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Biofuel potential and land availability: The case of Rufiji District, Tanzania

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Africa's attractiveness to potential biofuel investors is based on the assumption that there is plenty of unused land available for investment in different countries of the continent. However, their postulations are not based on any concrete studies on land available at country, regional or local level. This study investigates land availability for potential biofuel investment at the local level, using Rufiji district in Tanzania as a case study. We have analyzed different land cover/land use types and separated them into areas of potential biofuel investment and areas where biofuel investment is not possible by a process of elimination. The results suggest that land available is inadequate to meet the needs of biofuel investors. The land assumed to be unused or underutilized by biofuel investors is either part of the fallow system or used to harvest natural resources and for other traditional uses. Expropriating the assumed idle land will have impact on the livelihoods of the local communities.

Key words: Biofuel investment, land available, Rufiji District.

INTRODUCTION

The alleged existence of abundant underutilized land in Africa has attracted biofuel investors from wealthy countries to the continent (Cotula et al., 2009; Madoffe et al., 2009). The assertion is part of a long held dogma, where African lands are perceived to be unoccupied and therefore in need of investments (Neville and Dauvergne, 2012). However, there is a huge difference between those assertions and the appraisal of land available for biofuel production according to the International Energy Agency (Haugen, 2010). The discrepancy between the assertions of the potential biofuel investors and the assessment by the International Energy Agency can be attributed to little research on land availability in Africa, and emphasizes the need for more research and more high quality data (Cotula et al., 2009; Ahlberg, 2011). Nevertheless, there are recent studies estimating land availability for biofuel production at the global level using both coarse resolution remote sensing data (Cai et al., 2011) and high resolution remote sensingdata (Fritz et al., 2013). Using high resolution remote sensing data, Fritz et al. (2013) substantially lowered the amount of estimated land available for biofuel production. Yet, the remote sensing studies have neither considered land availability at country, regional or local level, nor have

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they considered other activities that might be competing for land apart from biofuel production.

Sulle and Nelson (2009:7) define biofuels as “liquid, solid or gaseous fuels that are predominantly or exclusively produced from biomass”. In general, biofuels, such asbiodiesel, ethanol and biogas are derived from crops, plant residues or garbage. The acquisition of land for biofuel and biodiesel production has increased worldwide, in particular in Sub-Saharan Africa (Havnevik, 2009), where the acquisition has been received with mixed feelings. Some construe the biofuel sector as important in revolutionizing agriculture and alleviating poverty. Others are afraid that the biofuel sector will inevitably lead to harmful land use changes once the land is converted to estate agriculture (Martin et al., 2009; Schoneveld et al., 2011).

Biofuel production is also evolving as a critical policy matter in agricultural development and natural resources management (Sosovele, 2010). In most African countries, policy institutions are passive in decision making (Romijn and Caniëls, 2011), and at the advent of biofuel investment in Africa, most countries did not have policies in place to monitor and control biofuel investments. As a consequence, national and local government agencies were trapped in a confusing role between defending interests of the local people and those of the biofuel investors (Cotula et al., 2009). Moreover, in dealing with biofuel investors, local communities are at a disadvantage in protecting their interests, because they do not comprehend the full effects of biofuel investments (Beyene et al., 2013).

There is a belief that Tanzania will reap the benefits of biofuel investments in terms of capital, expertise and knowledge transfer (Kweka, 2012). In addition, it is hoped that biofuels will lessen the economic burden of importing petroleum, thus improving environmental conservation and livelihoods (Martin et al., 2009). The optimism in the benefits of biofuel investments has resulted in Tanzania becoming a major destination for potential biofuel investors for the supposed existence of enormous unexploited lands (Habib-Mintz, 2010). However, Sulle and Nelson (2009) contend that land pursued for biofuel investment might be physically unoccupied but not unused. The land might be in fallow, or it may be common land used for example, charcoal production, and fuel wood and timber collection. If such land is lost to biofuel investment, not only will the livelihoods of the locals be affected, but this will also lead to shortened fallows that in turn will adversely affect soil fertility (Daley and Scott, 2011).

