Implications of present and future landcover change on small holder agriculture within the context of REDD+ in Tanzania: A case of Mgori forests in Singida rural District.

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Abstract

Mgori forest is located in Singida Rural district and is under Community Based Forest Management (CBFM). The forest has maintained its forest status and in general has demonstrated its potential for Reduced Emission from Deforestation and forest Degradation and conservation (REDD+) implementation because; i) communities living adjacent to these forest have experience on forest management practices; iii), have realized benefits from the forest including climate change mitigation and iv) they have willingness to conserve the forests and have very high expectations to get benefit in terms of financial emanating from carbon trade. The present study investigated the present and future land use and cover changes for years 2020, 2030 up to 2040. A cross tabulation analysis method was used to detect and explain changes, while future land and cover change was established using Markov Chain-Cellular automata analysis. The state of land cover at time 2 was predicted by observing a state of land cover at time 1 using a matrix of transition probabilities from one land cover to every other land cover. Findings in Mgori forest predictions showed that cultivated, bushland and thickets land covers will increase by 2020 and thereafter remain constant while woodlands will decrease by 2020 and then remain constant. It can therefore be concluded that for areas already under CBFM what is required under REDD+ is to improve the management of agricultural land to sustain productivity as the room for much expansion of land is not warranted. This can be achieved through capacity building to farmers and other agricultural stakeholders through their local agricultural innovation systems.

Key words: Agriculture, innovation systems, Kappa index, land cover, woodland

1.0 INTRODUCTION

In Africa it is widely and generally agriculture is the main source of income and livelihood of the majority communities living in both urban and rural areas (ADBG, 2010; Maitima *et al.,* 2011). We define smallholders as small-scale farmers who usually produce mainly for their own subsistence as well as pastoralists. In order to ensure that agriculture production is promoted and sustained, a number of policies and strategies have been formulated and implemented in various countries in east Africa (ref). Agriculture sector is the leading sector of the economy of Tanzania and accounts for over half of the Gross Domestic Product (GDP) (Kangalawe *et al.,* 2005). Other sectors which are also important in Tanzania include the mining, wildlife and tourism forest resource which also needs to be well managed.

In Tanzania it has been widely researched and documented that environmental change and degradation in particular climate change and degradation of soils and water has contributed significantly to declining or loss of agricultural production (Bohle *et al.*, 1994; Majule and Mwalyosi, 2005). Climate change in particular increase on temperature and increased variability of rainfall and to some extent increased drought negatively affects agricultural productivity (Lema and Majule, 2009). While climate change may impact smallholders' livelihoods directly

through a change in rainfall and temperatures, mitigation and adaptation strategies may also lead to serious challenges for smallholders due to restrictions on access to land. In most areas where forests are found or located there are still a number of challenges on forests including deforestation for expansion of agricultural, illegal harvesting of timber and woodlands and uncontrolled fire. On the other hand change on landuse cover in Tanzania is contributed by introduction new emerging economic activities such as mining or expansion of human settlements due to increasing human population (Majule, 2013). Normally it is known and accepted that REDD+ and at the same improve conservation and mitigation of climate change by increasing the sink of carbon will reduce climate change (Majule *et al*., 2011). Implementation of REDD+ projects in respective areas where agricultural production is being done it therefore mean productivity is going to be increased meaning both income and food security is maintained. In managing forest resources it should be given an upper hand by the government and communities to ensure that climate change mitigation is sustained. In Tanzania there are a number of REDD+ pilot projects which are being implemented by different institutions including NGOs. Some of the projects include those in Kolo Hill Forest, Kondoa district being implemented by Wildlife Society in Tanzania and MJUMITA. On the other hand there are areas which have identified to be potential REDD+ and some of them have been under Participatory Forest Management Practices. If REDD projects are implemented will contribute with knowledge that will be important for planners and decision-makers to avoid that the social costs of carbon-sequestration are born by Tanzanian smallholders. This paper focused more on potential forest area commonly known as Mgori forest located in Singida Rural, in Singida.

