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Analyses of Land Cover Changes from 1981 to 2016 in Pande Game Reserve, Tanzania

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Abstract

Pande Game Reserve is among the protected areas in the coast of Tanzania. The reserve is heavily degraded because of illegal anthropogenic disturbances. The patterns of land cover changes which occurred in the reserve between 1981 and 2016 were determined using GIS and remote sensing techniques. Five land cover types, namely woodland, bushland, grassland, natural forest and bare soils were detected. The base map of 1981 indicated natural forest covering 965 ha (63.2%) followed by bushland with an area of 462ha (30%), grassland covering 7% (100 ha) where the woodland and bare soils did not exist in the reserve. The natural forest decreased from 965 ha to 421 ha in 2016 and the woodland that evolved in 1995 (87 ha) increased to 500 ha in 2011 and then stabilised up to 2016. The bare soils were more pronounced between 1995 and 2011 and then decreased in 2016. The grassland covered 100 ha in 1981, which expanded to 355 ha in 1995 and then decreased to 124 ha between 2000 and 2016 following intensified management intervention. Thus, land cover changes that involved reduction in natural forest are considered to have impacted plant populations surviving in already extremely limited habitat range within Pande Game Reserve. GIS and remote sensing techniques are potential to inform conservation management interventions of the depleting coastal forests resources in Tanzania.

Keywords: Bushland; GIS-Remote sensing; habitat; land cover change; natural forest; protected area; woodland

Introduction

Globally, the importance of protected areas to mitigate species' loss has been appreciated in a number of studies (Maikhuri et al. 2000, Samant et al. 2000, Trakolis 2001, Geldmann et al. 2013, Lindsey et al. 2017). Tanzania is among the nations engaged in establishing protected areas that include forest reserves (Uluguru, Uzdungwa, Pande, Zaraninge, Pugu), game reserves (Selous, Maswa, Ikorongo) and national parks (Serengeti, Mikumi, Manyara, Katavi, Kilimanjaro to mention a few) to conserve natural biodiversity. The efforts generated a massive international support from International Union of Conservation of Nature (IUCN), United Nations Environment Programme (UNEP), and Wildlife Conservation Society (WCS) to conserve and protect biodiversity (Mascarenhas 1995), and by Conservation of Critical Ecosystems (CEP 2003), where a number of protected areas have been established and reserves were promoted of their conservation status. Pande Forest Reserve is among the protected areas of the eastern coastal zone in Tanzania that was promoted to a game reserve in 1990 in

efforts to increase natural resources protection and conserving biodiversity. The reserve is part of the Eastern African coastal forests ecosystem (Burgess and Clarke 2000), known as Zanzibar-lnhambane Phytochorion (White 1983), rich in endemic species (Burgess and Clarke 2000) and has been included as part of biodiversity conservation hotspots (Myers et al. 2000). The success in protecting biodiversity in the natural forests can be achieved through maintaining stable land cover diversity.

Despite its importance, Pande Game Reserve is among the most degraded reserves caused by anthropogenic disturbances (Clarke and Dickinson 1995) with a series of land cover changes since its establishment. The negative impacts of human activities in Pande Game Reserve have been long known, such that approximately 60% of the land cover has declined since the 1950s (Doggart 2003). Some of the activities, particularly timber sawing, pole cutting, and fuel wood collection targeted specific plant species, whereas charcoal making was nonspecific (Mwasumbi et al. 1994), that may have contributed largely to the existing land cover change within the reserve. However, land cover is described as the biophysical state of the earth's surface including biota, soil and topography (Lambin et al. 2003) as opposed to land use that exploit the land cover (Gessese 2018). Pande Game Reserve is a legally protected area and biodiversity conservation is the only land use type. The destruction of one land cover promotes cover of other types (Turner and Alli 1996) and this has impacted the reserves' biodiversity as reported by Mwasumbi et al. (1994). Therefore, this paper is addressing only the issues related to land cover changes caused by illegal human activities within Pande Game Reserve.