Despite all the optimism and potential of the biofuel sector, Tanzania lacks a coherent biofuel policy base (Sosovele, 2010). The existing policy does not address a wide range of energy options and has shaky institutional and legal frameworks. Under such circumstances, developing the biofuel industry will be a difficult task, some stakeholders in the biofuel sector have advised the government to halt the biofuel investments until appropriate policies are in place (Sosovele, 2010).

Biofuel potential in Rufiji district

Rufiji district covers a total area of 13,339 km^2 according to official figures (URT, 2013). The population density is among the lowest of any district in Tanzania according to the 2012 census, with 16 inhabitants per km^2, against the national average of 51 inhabitants per km^2. These figures might present a picture of huge tracts being available for biofuel investment in Rufiji District.

The choice of Tanzania by a Swedish company, SEKAB (now taken over by Eco Energy, to be referred to as SEKAB/Eco Energy), was based on the presumed availability of apt land for large scale biofuel investment (Havnevik, 2009). Authors have quoted various figures regarding what SEKAB/Eco Energy intended to acquire in Rufiji district, ranging from 250,000 (Neville and Dauvergne, 2012) to 500,000 ha (Cotula et al., 2009). Another company, Africa Green Oil (AGO), was negotiating with six villages in Rufiji District for 30,000 ha of land. In the course of their negotiations, they settled on 5000 ha, of which in the end only 2800 ha were actually available (Neville and Dauvergne, 2012). In Nyamatanga, one of the villages where AGO acquired land, the local population have not only lost agricultural land, but also income generated from the selling of products they were collecting from the acquired land (Daley and Scott, 2011). The direct engagement of biofuel companies with the villages without any government oversight has left the local people in a precarious position as far as their interests are concerned (Beyene et al., 2013).

The AGO narrative (seeking 30,000 ha of land but finding that only 2800 ha were actually available) demonstrates that there is a huge gap between the biofuel investor’s wishes and the actual land available for biofuel investments. According to Mwakaje (2012), Rufiji district offers one of the best case studies for biofuel investments because it has attracted a considerable number of potential biofuel investors. This paper aims to investigate the hypothesis that there is abundant, idle or unused land that can be used for large scale biofuel production at the local level in developing countries like Tanzania. The study will therefore contribute to developing methods of assessing land availability for biofuel investments at the country, regional or local level supplementing those done at the global level.

METHODOLOGY

Study area

Rufiji District is located in the Coast (Pwani) Region (7°30’S to 8°40’S and 37°50’ to 39°40’E) in Eastern Tanzania and is dominated by the Rufiji River that runs almost in the middle of the district embracing the flood plain on both sides and an extensive mangrove delta at the river mouth (Figure 1)

Rufiji district is one of the six districts in the Coast Region of

Tanzania. About 75% of the region's economy comes from the agricultural sector, mostly managed by smallholder farmers who do not practice improved farming. As a result, yield per acre is relatively low. Rufiji district has 482,466 ha of arable land (20.7%) out of which only 90,000 is under active crop production (URT, 2007). FAO (2010, p. 17) defines arable land as "land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category". This is an important distinction, as potentially arable land, such as land under fallow for prolonged periods, is not included in the definition.

Livelihood schemes in Rufiji demonstrate a strong interconnection of activities between the floodplain, the forested areas in the north and south and the lakes located close to the flood plain (Hamerlynck et al., 2010). In principle, there are three agricultural systems: the flood plain agriculture, practiced by the majority; the delta agriculture and the hill agriculture. The latter is characterized by low fertility and low yields (Havnevik, 1983). In all three systems, shifting cultivation is practiced. In the delta, where mangroves are cleared for agriculture, sedges replace crops during fallow phases (Semesi, 1989). In forests, north and south of the floodplain, cultivated fields are left fallow for a period of two to three years (Durand, 2003), and also in the flood plains, where cultivation is presently expanding, shifting cultivation is practiced (Hamerlynck et al., 2010).

Data sources

The study is based mainly on a literature review and on secondary data, mostly obtained from authorities and NGOs and from government offices in the Rufiji district council. Semi structured interviews were also conducted with relevant government officials.