Singida rural district was selected as an area which has a potential forests including Mgori well managed under PFMP which also is rich on other biodiversity including wildlife. Conflicts on land arise because of the tension between conservation and livelihoods around from natural resources available in forest. In general this paper has been able to scientifically map potential forests namely Mgori. Traditionally, land cover change analysis was performed by producing land cover maps for each year and calculating the area of each land cover category. The change was computed by calculating size differences of each land cover and or percentage of size change and presenting the result in tables. This procedure is usually referred to as change detection analysis. The overall objective of this paper to discuss major social economic activities and climatic characteristics and establishes the current land uses and potential REDD+ initiatives in Mgori and the future land use cover change scenarios based on probability maps and to explain their causes.

2.0 Methodology

2.1 Description of the study areas

Singida rural district lies between latitudes 3^{0} and 7^{0} South and longitudes and 34^{0} and 35^{0} East, in Singida region which is located in the central zone of Tanzania. The forest itself is located in the eastern part of Singida region (Figure 1) and it represents an area where woodland is managed in a participatory way by communities living adjacent to the forest. The five villages that surround the forest are; i) Unyampanda; ii) Mughunga; iii) Nduamughanga; iv) Dohama and; v) Ngimu.

Figure 1. Map showing the location of Mgori Forest studied

2.2 Collection of social economic data

In order to achieve triangulation within the study a range of methods including focus group discussion, key informant interviews, household survey as well as participatory field observation were used. Primary data were collected through different qualitative and quantitative techniques and encompass information such as people perceptions on the current changes occurred to agricultural land as well as the anticipated changes during the implementation of REDD+ project, trends and condition of forest products, climate change awareness and perceptions, gender issues as well as challenges for the REDD on other land uses. On the other hand secondary data were collected through review of different similar studies conducted in Tanzania and elsewhere. This also included review of different research reports and other documented materials available in Singida region. In terms of analysis, qualitative data from various sources were examined and presented in different forms while quantitative data were edited, coded and entered in a computer and the Statistical Package for Social Science (SPSS) software version 20 spread sheet was used for the analysis.

2.3 Assessments of landuse cover changes in study areas

In general, land use cover change analysis in forest is performed by producing land cover maps for a particular year in which the changes of interest each year and calculating the area of for a given time is required. It also depends on the availability of the set of image or aerial photographs. The change is computed by calculating size differences of each land cover and or percentage this procedure is usually referred to as change detection analysis (Majule *et al.*, 2012). In this project data collection was done based on Landsat images to cover the study area Mgori forest. Five scenes covering years, 1990, 2000 and 2010 were acquired for landuse cover analysis in both project areas and the images were used for field verification. Handheld GPS was used to geo-reference and identify the activities conducted in order to use as guidance information on image classification. After fieldwork, image classification was done using a procedure reported by Muganyizi (2009).

Image was interpreted to detect landcover/use and potential areas for REDD for in Mgori area in Singida.

2.4 Predictions of the future land use cover changes

Knowing the changes that have occurred in the past may help predict future changes. Various methods for predict land cover changes are available. Some of these methods are deterministic which predicts future scenarios based on factors such as maps, socio-economic and biophysical factors. Other set of land cover prediction are stochastic models. In this project; the Cellular Automata were used with this model. Future scenarios for land uses were modeled based on transition probability matrix. The Marcove Chain analysis was used to determine the transitional probability matrix for change from the year 2000 to 2010. The probability matrix and the transition potential map of each land cover, where supplied to Cellular Automata model in-built in GIS software (IDRISI Kilimanjaro) to predict the future land cover in year 2020.

The maps of land covers produced from the 1990, 2000 and 2010 images were cross classified for the periods of 1990-2000 and 2000 -2010 to explain land use changes occurring in the area. The Kappa Index of Agreement (KIA) was calculated to determine the land cover that exhibit significant changes.