Over the years, Pande Game Reserve has been surrounded by an ever increasing urbanisation with an apparent increase in forest resource demands (Burgess and Hipkiss 2002, Doggart 2003). These have been among key drivers of land cover changes experienced in the reserve within the specified study time period. Before the establishment of the reserve, local people from the surrounding settlements had access to the forest resources, despite they were legally restricted entry into the reserve after being declared in 1990. As a result, illegal activities such as fire wood collection and charcoal making intensified that contributed to degradation and land cover changes within the reserve from 1981 and 2016. Changes in land cover types may cause shrinkage of natural habitats and generate potential threats to the survival of plant species (Doggart 2003). However, little was known about the land cover changes under the influence of anthropogenic disturbances within in Pande Game Reserve because of limited studies. Some plants have been reported endemic to Pande Game Reserve (Doggart 2003) which are found in the natural forest cover, and therefore, disturbance may contribute to the disappearance of habitat suitable for their survival. Besides, disturbance may result into loss of forest-dependent plant species that cannot recover through natural regeneration, nevertheless the rate of recovery of plant populations under the improved protection of the reserve is not known. A study in Pugu Forest Reserve which is also found in the outskirts of Dar es Salaam indicated a slow rate of natural forest recovery following the 2008 fire impacts (Mligo 2019). Therefore, assessment based on a large time interval between 1981 and 2016 is ideal to determine the dynamics of plant communities that can be depicted through land cover changes within Pande Game Reserve. The application of digital methods with reference to geo-registered multi-temporal remote sensing data to elucidate land cover changes is useful in determining the influence of human activities on the natural habitats and their impacts on biodiversity conservation (Turner et al. 1994). The aim of this study therefore, was to determine the patterns of land cover changes that have occurred from 1981 to 2016 in the Pande Game Reserve.

Materials and methods

Description and location of Pande Game Reserve

Pande Game Reserve is located in the outskirts of Kinondoni Municipality of Dar es Salaam Region, Tanzania. The reserve covers a land area of 12.3 km^2 (Burgess and Hipkiss 2002) and it is found between latitudes 6°41S-6°44S' and longitudes 39°04'E-39°06E (Figure 1), at an elevation of 100 - 200 meters above sea level. It was designated and gazetted as forest reserve in 1952 and large part of scrubland was left out to meet the needs of the growing population of the surrounding local communities. Regardless of being gazetted, harvesting within the forest continued up to 1970s (Lupala 1997). It was previously proposed by Pande Game Reserve Limited in 1987, a private company to change the reserve into a zoo. This idea was supported by the Ministry of Natural Resources and Tourism that issued a revocation order in 1988 (18.10.1988) and the forest was again regazzetted as Pande Game Reserve (GN 461) in 1990. The Ministry of Natural Resources and Tourism issued a title deed for the reserve to the private company (Pande Game Limited) with the aim of creating a zoo on the site. However, instead of establishing a protected animal and plant sanctuary, the private company exploited its natural resources heavily resulting into severe degradation of the reserve. The Government of Tanzania decided to suspend the private management of the reserve in 1996 (Burgess and Hipkiss 2002). Since then, Pande Forest is managed by the central government as a game reserve through Tanzania Wildlife Authority (TAWA) which is under the Ministry of Natural Resources and Tourism of the United Republic of Tanzania. However, exploitation continued during the period between 1989 and 2001 and much of the reserve areas were affected, especially at the centre which was completely exhausted of valuable trees (Burgess and Hipkiss 2002).

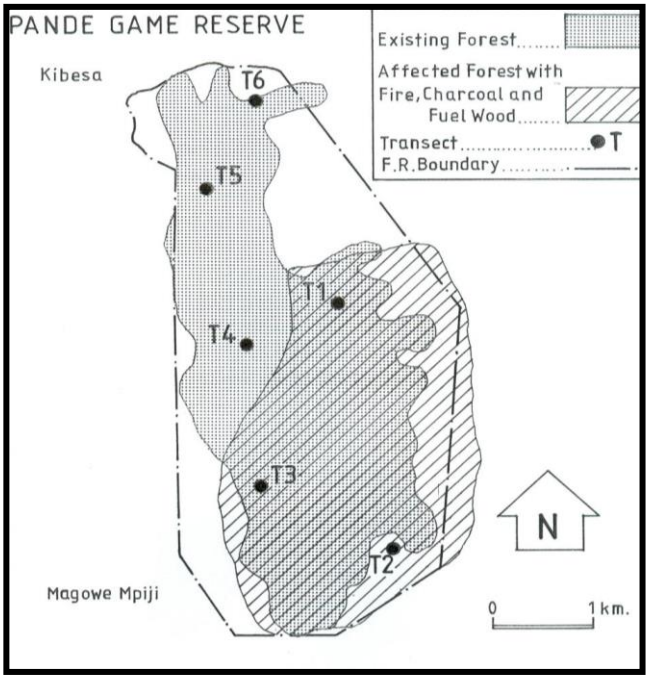

Figure 1: Map of Pande Game Reserve showing the location of monitoring and ground verification sites of land cover types.