Land use/land cover

Land use/land cover digital maps and boundaries of protected areas (game and forest reserves) were obtained from the database at the Tanzania Natural Resources Information Centre (TANRIC) at the Institute of Resource Assessment, University of Dar es Salaam. Land use/land cover types are based on Landsat TM images of 1994/95 (Hunting Technical Services, 1997). Of 64 land use/land cover digital sheets at the scale of 1:250,000 covering Tanzania, Rufiji District is covered by four sheets. We have modified the original classification of land use/land cover types based on extensive field experience from working in Rufiji District. For example, classes such as dense bushland, open bushland, bushland with emergent trees, have been merged into a single class called bushland. Likewise, closed woodland and open woodland have been merged into a single class called woodland.

Boundaries of protected areas

The best available map delineations of protected area boundaries have been used. The protected areas in Rufiji District consist of one game reserve and nineteen central government forest reserves including the Rufiji Delta (Appendix 1). A list of these forest reserves (Appendix 2), provided by the Rufiji District authorities contain discrepancies in size as compared to the size generated in GIS (Appendix 1), despite the fact that on the maps, they appear similarly in shape. In some cases, the area of certain forest reserves is not indicated at all in the official list. In addition to central government forest reserves, the list from Rufiji District officials contains local government forest reserves (owned by the district council) and community based village forest reserves (owned by village governments). It also includes a number of proposed community village forest reserves whose sizes are not indicated. The total area from the district list for all types of forest reserves (community, local government and central government) is 2278.2 km^2, while the area under protection, as calculated in GIS, reaches 5227.1 km^2. Though the mangroves are a forest reserve, they have been considered separately. Unlike the rest of the forest reserves, mangrove forest reserves have no definite boundary, but are defined by the intertidal range. Thus, the boundary delineation is based on extent of mangroves as mapped from the images. The Selous Game Reserve, one of the largest faunal reserves in the world with an area estimated to be 54,600 km^2, cuts across several regions and districts, with 6.5% of its area in Rufiji District alone.

The digital district boundary used is the same as the one that appears on various documents. The area of Rufiji District from this digital source is 12,998.5 km^2, which is 97.4% of the figure quoted in official documents. This discrepancy in area is common in many administrative units (region, district) between the official figures and digital sources even from those obtained from the Survey and Mapping Division – the ultimate mapping authority in Tanzania.

GIS manipulation

We have applied a Geographical Information System (GIS) to produce maps and to generate data. The process of obtaining the area that might be considered for biofuel investment was done by elimination or subtraction (Figure 1). First, relevant digital land use/land cover sheets coverage was merged. Then, the land use/land cover map of Rufiji district was clipped (extracted). This was followed by superimposing boundaries of the protected areas (the game reserve, forest reserves, and the extent of mangroves) on the district land use/cover map. The areas covered by protected areas were then subtracted, leaving possible areas to be considered for biofuel investment.

The figure obtained from the GIS manipulation was used to deduct arable land (URT, 2007) from various land use/land cover-types to obtain the possible biofuel investment areas. The main limitation of this study was the inability to map or segregate arable land from different land use/land cover types (non GIS in Figure 2).

RESULTS AND DISCUSSION

Various land use/cover type

Land use/land cover in Rufiji District is dominated by woodland, wooded grassland and the floodplain (Table 1). Cultivation is represented by two land use/land cover types, mixed cropping and scattered cultivation. The sum of the two cultivation land use/land cover types is relatively low. Given that the size of the farms on an average is approximately 1.2 ha per household (Turpie, 2000), it is likely that cultivated land is underrated, as such small areas cannot easily be detected with the 30 x 30 m resolution of the Landsat images. However, also without taking cultivated land into consideration, the results suggest that a huge portion (40.2%) of the district is covered by protected areas (game and forest reserves), a portion of Rufiji district that cannot be considered for biofuel investment.

