respondents on grazing area**

Grazing area	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
Reduced thus increased stoking pressure	64	71.1	68	75.6	68	75.6
Increased thus decreased grazing pressure	2	2.2	4	4.4	2	2.2
Remain the same	24	26.7	18	20.0	20	22.2
<b>Total</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>

**Table 11: Responses of respondents on water source**

Water source	1991		2000		2015	
	Frequency	%	Frequency	%	Frequency	%
Permanent stream	22	24.4	8	8.9	4	4.4
Seasonal stream	18	20.0	21	23.3	10	11.1
Dam/ponds	2	2.2	18	20.0	31	34.4
Mixed	48	53.3	43	47.8	45	50.0
<b>Total</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>	<b>90</b>	<b>100</b>

#### 4. DISCUSSION

Historically, Melela village is a pastoral enclave having been designated as such by Government, which, as a result saw an influx of migrants to the area in the period leading up to the early 1990s. Widespread degradation of land resources due to overstocking has been a major problem ever since (Suleiman and Ahmed, 2013). Incidences of livestock diseases in the area have increased with time. According to Lankester and Davis (2016), the dynamics of using grazing land for agriculture and other uses reduce the potential of prevention of infectious diseases in livestock. As highlighted by the respondents, when mobility is increasingly restricted, traditional strategies such as grazing livestock in a disease-free zone become more difficult to practise. Lankester and Davis (2016) report that as grazing options become increasingly limited, herds are forced to share pastures, which increases the risk of transmissible and vector-borne diseases. As agricultural land has been expanding in Melela

ward as detected in LULC dynamics analysis as well as from respondents' observations, so have the conflicts between famers and pastoralists. These conflicts arise as a result of blocking of livestock routes to watering points through cultivated land with pastoralists trying to access the routes by force. According to Suleiman and Elagib (2012), land degradation and blocking of animal routes are one of the paramount factors that led to pastoralist sedentarization, urbanization and the breakdown of traditional pastoralist livelihood system. In addition to loss of grazing land, agricultural expansion has also blocked livestock migratory routes between dry and wet season pastures. The situation is more or less similar with that existing in other countries in Africa where commercial agriculture is reported to threaten the existence of livestock migration routes (Flintan, 2011).

Grassland/shrub land is the prevailing LULC type in the Melela area, and field visits and interviews with herders clearly showed the qualitative degradation of pasture in terms of composition. The respondents considered open access and uncontrolled grazing as the principal causes of overgrazing and land degradation.

The reason why agriculture and grassland/shrubland were dormant in losing but active in gaining especially so for agriculture during the period 2000-2016 could be a result of increased population growth, increased pastoral activities, increased catchment degradation, expanded market and increased conflicts over resources. Interviews with farmers and ground truthing ascertained this hypothesis, which showed most woodland and bushland areas to have been cleared for agricultural purposes. Also, tree felling for commercial charcoal production was found to be a dominant activity in villages close to woodland. A similar observation was reported by Zewdie and Csaplovics (2015) in North West Ethiopia in the period from 1984 to 2000, for which the cropland expanded to reach 22.56% of the total area and from 2000 to 2010 cropland areas stretched further to 55.23% of the area. In the said study, woodland was the major loser to the newly emerged cropland. These significant increases in croplands coupled with rapid population growth and recurrent drought contributed to major deforestation and woodland degradation (Lemenih *et al.*, 2012). Other studies have also shown gains in area of agriculture and losses in the area of woodland (Lyoba, 2009). Furthermore, a study conducted by Kisoza (2007) in Mkata plains, Kilosa district in Tanzania on the role of local institutions in the management of agropastoral and pastoral systems, revealed that between 1970-2000, the cultivated area had undergone a slight loss of -416 ha equivalent to -0.2%. The loss could probably be due to cultivation area that had reverted into bush and fallow land.

The increasing trend in the use of ponds/dams as water sources for livestock in lieu of permanent streams could be due to observable changes in climate brought about by increased pressure on the environment mainly anthropological factors (Kihupi *et al.*, 2015) leading to decreased stream flows and even changes to the nature of the stream itself, i.e., from permanent to ephemeral. As such, there has been a growing limitation to access to water sources for livestock use.

Overgrazing, expansion of rain fed agriculture, and charcoal burning have exposed the soil surface to accelerated water erosion in areas along the Melela River. This reduces vegetation cover and increases exposure of soil surfaces to erosion leading to more land degradation. A similar observation was made by Wezel and Haigis (2000) who reported that a decrease or disappearance of certain plant species reduces vegetation cover and increases the exposure of soil surfaces to wind and water erosion, leading to more land degradation.

According to herders, the amount and timing of precipitation were the most important determinants of change in vegetation. They see factors such as changes in rainfall pattern as playing a significant

role in LULC change. For example, late and erratic rainfall is not favourable for the growth of edible vegetation, while it is suitable for the growth of inedible vegetation. Erratic rainfall patterns make it more difficult to predict grazing land productivity and changes in the availability of water and pasture resources, making pastoral production more uncertain than ever before. This trend coupled with conflicts and other socio-economic disadvantages make pastoralists less able to cope with the changes making them suffer the most.

Communal grazing lands require individual users to come together and determine the optimal number of livestock to be allowed in the village and to distribute grazing rights among all users so that the total number of livestock does not exceed the carrying capacity of the land. However, experience has shown that in the absence of strong institutional controls over individual stocking decisions, it is difficult to enforce this kind of agreement (Kisoza, 2007).

Although natural grazing land and forage supplies in Melela area have been depleted due to recent changes in land use, they are now supplemented by livestock feed sources provided by arable farms. Crop residues, fallow fields, and failed crops in the area now provide grazing and forage sources for the entire area, albeit at a cost as has been the case elsewhere (Kisoza, 2007).