Land cover change detection and classification

The vegetation cover detection was approached using supervised classification method as described by Mbilinyi (2000), Atesoglu and Tunay (2010), Kashaigili and Mbilinyi (2010) and the results were normalized for difference land cover types. Identification of land cover changes and the post-classification was done using ArcGIS10 software. The classified land cover layers from 1981, 1995, 2000, 2007, 2011 and 2016 images were used, and the quantitative data of the overall land cover changes as well as gains and losses in each category between 1981 and 2016 were then compiled. Two analysis tools extract and an overlay were used to determine the land cover changes and changed areas, respectively. The clip function was used to determine changes of individual land cover classes from the year 1981 to 2016 where the land cover classes from year 1981 features were the extracted and overlaid with selected vegetation cover classes from cover layer of 1995 and then the years that followed. The overlay tool then combined attributes from the two land cover layers and determined which areas changed from one cover to another and the areas that were not changed. The base maps that were prepared based on the satellite images acquired in October 2016 were used for ground truthing exercise. The exercise of truthing was performed by the help of Geographic Positioning Systems (GPS), and this enabled to normalize the misclassified land cover types, and were accurately located within the reserve. The dominant plant species were identified during ground verification in 2007, 2016 and 2018 and related with the land cover changes between 1981 and 2016 following the continued illegal human activities.

Results

The land cover types between 1981 and 2016 in Pande Game Reserve

The land cover types obtained through elucidation and analyses of temporal satellite imageries for Pande Game Reserve are shown in Table 1 and the temporal land cover changes in each specific period from 1981 to 2016 have been indicated in Table 2. The land cover maps that indicate the visual outputs and diagrammatical presentations of the land cover changes in the period between 1981 and 2016 have been presented in Figure 2. Otherwise the bar graph in Figure 3 provides additional information on the patterns of changes in each land over type over the years from 1981 to 2016.

The land cover classification data indicated five land cover types, namely woodland, bushland, grassland, natural forest and bare soils (exposed mineral soils) (Table 1, Figure 2 and Figure 3). The base-map of 1981 indicated the woodland and bare soils did not exist and were not detected in this period. The natural forest covered the largest land area equivalent to 63.2% (965 ha) of the game reserve followed by bushland cover with an area of 462 ha (30%) and grassland covered the smallest land area 7% (100 ha) of the reserve. The proportion of natural forest in relation to other land cover types was relatively the same between 1981 (63.2%) and 1995 (62.80%), regardless of the decrease from 965 ha of the former year to 959 ha in the later year. The overall dynamical pattern in natural forest cover was accompanied with a retrogressive change from (63.2%) that was detected in the satellite images of 1981 to 421 ha (27.55%) observed in 2016 (Table 1). The observable changes in other land cover types to the woodland were observed in the 1995 satellite images that covered the land area of 87 ha (5.7). The area covered with woodlands has ever continued to change progressively to 184 ha (12%) in 2000 and 300 ha (19.71%) in 2007 to a maximum of 500 ha (32%) in 2011 and then stabilized in

its percentage cover at the same level similar to that observed in 2016 (Table 1, Figure 3).

The grassland cover was 100 ha (7%) of the total land area of the reserve in 1981 and then increased to a maximum of 355 has (23%) and then started to drop to 258 ha in 2000. Ever since the grassland cover continued to decrease to 130 ha in 2007 and 124 ha (8%) in 2016 (Table 1). The bushland covered 462 ha (30%) of the reserve in 1981 which decreased to 89 ha (5%) in 1995. However, the bushland cover rejuvenated to 192 ha (12.5%) in 2000 and progressively changed up to 480 ha (31%) in 2016. Although the bushland cover decreased from 462 ha in 1981 to 89 ha in 1995, it rejuvenated to 192 ha in 2000 and progressively increased in cover up to 478 ha (31%) in 2016 an average area cover similar to that of 1981 (Table 1). On the other hand bare soils created through fire encroachment and charcoal making negatively affected large part of the natural forest as it expanded by 37 ha in 1995 to 60 ha in 2000, 43 ha in 2007 and 53 ha in 2011 and then significantly dropped to 6 ha in 2016 (Table 1).

