The Role of Plantation Forestry in Addressing Climate Change Adaptation and Mitigation Issues In Tanzania

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Abstract

Forest plantations play duo role of climate change adaptation and mitigation measures. Tanzania's forest plantation area covers more than 250,000 ha and it is estimated that, forest plantations in Tanzania hold about 8.8 million tons of carbon, and 15.9 tons Carbon/ha which corresponds to Co_2e *58.2tons/ha. Climatic change incidences have repeatedly altered ecosystem balance and function in unpredictable ways. Cited examples, some with cost implications; include: Cypress aphid infestations in Cupressus lusitanica and other genera in the Cupressaceae family in the late 1980s. Recent insect pest outbreak in a 500 ha Pinus patula stand at Itimbo West, Sao Hill. In the 2000s, P. patula needle browning has been observed at Shume and Meru Plantations, while in Rungwe District the species is progressively becoming invasive and growing well at higher altitudes in the Mount Rungwe crater. Late flushing and flowering has been observed in teak plantations in Longuza, and in Eucalypts stands at Malya. Weed growth rate in plantations seems to be intensifying. It is expected that these stressors will most likely intensify as the climate changes. It is proposed that management for adaptation has to focus on maintaining/restoring forest health, and has to seek overlap areas with management for mitigation, and both need uphold cognizance of the concept of sustainable forest management (SFM) as their core objective. Current plantation forest management practices do not seem to augur well with the concept. Suggestions for securing improvements are provided.*

Introduction

Forest Plantations are those forest stands established by planting or /and seedling in the process of afforestation or reforestation, involving introduced or indigenous species that meet a minimum requirement of 0.5 hectares and contains trees higher than five metres with a canopy cover of more than 10 per cent (FAO, 2004). Viewed in the context of developments before and after the National Forest Policy 1998 (Ahlbäck 1988; Ngaga 2011), and the Forest Act [Cap. 323 R.E 2002]; many more than half hectare areas have been planted with trees. This has obviously entailed species selection, site preparation, use of various types of planting stock in an array of planting patterns, and sizeable number have management goals; and therefore qualify recognition as forest plantations. Major direct end products for plantation forests are wood and fibre for both industrial and domestic use to supplement supply from natural forests. Other products and services provided by plantation forests include non-wood forest products, improvement of water catchment areas, waste assimilation, carbon sequestration, protection against soil erosion and non use biodiversity values. In other parts of the world, terms such as "human made forests" or "artificial forests" are used as synonyms to capture rubber (*Hevea brasiliensis*), mangroves and bamboo plantations due to their increase provision of fibre to wood industries. Altogether, Tanzania's forest plantation area covers more than 250,000 ha. Public plantations cover 90,000 ha, while privately owned plantations cover some 60,000. More than half hectare forests belonging to out growers and woodlot owners occupy between 80,000 – 140,000 ha in total (Ngaga 2011, Chamshama and Nshubemuki 2011). The aggregate contribution of these more than half hectare forests to the mitigation of climate change, deserves consideration because they are widespread. However, management goals, and stand treatment approaches vary greatly. A study specifically restricted to this group of plantations seems imperative. Nevertheless, some climate change lessons learnt from industrial plantation practices which is the focus of this paper, may be beneficial. Distribution of public plantation forest in Tanzania is as presented in fig. 1.

This paper has its focus on the operational questions namely: What are climate change challenges which plantation forestry in Tanzania, has lately been facing? What are the implications of those challenges? In view of these challenges, will the practice given present management protocol; retain its contribution to the process of climate change adaptation and mitigation?

Methodology

This paper is based on the field observations, consultations from public plantation managers on climate related management challenges and literature review on the industrial plantations in Tanzania.

Study sites

Information contained are extracted from the public plantations of Sao Hills, Ukaguru, Shume, West Kilimanjaro, Rondo, Longuza, and Buhindi covering different ecological zones of Tanzania as presented in Fig.1.