Pastoralists appear to opt for more than one adoption strategies so as to ensure their livelihood. Majority of the respondents move their livestock to dry season grazing areas targeting for the crop harvesting season in Kilosa and coastal areas, and return back to their respective settlements during the wet season. Kisoza (2007) reported of the prevalence of livestock mobility practices in terms of access to various grazing areas in Mkata plains and Ngorongoro area. A grazing cycle starts at the beginning of the short rains and continues towards the end of January when animals return to permanent villages and continue to graze on village land throughout the rainy season. As dry season sets in mid-May, animals are moved progressively towards pasture reserves along river banks. As dry season progresses, towards the end of June, most herders cross into farming villages to feed on crop residues or graze on wetland patches found along river valleys.

Mobile livestock grazing is a traditional mechanism developed by herders to cope with changes induced by climate variability which affects availability of water and fodder at different places and times. Some pastoralists have adopted partial sedentarization, by leaving children, wives and the elderly in settled locations, practising agropastoralism in order to make movement practical and easier. These pastoralist groups benefit from having permanent settlements, as can be seen in Melela, Kibaoni and Mangae villages within the study area where they can more easily access services such as health, markets, and education. However, by doing so, pastoralists do not intend to abandon their traditional ways of keeping animals. Many have developed an advanced form of transhumance, as can be seen among the Maasai ethnic group in Melela ward. The movements of Maasai who practise agropastoralism are no longer shortened by lack of water in places where grazing is available for their animals. They have developed a system of using local tankers, dams and water ponds along seasonal rivers to take water to the animals where they can have enough grass for grazing. During this period, some members of the families are settled in places where they can have access to necessary services.

Destocking and splitting of herds into groups are the strategies adopted by many pastoralists in order to cope with climate variability and to provide money for purchasing crop residues for their livestock as well as other requirements.

## **5. CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Conclusions**

This study examined the LULC dynamics for the period 1991–2016 in Melela ward to provide current and historical conditions for the area. A cross tabulation matrix was used to assess the total change of land categories based on gain, loss, and transition intensity over the study period. The study findings indicated a significant change in LULC as evidenced by an increase in agriculture and a loss of woodland within the plain. The period 2000-2016 has shown gains of agriculture and losses of woodland areas. Changes in the crops grown, increased immigrants of pastoralists, population growth, charcoal burning and livestock keeping contributed to an overuse of the existing land resources, which resulted in significant variations in the spatial-temporal patterns of land use changes with respect to specific socio-economic drivers. The results of this study quantify the dynamics of land use/cover and its drivers on sustainable use of land. In the face of increasing population, pastoralism, and charcoal burning, there is a need for sustainable utilization of land resources.

Based on LULC dynamics analysis using satellite imagery, combined with local knowledge from pastoralists, this study has quantitatively and qualitatively analysed the spatial-temporal changes of grazing resources in Melela ward from 1991 to 2016. The information generated from the LULC pattern of the study area is expected to be helpful in formulating policies and programmes required for development and land use planning in the pastoral sector.

Assessment of changes in grazing land in Melela ward has shown that the current patterns are going to increase the existence of pastoralists in the region. Farmers on the other hand find that pastoralists among the immigrants and grazing pressure on their farms in Melela ward form one of the major problems that they face.

Pastoralists have to destock as a strategy for their livelihood. Although this may sound like a change in the right direction in as far as environmental conservation is concerned, change of mindset is far from being realized.

### **5.2 Recommendations**

Based on the findings and discussion, the following recommendations can be made:

- (a) Land use planning in villages is essential in order to reduce human pressure on the land resources as well as ensure enforcement of laws that govern land management and land use.
- (b) Individual land should be surveyed and/or issued with title deeds. The issuance of certificates of titles would help as securities to the people in Melela ward
- (c) Policy makers should aim at improving and sustaining productivity of pastoral systems by establishing secure land tenure of common grazing areas to specific groups of users. This measure will limit the nomadic movements of pastoralists, improve grazing land and set rules to access and limit the number of animals that can be grazed in their area.
- (d) Further research should be carried out in order to establish sustainable livestock carrying capacities and to determine the sustainable grazing system for Melela ward.
- (e) Use of high-resolution images in future studies to achieve much better results. Landsat images used in this study were of low resolution (30 m by 30 m).

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## **AUTHORS' CONTRIBUTIONS AND ROLES**

**P. Hieronimo:** methodology, data analysis, validation, and interpretation of results, writing the first draft, reviewing and editing of the manuscript

**R. Kwayu:** conceived the study, methodology, data collection and analysis, interpretation of results, writing the first draft

**N. I. Kihupi:** conceived the study, reviewing and editing of the manuscript

**A.K.P.R. Tarimo:** conceived the study, interpretation of results and writing the first draft

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## **KEY TERMS AND DEFINITIONS**

**Land cover:** The observed physical cover, as seen on the ground or through remote sensing, including the vegetation (natural or planted) and human constructions (buildings, etc.), that cover the earth's surface. Water, ice, bare land, and salt flats or similar non-vegetated surfaces are included in land cover

**Land use:** A series of operations and associated inputs on land, carried out by humans, with the intention of obtaining products and/or benefits through using land resources

**Land cover change:** Refers to the complete replacement of one cover type by another, e.g. deforestation

**Land use change:** This includes the modification of land cover types, e.g. intensification of agricultural management or other changes in the farming system

**Pastoralism:** Is as a system of animal production. Pastoralism is commonly practiced in arid and semi-arid environments where resources (water and pasture) are variable in time and space.

**Agriculture:** This is defined according to Tanzania National Agriculture Policy 2013 as being referring to crop production