The land cover changes in Pande Game Reserve from 1981 and 2016

The land cover maps that compare land cover types and changes between 1981 and 2016 are shown in Figure 2. Data revealed obvious changes in land cover patterns at a certain time interval by increasing or decreasing in the area covered. The shrinkage in bushland cover and natural forest in favour of grassland and woodland was observed in 1995 and this was followed by the rejuvenating cover through natural regeneration processes that can be verified in Table 2 and the land cover map of 2016. The natural forest which is the focal land cover type in the conservation efforts of Pande Game Reserve was observed to decrease in 1981-1995 by 6 ha and then decreased by 126 ha in the span of five years, i.e., 1995-2000. The major decline in natural forest cover was observed in 2000-2007 with decrease by 397.13 ha and decreased by 106 ha in 2016 (Table 2). The bushland cover decreased by 373 ha in 1981-1995 but it recovered by 103 ha, five years later in 2000. The bushland gained 42.14 ha of land coverage in 2000-2007 and positively changed in 2007-2011 with an increase of 245.86 ha and then extended further in its land cover by 161 ha in 2011-2016. The woodland increased by 87 ha in 1981- 1995 and then by 97 ha in 2000 to a maximum of 196 ha in 2011 before it declined by 3 ha in 2016 (Table 2). The dynamic patterns of grassland cover since its existence in 1981 had resulted into a net loss over the years up to 2016.

Table 1: The land cover types by proportions within 2918-2016 Pane Game Reserve

Land cover types	1981		1995		2000		2007		2011		2016	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bushland	462	30.26	89	5.83	192	12.57	234.14	15.34	319	20.88	480	31.41
Bare soil		0.00	37	2.42	60	3.93	43.11	2.82	53	3.47	6	0.39
Grassland	100	6.55	355	23.25	258	16.90	130.42	8.54	128	8.38	124	8.12
Natural forest	965	63.20	959	62.80	833	54.55	818.13	53.59	527	34.49	420	27.55
Woodland			87	5.70	184	12.05	300.96	19.71	500	32.72	497	32.53
Total cover	**1527**	**100**	**1527**	**100**	**1527**	**100**	**1527**	**100**	**1527**	**100**	**1527**	**100**

Table 2: The extent of the land cover changes between 1981 and 2016 in Pande Game Reserve

	1981-1995		1995-2000		2000-2007		2007-2011		2011-2016	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bushland	–373.00	–24.43	103.00	6.75	42.14	2.76	245.86	16.08	161.00	10.54
Bare soil	37.00	2.42	23.00	1.51	–16.89	–1.11	–37.11	–2.43	–47.00	–3.08
Grassland	255.00	16.70	–97.00	–6.35	–127.58	–8.35	–6.42	–0.43	–4.00	–0.26
Natural forest	–6.00	–0.39	–126.00	–8.25	–14.87	–0.97	–397.13	–26.03	–106.00	–6.94
Woodland	87.00	5.70	97.00	6.35	116.96	7.66	196.04	12.81	–3.00	–0.20