The results can be analyzed under two scenarios (Table 2). The first scenario assumes that protected

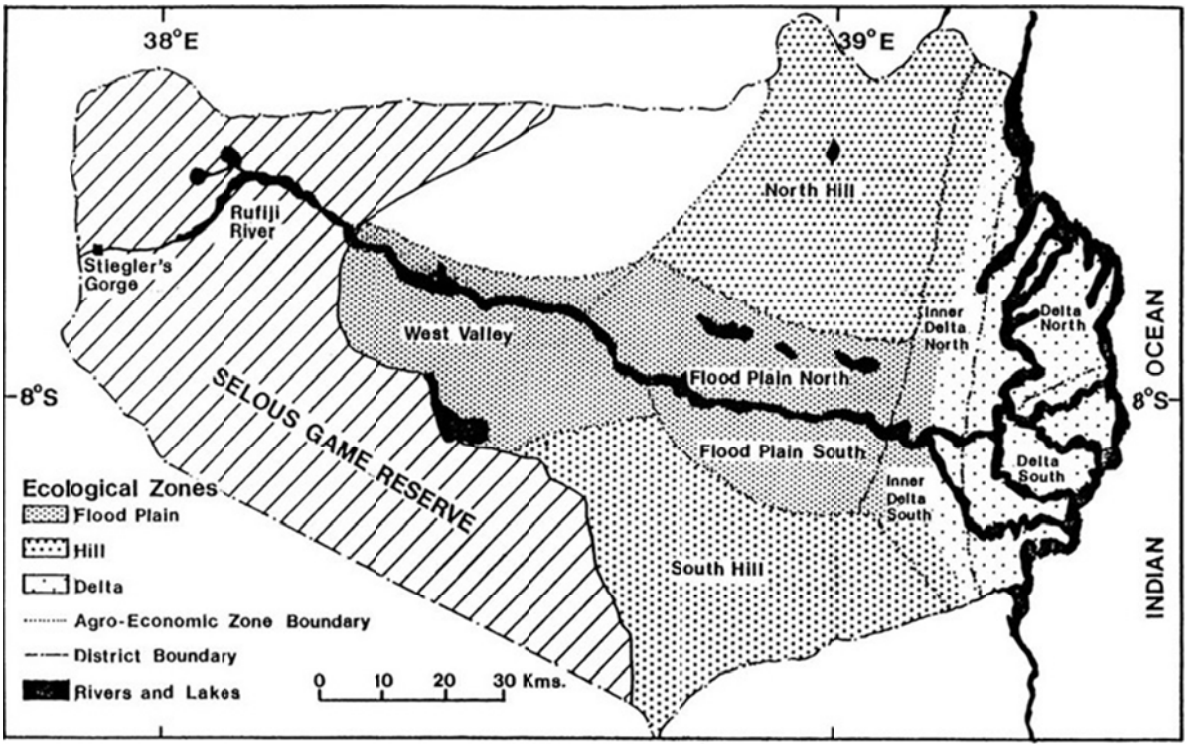

Figure 1. Rufiji District Agro-Ecological Ecological Zones (AEZ). Source: Havnevik (1981).