3.0 Results and Discussion

3.1 Social economic characteristics of respondents in study villages

The social economic activities of villages surrounding Mgori forest in Singida Rural District are summarized in Table 1. Findings show that, agriculture is the mainly subsistence and depended on rainfall and this is reported to be challenged by several social and environmental factors including lack of productive seeds, attack by pest and diseases, poor and declining soil fertility and frequent drought associated with seasonal climate variability. Major crops grown are only annual including maize, sorghum, milled, cassava and bulrush millet. The second main activity across villages is livestock keeping which provides income and food to community as well as meeting demand of cultural aspects in particular payment of dowry. Most of the livestock kept are local and therefore are subject to several challenges including diseases and pests.

Although all villages surround Mgori Forest one would expect much of the livelihood to be contributed by use of natural products from the forest. This is not the case for the moment as less than 10% is reported in all cases not to be from the forest products. This therefore shows that conservation through CBFM is very effective and this provides opportunities for effective REDD implementation

Table1: Main social economic activities per village in Mgori forest (%)

	Villages adjacent to Mgori Forest				
Activities	***Nduamughanga***	***Unyampanda***	***Ngimu***	***Pohama***	***Mughunga***
Agriculture production	70	65	70	60	68
Livestock keeping	20	20	15	25	20
Small Business	03	05	04	05	04
Crafting	02	-	04	02	02
Beekeeping	02	05	1.5	03	02
Timber	01	03	01	01	02
Charcoal	01	03	01	01	01
Fire wood	01	-	02	02	01
Total	**100**	**100**	**100**	**100**	**100**

On the other hand, the main economic activity in the all villages surrounding Duru forest is agriculture production (crops and livestock) for both income and food. This activity has appeared to be much practiced in Boay village (70%) compared to other villages and it also largely contributes to majority livelihood as well as village economy. The main cash crops grown includes pigeon peas, groundnuts, beans, ngwara, millet, and sunflower while the food crops are maize, sorghum, cassava and sweet potatoes. Livestock keeping is the second economic activity practiced by most of people within the village and is dominant in Bubu village. The main livestock kept include cattle, goats, sheep, children, donkey, pigs, ducks, dogs, cats and pigeon. There are also other activities as well contributing to the villages economy and livelihoods, these includes small business such as shops selling daily house commodities, selling of local bear, kiosks and food vendor, casual labor, artisans, extraction of firewood, craft works as well as honey and timber harvesting.

3.2 Perceptions of climate change in study villages

Climate change awareness and perceptions vary among villages. During focus group discussion by villagers surrounding Mgori forest in Singida Rural it was revealed that; i) there are significant changes in climate that have occurred in the area. For instance, among the mentioned impact is increase of temperature and frequency occurrence of drought in the villages of Nduamughanga, Unyampanda, Ngimu, Pohama and Mughunga. For example, Unyampanda village used to have rain from January to June and it was good, but now it has changed and the onset rainfall is unpredictable. The rain can come early or late on December and cut off in March. Now day it is becoming common for a rain to cut-off before the maturity of the crops grown. On the other hand, Pohama village used to have rain from November to April, but now it have changed and the onset rainfall are from December to March. Some times can come early and cut off early or come late and cut off early. Generally the rainfall is becoming unreliable and unpredictable. The temperature had been increased and the frequency of drought also increased as compared to the past. The major impacts to this trends where almost similar among all villages and includes; decrease and dry out of water, decrease in crop production resulting to food shortage, decrease of wild fruits, drying of trees, decrease of honey, tree plants not flowering as well as decrease of pasture for wild animals. Participants went further by mentioning a number of climate change related events over the last ten years and its associated impacts which include the presence of livestock diseases, army worms, occurrence of high rainfall (El Nino) and drought. All these findings signify that climate change is really within the study area.