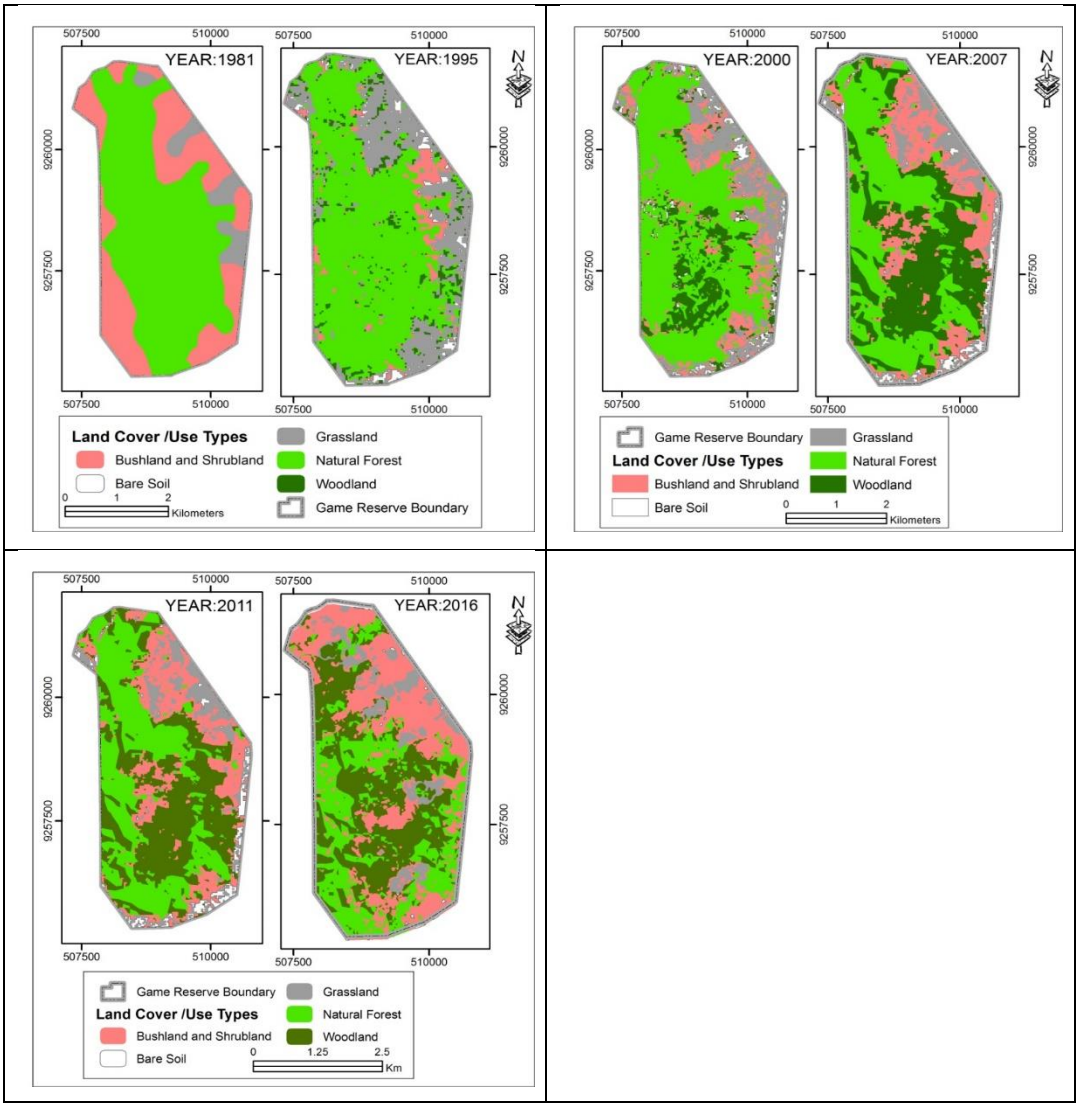

Figure 2: Maps indicating the land cover change in Pande Game Reserve between 1981and 2016.

The land cover changes in terms of gains and losses of each cover type in Pande Game Reserve in the period between 1981 and 2016

The results on the direction of changes among the land cover types within Pande Game Reserve are presented in the cross-tabulation matrices in Table 3 to Table 6. The focal land cover type for biodiversity conservation was the natural forest that formed the basis of the direction of changes because of the impacts of anthropogenic disturbances. However, the possible closest land cover types resulting from the degrading natural forest being the woodland or shrubland/bushland. Data in the possible gains and losses in land cover types between 1981 and 1995 are presented in Table 3. Of the 965 ha of natural forest cover that existed in 1981, only 762 ha remained unchanged in 1995 and the rest changed to other land cover types. A total area of 204 ha of the natural forest was lost and converted into woodland (42 ha), grassland (100 ha), bushland (50 ha) and bare soil (12 ha). Although the natural forest lost a total area of 204 ha, there was a net gain of 198 ha in 1995 (Table 3). There were 193 ha of the bushland that were consumed by fires and changed to grassland, whereas 176 ha regenerated to natural forest (Table 3).