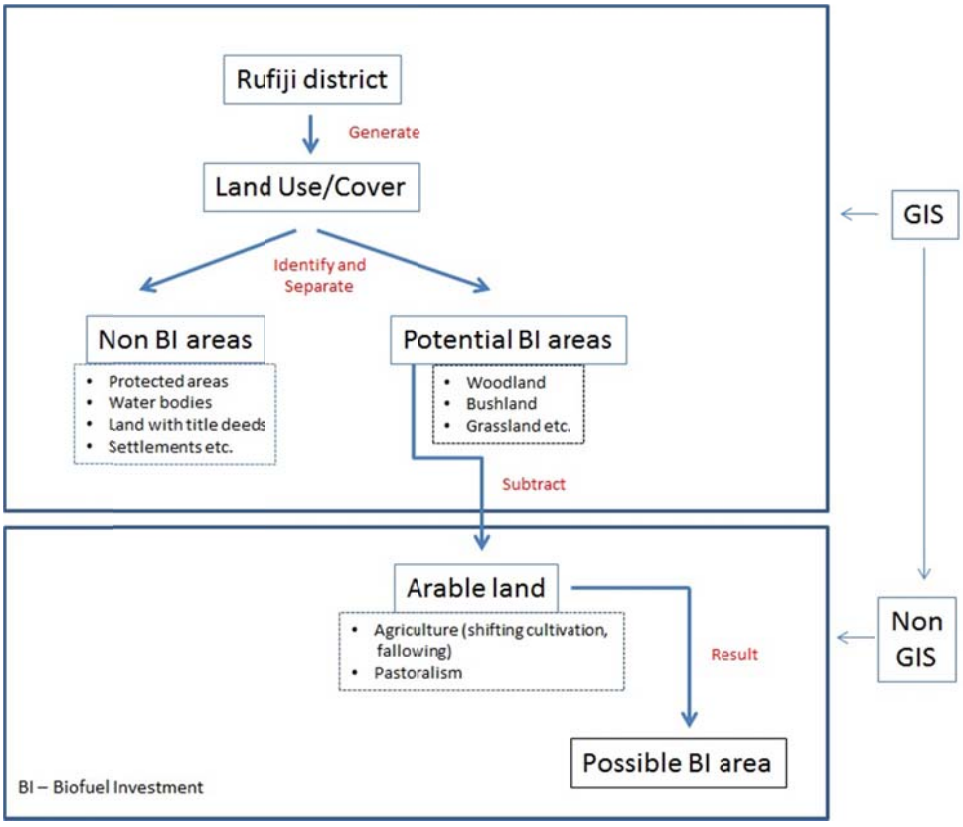

Figure 2. Flowchart of GIS manipulation.

Table 1. Distribution of land use/cover types in Rufiji District.

Land use/cover	Total area		Protected areas		Non-protected areas	
	Area (x 100 km^2)	%	Area (x 100 km^2)	%	Area (x 100 km^2)	%
Mangroves	4.8	3.7	4.8	3.7		
Natural/Riverine Forest	2.4	1.9	0.9	0.7	1.6	1.2
Forest Plantation	0.0	0..			0.0	0
Woodland	54.5	41.9	23.7	18.3	30.7	23.7
Bush land	7.4	5.7	1.2	0.9	6.2	4.8
Scattered Cultivation	8.7	6.7	3.0	2.3	5.7	4.4
Wooded Grassland	21.6	16.6	15.1	11.6	6.4	4.9
Flood Plain	19.5	15	1.1	0.8	18.4	14.2
Mixed Cropping	6.2	4.8	0.3	0.2	5.9	4.6
Bare Soil/Sand Dunes	0.8	0.6	0.2	0.1	0.6	0.5
Permanent Swamp	2.3	1.7	1.4	1.1	0.8	0.6
Lakes/Major River	1.8	1.4	0.5	0.4	1.3	1
Settlements/Urban Areas	0.1	0			0.1	0
	130.0	100	52.2	40.1	77.7	59.9

Source: University of Dar es Salaam - Land Use / Cover based on Landsat TM of 1994/95.

Table 2. Comparison of biofuel investment scenarios.

Scenario 1		Scenario 2	
District total area (x 1,000 km^2)	13.0	District Total Area (x 1.000 km^2)	13.0
Protected areas	5.2	Protected areas	5.2
Arable land	4.8	Arable land under crop production	0.9
SEKAB/Eco energy investment request	2.5	SEKAB/Eco Energy Investment request	2.5
	12.6		8.6
Balance after SEKAB/Eco Energy investment	0.4	Balance after Eco-Energy investment	4.4