On the other hand in terms of villages surrounding Duru forest the results where more or less similar to those reported in Mgori forest. Majority of participants in all villages mentioned that formerly they used to have rain from November to May, but now it have changed and the onset rainfall are from December to May and sometime it may start on January. Temperature has increased and there is no specific season, in past high temperature used to be on September and November and the cold period was June and July.

3.3 Impact of climate change on livelihood of villages

The impacts of climate change to livelihoods were revealed by majority of participants during focus group discussion in all villages surrounding Mgori forest in Singida rural district. Among many, some of them include decrease of the volume of water in river, destruction of crops resulting to food insecurity, decrease in crop production resulting to food shortage, decrease of livelihood income, remarkable effects on forest products such as drying up trees, decrease of honey production, bees and fruits as well as loss of animal due to lack of pasture and water. All these have increased incidence of poverty and therefore

resulting to severe livelihoods challenges among villagers in the study area. However despite all these challenges, REDD present an opportunity for the improvement in climatic condition through increased efforts in forest management. This is expected to improve water sources, increase production, as well as increase community income.

3.4 Futurelanduse cover change and implications on REDD+

In general the present landuse cover change for Mgori Forest as reported by Majule *et al*. (2012) showed that deforestation was associated with expansion of agricultural activities and population growth leading to expansion of human settlements. On the other hand, transitional land cover change detection (Table 2) shows change of individual land cover by determining the deference of land cover in subsequent years, but does not show to what land cover each land cover category has transformed to. In general change detection methods show an area reduction or increase with time of land cover in question. Such change detection analysis shows for example the forest has increased or decreased but does not show the increase or decrease of forest cover/ is on expenses of what land cover. With this analysis it is difficult to see directly what is contributing to change. In order to identify factors that contribute to the increase or decrease of particular land cover cross tabulation analysis is used

.Table 2. Mgori proportional land covers change to 2000 to 2010

Area Hectares	Land Cover Change From - To	Category Code	Area Hectares	Land Cover Change From - To
20131.04423	Unk-Unk	18	38.9695243	Gos - Gos
0.0899989	Unk-Ort	19	799.4602416	Wol - Gos
2015.165403	Bus - Bus	20	0.1799978	Unk - Wol
617.5724618	Cul - Bus	21	902.6889816	Bus - Wol
44.4594573	Grl -Bus	22	215.3673712	Cul - Wol
216.5373569	Gos - Bus	23	26.0096825	Grl - Wol
10781.4184	Wol - Bus	24	156.5980885	Gos - Wol
0.0899989	Unk - Cul	25	8098.101153	Wol - Wol
779.7504822	Bus - Curl	26	826.0999165	Bus - Thc
1069.366947	Cul - Cul	27	104.0387301	Cul - Thc
18.1797781	Gos - Cul	28	21.1497418	Grl - Thc
820.159989	Wol - Cul	29	702.2614281	Gos - Thc
80.6390157	Bus - Grl	30	2318.191704	Wol - Thc
11.2498627	Cul - Grl	31	4879.920435	Thc - Thc
1116.796368	Wol - Grl	32	0.6299923	Bus -Set
138.9583038	Bus - Gos	33	41.5794925	Cul -Set
23.6697111	Cul - Gos	34	2.5199692	Wcl -Set
54.809331	Grl - Gos	35	0.3599956	Set - Set

Legend: *Bus-Bushland; Grl-Grassland; Wol-Woodland; Cul-Cultivated land; Thc-Thicket Set-Settlement; GoS-Seasonal inundated grassland*

The result from the cross abulation/ classification matrix indicate that the large proportion of woodland changed into thicket (about 2,318.20ha) while agriculture claimed about 820.16ha of woodland. However about 1,116.80ha of woodland has been transformed into grassland. Area of woodland still exists (8,098.10ha). Such changes imply that non farming activities such as converting woodland to thicket frequent burning. Agriculture claims much less woodland compared to non-agriculture

livelihood activities, and next to woodland. Agriculture claimed about 779.80ha of bushland since agriculture is utilizing woodland; effort need to be put in place under REDD initiative to utilize the 2,015.17ha of bushland for agriculture to serve the remaining woodland.