Data on the losses and gains between 1995 and 2000 are presented in Table 4. Of the total natural forest area of 959 ha that was available in the reserve in 1995, only 738 ha remained unchanged in 2000 and a total area of 221 ha was lost and changed to woodland (143 ha), grassland (20 ha), bushland (49 ha) and 10 ha had exposed mineral soil (Table 4). Although the natural forest lost a total area of 221 ha, there was a net gain of 96 ha in 2000 following the regeneration of woody plants in the woodland and bushland cover type (Table 3). The bare soil decreased by 17 ha that changed into herbaceous/grassland cover.

Table 3: The cross tabulation matrix indicating the land cover gain and loss between 1981 and 1995

	Year: 1981				
Year: 1995	Bushland/ Shrubland	Grassland	Natural forest	**Total cover in 1995**	**Gross gain**
Bushland/Shrubland	33	6	50	**88**	55
Bare soil	20	5	12	**37**	37
Grassland	193	63	100	**356**	293
Natural forest	176	22	762	**959**	198
Woodland	40	5	42	**86**	86
Total cover in 1981	**462**	**100**	**965**	**1527**	
Gross loss	429	37	204		

Table 4: The cross tabulation matrix of the land cover gain and loss between 1995 and 2000

	Land cover of 1995						
Year 2000	Bushland/ Shrubland	Bare Soil	Grassland	Natural forest	Woodland	**Total in year 2000**	**Gross gain**
Bushland/ Shrubland	14	5	100	49	22	**191**	176
Bare soil	6	10	31	10	2	**60**	49
Grassland	25	17	176	20	21	**259**	83
Natural forest	29	2	33	738	33	**835**	96
Woodland	15	3	15	143	7	**183**	176
Total cover in 1995	**88**	**37**	**356**	**959**	**86**	**1527**	
Gross loss	74	27	180	221	79		

In 2007, the natural forest lost a total area of 278 ha but gained 264 ha (Table 5). The woodland lost and area of 91 ha but gained 208 ha from natural forest (174 ha) and bushland (21 ha). The grassland cover also decreased by 197 ha in 2007 that changed to bushland (90 ha).

Table 5: The cross tabulation matrix of the land cover gain and loss between 2000 and 2007

	Year: 2000						
Year 2007	Bushland/ Shrubland	Bare Soil	Grassland	Natural forest	Woodland	**Total in year 2007**	**Gross gain**
Bushland/ Shrubland	47	15	90	68	13	**234**	187
Bare Soil	5	4	17	11	6	**43**	39
Grassland	27	10	61	25	6	**131**	69
Natural forest	91	28	78	557	66	**820**	264
Woodland	21	2	12	174	92	**300**	208
Total cover in 2000	**191**	**60**	**259**	**835**	**183**	**1527**	
Gross loss	144	56	197	278	91		

The land cover changes in terms of losses and gains between 2007 and 2001 are presented in Table 6. Of the 820 ha observed in 2007, only 409 ha remained unchanged in 2011, and 411 ha lost and changed to woodland (250 ha) and bushland (114 ha). Although there was a total loss of 116 ha of the woodland in 2007, the gain was twice as much (317 ha) in 2011 (Table 6). The bushland lost a total area of 143 ha of the previous cover (234 ha) that was observed in 2007 that changed to grassland, natural forest and woodland with only 91 ha remained (Table 6).

Table 6: The cross tabulation matrix of the land cover gain and loss between 2007 and 2011

	Year: 2007						
Year 2011	Bushland/ Shrubland	Bare Soil	Grassland	Natural forest	Woodland	**Total cover in 2011**	**Gross gain**
Bushland/ Shrubland	91	12	52	114	49	**317**	226
Bare soil	20	4	8	20	1	**53**	49
Grassland	43	13	41	27	4	**130**	88
Natural forest	40	5	12	409	62	**527**	118
Woodland	39	10	18	250	184	**501**	317
Total cover in 2007	**234**	**43**	**131**	**820**	**300**	**1527**	
Gross loss	143	39	89	411	116		

The cross-tabulation matrix of the land cover losses and gains between 2011 and 2016 is shown in Table 7. Out of the 527 ha that were a natural forest cover in 2011, only 193 ha remained unchanged in 2016, while 334 ha were converted to woodland (177 ha) and bushland (122 ha), and the rest was grassland (35 ha). At the same time, the decrease in woodland from 2011 to 2016, was mainly an area from 500 ha to 496 ha that gained the same areas as were lost within this period. The gain was mainly from the regenerating shrubland (104 ha) and partly was converted to natural forest (132 ha). There was a total loss of 173 ha of bushland cover in 2011 to woodland (74 ha) and natural forest (62 ha) but gained an area of 336 ha in 2016. The bare soil decreased by 51 ha in 2016 because of coverage by grasses (Table 7).