areas and presently cultivated land will not be considered for biofuel investment, while the second scenario assumes that only arable land under crop production will be considered for biofuel investment. The most conservative figure among the many figures is quoted by different authors for biofuel investment in Rufiji District, as suggested by SEKAB/Eco Energy, 2500 km^2. In the first scenario, only some 450 km^2 will remain for other land needs. In the second scenario, if the wishes of SEKAB/Eco Energy were to be granted, some 4400 km^2 would be available. However, there are other important issues to consider. First, the area under forest reserves is a very conservative estimate by any means. Only central government forest reserves have been considered, while some of the reserves, owned by district and village councils, whose figures are in some cases not available (Table 2), were neglected. Second, although only 900 km^2 of 4824 km^2 is estimated to be under crop production according to the Coast Region Social-economic profile (URT,2007), the area used for agriculture may be considerably higher, as the estimation of areas of arable land under crop production is very difficult in places where shifting cultivation and land fallowing is the norm. Third, only one potential investor (SEKAB/Eco Energy) has been considered, leaving out others like AGO. And finally, land availability has been gauged against the most conservative figure among those quoted for SEKAB/Eco Energy.

Africa Green Oil's proposed investment

The proposed investment proposal of Africa Green Oil (AGO) sheds some light on the flawed perception of biofuel investors about vast lands being available for biofuel investment. The initial request was 30,000 ha in six villages - Mangwi, Nyamatanga, Nyanjati, Ruaruke A, Ruaruke B and Rungungu (Figure 3). The total area of the six villages obtained from a scanned map of village survey in the north eastern part of Rufiji district by the Regional Secretariat Surveyor is 35,003 ha. This means that AGO was requesting 85.7% of land in those six villages. This suggests that AGO had only vague ideas about the total area of the six villages before making the claim for30,000 ha. Some preliminary investigation of land use