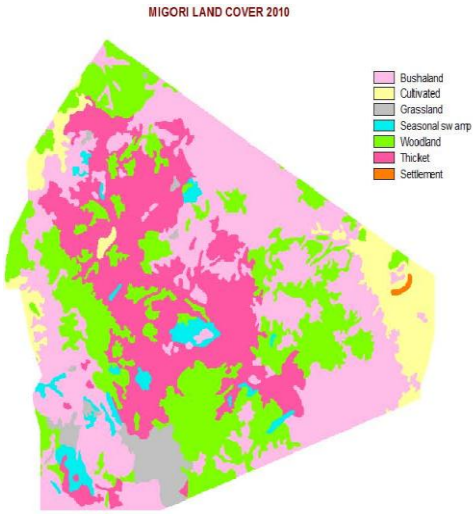
Table 3 presents different land use cover in the area based on both social economic, social and environmental factors in particular climate change. In general and as depicted by the analytical data the proportional of land in 2000 to a large proportional (61.45%) was covered by woodland indicating that carbon concentration in that area was high in that area. This further suggests that this area was rich in biodiversity including wildlife. On the other hand Land cover which follows by that time were thickets and bushland, cultivated where as land under settlement was the least. After 10 years land under woodland decreased with a significant increases of land under thickets and bushland indication deforestation.

Table 3. Mgori Projected Area Matrix particular climate change

Land cover (per ha)	2000		2010		2020		2030		2040	
	Area	%	Area	%	Area	%	Area	%	Area	%
Bushland	4744	12.18	13675	35.11	11410	29.29	11409	29.29	11413	29.3
Cultivated	2083	5.35	2688	6.9	3970	10.19	3967	10.18	3966	10.18
Grassland	146	0.38	1209	3.1	684	1.76	687	1.76	679	1.74
Seasonally inundated	1133	2.91	1056	2.71	1236	3.17	1235	3.17	1235	3.17
Woodland	23937	61.45	9399	24.13	6422	16.49	6420	16.48	6426	16.5
Thicket	4880	12.53	8852	22.72	13107	33.65	13109	33.65	13107	33.65
Settlement	0	0	45	0.12	102	0.26	103	0.26	102	0.26
Total Area	**38952**	**100**	**38952**	**100**	**38952**	**100**	**38952**	**100**	**38952**	**100**

Based on the data shown in Table 3 result shows that from the model from year 2000-2030 up to year 2040 agricultural cultivated land will increase at a rapid rate predicted from 5% to 10% (Figure 2, 4 and 5). Such an increase still suggests that woodland in Mgori can still be conserved to allow the implementation of REDD+ project in the area. In general the woodland will tremendously decreases predicted from 61 % to 16.5% and the settlement areas and bush lands will increase (see Table 3 and Figure 3 and 4). Thicket will almost triple from 12.53% to 33.65%. Cultivated land and bushland will almost double based on the prediction. In this case REDD and conservation initiative in Mgori needs to be advocated effectively on the expense of agriculture in order to sustain community livelihoods in surrounding villages.

In general findings (Table 3) indicate that the highest land cover change occurred on bush land on seasonally inundated swamp. Highest change in water areas is due resulted to misclassification as water bodies in 2000. Woodland also show a significant change of 62% compared to cultivated land with a least change of about 26%.