Table 7: Cross-tabulation matrix of the land cover gains and losses between 2011 and 2016 (area in ha)

	Year: 2011						
Year 2016	Bushland/ Shrubland	Bare Soil	Grassland	Natural forest	Woodland	**Total cover in 2016**	**Gross gain**
Bushland/ Shrubland	145	29	81	122	104	**481**	336
Bare soil	2	2	2	0	1	**6**	4
Grassland	35	2	23	35	29	**124**	101
Natural forest	62	17	17	193	132	**421**	228
Woodland	74	3	8	177	235	**496**	262
Total cover in 2011	**317**	**53**	**130**	**527**	**501**	**1527**	
Gross loss	173	51	107	334	266		

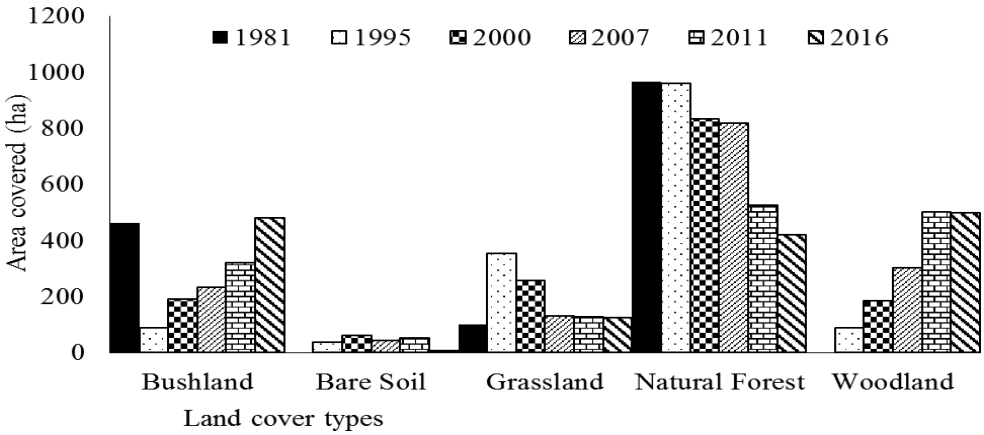

Figure 3: The pattern of land cover change between 1981 and 2016 in Pande Game Reserve.

Discussion

The land cover changes observed in Pande Game Reserve have apparent impacts on plant species natural habitats in the past 35 years. The multi-temporal satellite data generated from the reserve (Figure 2, Figure 3 and Tables 1-7) provide evidence on the detected changes in land cover types based on the levels of management interventions. The impacts of human activities as the major drivers of land cover changes have been appreciated in a number of studies (Bewket 2002, Solomon 2005, Ellis and Pontius 2007, Prakasam 2010). The land cover changes occurred within the study period were characterized by shrinkage and expansion directions through proportional gains and losses among land cover types

from 1981 to 2016 (see from Tables 3-7). Ellis and Pontius (2007) pointed out that biodiversity is reduced when land cover has changed from a relatively undisturbed state to more intensively exploited trees. The natural forest cover forms the major focus of this discussion because it provides the basic habitat for a number of coastal forest dependent plant species.