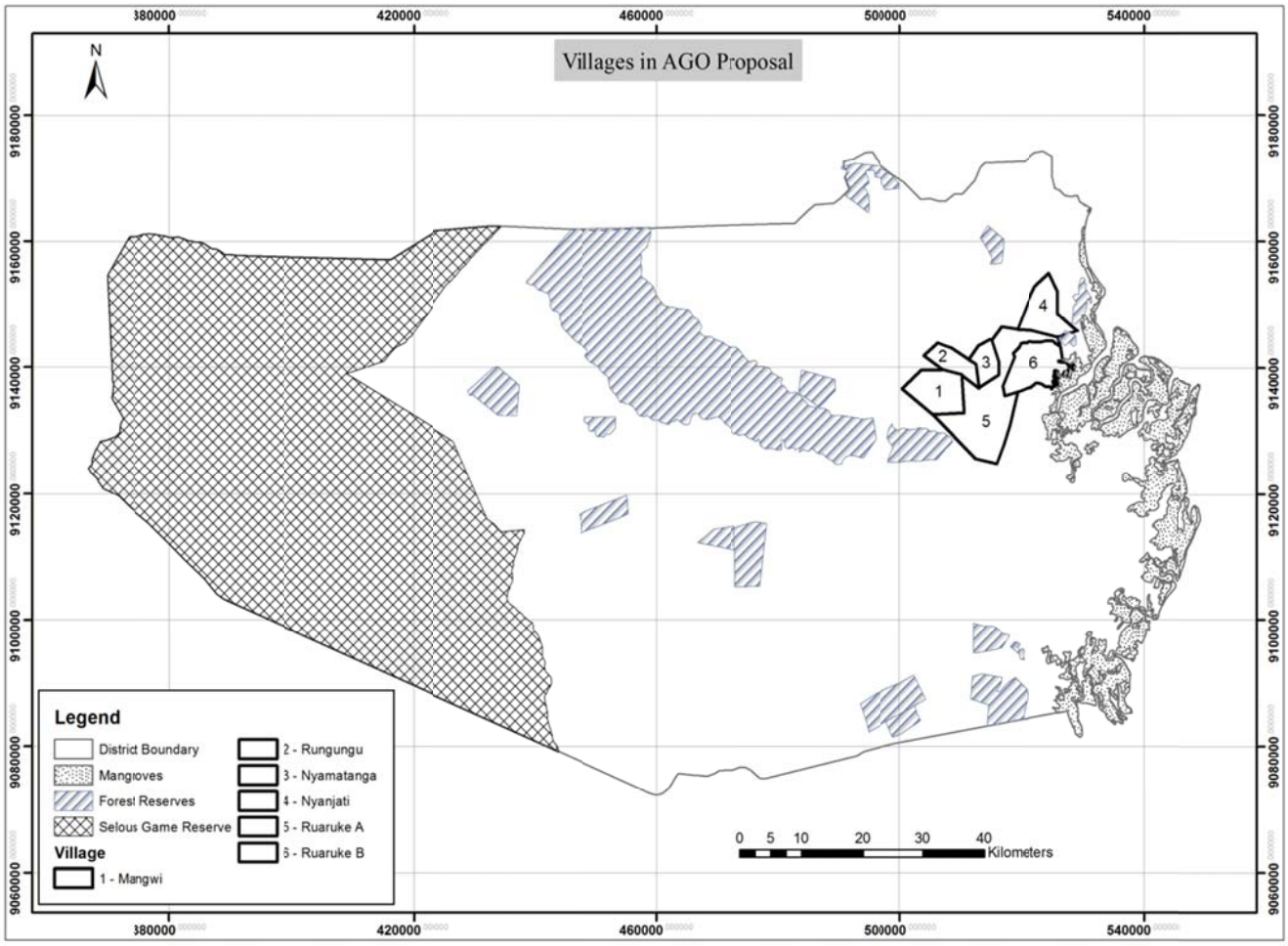

Figure 3. Rufiji district- Location of villages proposed for investment by AGO. Source: Regional Secretariat Surveyor – Coast Region. Registered Plan No. 45274 (30/01/2007).

and availability in the six villages, could have prompted AGO to further investigate the possibility of biofuel investment before committing resources and then realizing the futility of their expectations. The procedure outlined in Figure 2, with the necessary modification could constitute a starting point for accessing land availability for biofuel investment at the local level.

Possible consequences of biofuel investment in Rufiji District

Expansion of agricultural areas for biofuel production should not deprive the local communities of their land (Haugen, 2010). In Rufiji district, livelihoods are often complemented with the use of natural resources obtained from rivers, lakes and forests (UNDP, 2012). Land acquisition by biofuel investors like AGO has resulted in the local population losing income generated from the selling of products they were collecting from land (Daley and Scott, 2011). After losing their land, the displaced communities will be compelled to seek alternative areas for settlements, farming and grazing (Madoffe et al., 2009). Seeking alternative areas after being displaced can be best illustrated by the Ujamaa villagization program that was implemented in Tanzania in the 1970s. It was aimed at settling people in designated villages, but some of the people refused to be settled in assigned villages and eventually settled in the inner delta (Figure 1), a transi-tion zone between the mangroves and the floodplain, where they cleared mangroves to establish new farms to support their livelihoods (Ochieng, 2000). After all, seeking refuge in the forests, including the mangroves of Rufiji Delta, in times of crisis is not a new phenomenon in Rufiji district. During the Maji Maji rebellion against the colonial German government, the Rufiji villagers made use of the forests as safe havens for the duration of the war. After the war, they continued to live in the forests and river islands of the delta to avoid forced labor, colonial government levy and controls imposed on their use of natural resources (Sunseri, 2003). Displacing people by biofuel investments could possibly result in the same situation exacerbating mangrove degradation.

Conclusion

This study has demonstrated the possibility of assessing land availability for potential biofuel investment at the local level. However, the assessment must take into consideration the relevant biofuel investment policies. The case of Rufiji district has revealed that the existence of huge amounts of unused land or under-utilized is an incorrect perception. This suggests that biofuel investment in Rufiji district is only possible if the land currently used (or fallowed) by the people for their livelihoods is assumed to be unused. The unused land may be physically unoccupied but used for shifting cultivation or extraction of natural resources like harvesting of forest and non-forest products. Taking such land by whatever means will amount to land grabbing with the implied consequences for the livelihoods of people who have been using, are still using and will be using the land for their livelihoods. The procedure applied to assess land availability for biofuel investments in Rufiji district could be used with the necessary adjustment or modifications in other areas at the local level.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Appendix 1. Protected areas in Rufiji District as generated from GIS.