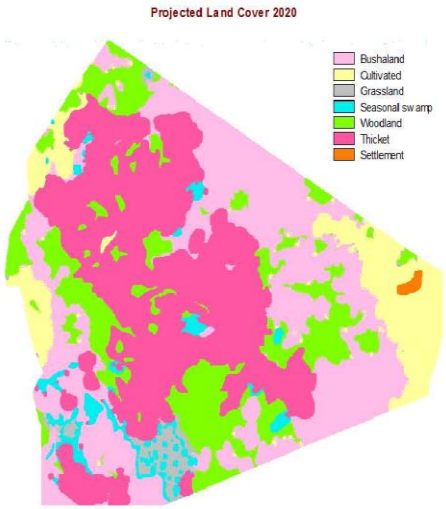
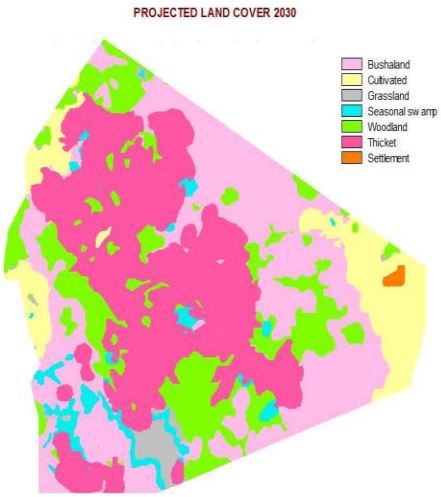


Figure 2. Mgori land covers 2010 Figure 3. Mgori Projected land covers 2020



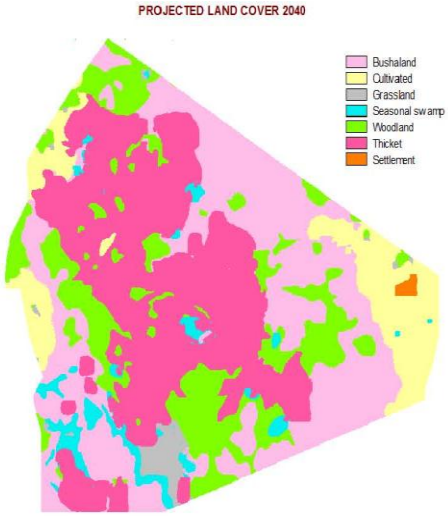


Figure 4. Mgori Projected land covers 2030 Figure 5. Mgori Projected land covers 2040

Table 4. Kappa Index Area for land cover types for Mgori in Singida

Category code	Land cover type	KIA
0	Unknown land cover	1.0000
1	Cultivated	0.7418
2	Grassland	0.0524
3	Woodland	0.3834
4	Seasonal	-0.0051
5	Water	-0.0028
6	Bush land	0.0084
Overall Kappa		0.7053

The overall Kappa of 0.7053 (Table 4) generally indicates land cover change for the year was generally low about 29%.

4.0 Conclusions

In Mgori forest predictions showed that cultivated, bushland and thickets land cover are going to increase by year 2020 and thereby remain constant after that year. On the other hand, woodlands will decrease by year 2020 and then remain constant. In the area woodland continues to shrink and being converted to thicket, that signify the biophysical changes in soil and moisture retention that may results for frequent burning. Agriculture is claiming significant hectare of woodland despite of the available bushland that can be used for agriculture. Despite the decrease of woodland, Mgori forest is still a potential site for REDD+ project implementation and still require participatory forest management to be implemented. Under REDD+ there is a room for improving agriculture production since the expansion of agriculture is not significant in the future

5.0 Recommendations

There is a need to strengthen capacity building to farmers and other agricultural stakeholders through their local agricultural innovation systems. Since the area has been under CBFM for quite a long time, what is required under REDD+ is to improve the management of forest and agricultural land to sustain productivity as the room for much expansion of land is not warranted. It is still very important to depart knowledge to the community and local leaders as well as higher level leaders on what is likely to happen in the future on landuse cover changes and how this will change their livelihoods. This is very important as REDD+ if well implemented will be able to address these challenges.

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