The temporal changes in land cover types based on the spatial scale impacts of anthropogenic disturbances within the game reserve have been illustrated in land cover maps shown in Figure 2. Since 1981, the game reserve has undergone both positive and negative changes among the land cover types that are contributed by variations in intensity of anthropogenic activities in space and time (Figure 2). The decrease of shrubland/bushland cover in the first five years from 1981 to 1995 was contributed by fire encroachment within the reserve that promoted the increase in grassland cover (Table 1). The decrease in bare soil was a result of suppression of charcoal making and fire control that made the bushland cover to rejuvenate in 2000. Although the government has intensified the protection of the reserve, the drivers of land cover changes have continued to exist and the natural forest has continued being destroyed and changed to bushland/shrubland and woodland as observed during ground truthing of 2016. The ground verification of the land cover types in 2016 and 2018 that covered a few exposed mineral soils and the recent charcoal kiln areas (bare soil) in the natural forest provide evidence of the accessibility of the forest resources by the local communities regardless of the reserve being a protected area. Bhuju et al. (2007) observed an increase in agricultural land cover at the expense of natural forest cover in unprotected areas in Himalaya. Being a protected area, the continued human activities in Pande Game Reserve is rather abnormal and this generate a lot of questions on the commitment by the staff of the reserve to tighten the regulations governing the establishment of the reserve. With a relaxed and loose management, the local communities have learned that, forest resources are still accessible and the observed loss in natural forest cover between 2007 and 2016 (Table1, Figure 2) is an indication of the protection and management inefficiency of the Pande Game Reserve.

It was observed a spatial recovery and degradation of the natural forest within the reserve based on the 2016 ground verification. While the natural forest cover recovery occurs in fragments within the reserve, the central and southern parts of the reserve continued to change into bushland/shrubland and woodland cover. The increase in the woodland cover was contributed by the regenerated *Spirostachys africana* in the northern part and the *Scorodophloeus fischeri*, *Manilkara sulcata* and *Haemenaea verrucosa* in some zones at the centre of the reserve in addition to the appreciable cover in the western zone of the reserve (Figure 2). The progressive decline of the natural forest cover within 1981-2016 period was contributed by the illegal human activities in combination with fire burning at the eastern and central zone of the reserve as observed in the 2018 ground truthing. Zhao and Jackson (2014) pointed out that the extent of land cover in natural forest is determined by plant species at different growth forms and changes are contributed by disturbances. This observation was further supported by Oli and Subedi (2015) that anthropogenic activities contribute to interference of plant cover through changes in plant species compositions. Although the impacts of land cover change on plant species composition within the reserve were beyond the scope of this study, a few dominant species recorded during ground verification provide evidence on the impacts of anthropogenic disturbances on natural forest cover and the associated species compositions within the reserve**.** Since Pande Game Reserve is part of the major centres of endemism as described by White (1983); change in natural forest cover to woodland, grassland and bushland affected the necessary favourable habitats for endemic and threatened plant species. The

observed shrinkage of natural forest cover in favour of woodland, bushland and grassland that occurred between 2007 and 2016 affected the population of *Coffea sessiliflora*, *Tricalysia pandensis* and *Uvaria pandensis* which are endemic and threatened plant species reported in Pande Game Reserve by Doggart (2003). Similarly, Wingfield (1974) and Hawthorne (1984) pointed out that *Scorodophloeus fischeri* grows in association with *Brachylaena huillensis, Tessmannia burtti, Cynometra spp., Dialium holtzii*, *Baphia kirkii* and *Newtonia paucijuga* and most of these are threatened species according to the 2016 IUCN redlist (IUCN 2016). The shrinkage of natural forest cover at the expense of other land cover types, have negative impacts on populations of the aforementioned endemic and threatened plant species and their ecological association within the Pande Game Reserve. The land cover changes driven by illegal human activities in protected areas provide a potential challenge in biodiversity conservation.

Conclusion

It is concluded that the land cover change which occurred between 1981 and 2016 was driven by human activities associated with the pursuit of plant resources from Pande Game Reserve. The observed changes were characterized by proportional gains and losses among cover types over the assessed time periods. The natural forest which is the target for conserving forest dependent plant species was kept on changing retrogressively from 1981 to 2016. The bare soils and woodland cover that were uncommon in the forest in 1981, they were more pronounced in 1995 because of the impacts of human activities. Protection of natural forest through fire suppression in combination with other management interventions can contribute to the recovery of the degraded parts in the reserve. The decline in natural forest cover can be considered to impact negatively the plant populations surviving in already limited habitat range (endemic and threatened species) in Pande Game Reserve. Thus GIS and remote sensing techniques are useful to establish land cover changes in space and time which is potential to inform conservation management interventions of natural resources in the coastal forests ecosystem in Tanzania.

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