Protected area	Name	Area (x 100 km^2)	Total (x 100 km^2)
Game Reserve	Selous	35.5	35.5
Forest Reserves	Marenda	0.0	
	Mtita	0.3	
	Kingoma	0.1	
	Ruhoi	7.9	
	Mchungu	0.1	
	Kikale	0.0	
	Mtanza	0.4	
	Ngulakula	0.2	
	Kipo	0.1	
	Nyumburuni	0.5	
	Iyondo	0.2	
	Katundu	0.5	
	Utete	0.1	
	Mohoro	0.2	
	Mohoro River	0.0	
	Tambulu	0.5	
	Namakutwa	0.5	
	Nyamyete	0.1	12.0
Mangroves	Rufiji Delta	4.8	4.8
			52.3

Appendix 2. Forest Reserves from Rufiji District Council.

Forest reserve	Authority	Reference	Year established	Size (x 100 km^2)
Nyamakutwa-Namuete FR	Central Government	Jb.2320	1930	0.4
Muhoro FR	Central Government	Jb.615	1930	0.2
Muhoro River	Central Government	Jb.602	1930	0.0
Ngumburuni FR	Central Government		1930	0.3
Kingoma FR	Central Government		1930	
Mtita FR	Central Government	Jb.1026/RE/R/7/1	1930	0.3
Mangroves	Central Government	Jb. 634	1930	6.8
Utete FR	Central Government	Jb.625	1930	0.1
Utete warm spring FR	Central Government		1930	0.1
Tamburu FR	Central Government	Jb. 1620	1930	0.6
Kipo FR	Central Government	Jb. 1084	1930	0.2
Kikale FR	Central Government	Jb 1983	1930	0.1
Mpanga FR	Central Government	Jb.1959b	1930	0.5
Mtanza FR	Central Government	Jb.	1930	0.5
Rupiage FER	Central Government		1930	0.4
Katundu FR	Central Government	Jb 1086	1930	0.6
Mbumi FR	Central Government		1930	0.1
Mchungu FR	Central Government	Jb.1082	1930	0.1
Ngulakula FR	Central Government		1930	0.2
Nandundu FR	Central Government	Jb.RE/R/2/1	1930	0.0
Marenda FR	Central Government		1930	0.0
Kiwengoma FR	Central Government	Jb. 2310	1930	0.4
Kirengoma FR	Central Government	Jb. RE/R/6/1	1930	0.0
Kumbi FR	Central Government	Jb. E/R/2/1	1930	0.0

Appendix 2. Contd

Nerumba FR	Central Government	Jb.E/R/2/1	1930	0.0
Ruhoi LAFR	Rufiji district Council	Jb.508	1965	6.9
Kichi LAFR	Rufiji district Council		2000	1.5
Mtanzamsona VLFR	Village Council		2009	0.9
Tawi VLFR	Village Council	Jb.2351	2007	0.3
Nyamwage VLFR	Village Council	Jb.1200	2007	0.1
Nambunju VLFR	Village Council	Jb.2353	1998	0.2
Mbwara VLFR	Village Council	Jb.2354	2007	0.2
Mkoko VLFR	Village Council		2011	0.1
Utunge VLFR	Village Council		2010	0.4
Yelya VLFR	Village Council	Jb.1300	2007	0.1
Nzenge VLFR (prop)	Village Council		2011	0.1
Nyamitandai VLFR (prop)	Village Council		2011	0.2
Mbingo VLFR (prop)	Village Council		2009	
Urembo VLFR (prop)	Village Council		2009	
Jogoobahari VLFR (prop)	Village Council		2009	
Mkupuka VLFR (prop)	Village Council		2011	
Muyuyu VLFR (prop)	Village Council		2011	
Mangwi VLFR (prop)	Village Council		2011	
Ruaruke VLFR (prop)	Village Council		2009	
Minganje VLFR (prop)	Village Council		2009	
Nyambawala VLFR (prop)	Village Council		2009	
Mtunda VLFR (prop)	Village Council		2009	
Nyambawala B VLFR (prop)	Village Council		2009	
				22.8

*Source: Tarimo, Gaudence (District Forest Officer) and Mongo, Kennedy (District Fisheries Officer). Rufiji District Council (2011).