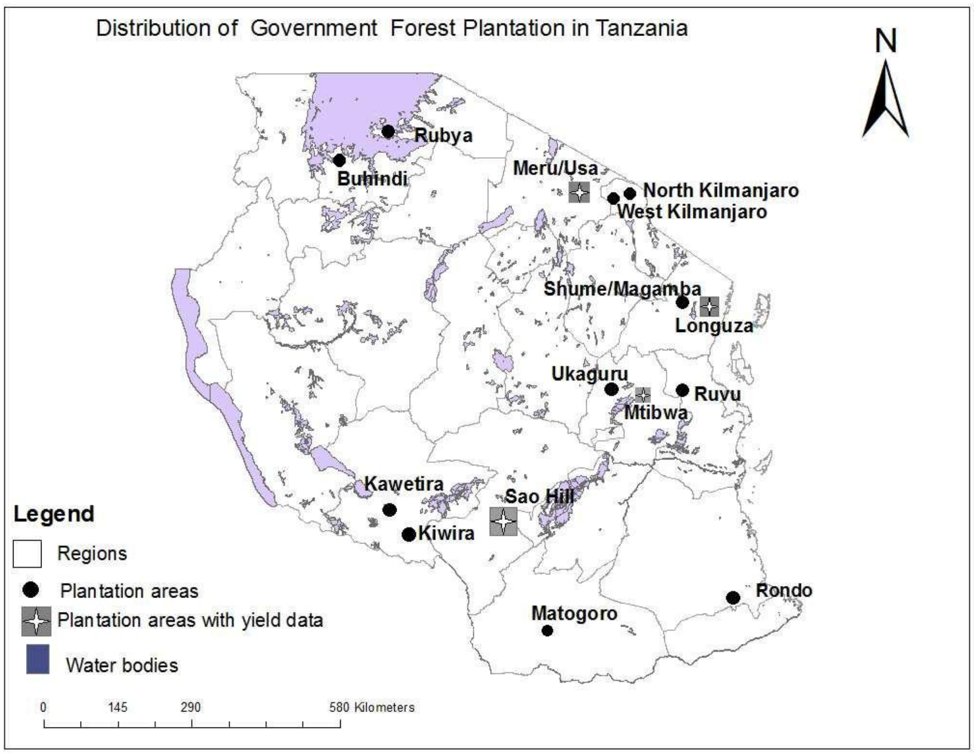

Figure 1. Distribution of government forest plantations in Tanzania(Source: Ngaga, 2011)

Data analysis

Data on plantation forest species composition, potential carbon assimilation potential, incidences of fire and diseases, were analysed using excel package. Other information was synthesised to bring up a bigger picture.

Results and Discussion

Public forest plantation extent and growing conditions

The extent and tree species grown in the public plantations are as indicated in Table 1 in which altitude, mean annual rainfall and soils are also shown. These attributes have major impact on the tree-species site matching. Age class distribution of trees grown, about 50% constitutes of trees below 10 years (Ngaga, 2011).

Table 1: Public plantation extent, tree species and growing conditions

SN	Name	Plantation area (ha)		Altitude	Mean annual rainfall	Soil	Tree species
		Total	Planted				
	Public Sector						
1	Sao Hill	135,000	45,000	1 400-2 000	750-2 010	Moderately acidic, drained & of various types	*Cupressus lusitanica Pinus sp. Eucalyptus spp*
2	Ruvu	*67,000	8,355				
3	Buhindi	11,000	3,420	1 150	1 300	Varies, sandy loam, loamy sandy & clay loam	Pines *Cedrella odorata*
4	Meru	6,900	6,600	1 500-2 500	844-1 040	Deep, dark brown or black and well drained with pH 5.5-6.5	Pines Cypress *Grevillea/Olea Acacia melanoxylon Cassuarina spp Eucalyptus spp* Others; Senna, Cedrella, Acacia
5	Rongai	6,254	6,054				
6	West Kilimanjaro	6,019	4,500	1 562-3 125	700	Volcanic, porous and free draining	*Pinus patula Cupressus lusitanica Grevillea robusta Eucalyptus saglina* Other spp
7	Matogoro/Wino	5,550	352	1 372-1 520	150	Clay silt soils, brownish red or yellow soils.	*Pinus patula Grevillea robusta* Other species Indigenous spp Natural forests
8	Shume	4,360	4,250	1 967 and 1 970	700	Mainly loams varying in colour from red through gray brown to black with pH 3.0 to 3.5	Pines and Cypress spp *Eucalyptus spp Juniperus procera Acacia melanoxylon Grevillea robusta Other species Cinamom camphora Acacia mearnsii* Seed stands (TTSA) Trial plots under TAFORI Natural forests

9	Kawetire	3,245	2,080	2 235	1 099	black loam soils rich in clay particles	*Pinus patula Eucalyptus maidenii*
10	Mtibwa	3,115	1,640	640	1 200	Alluvial and fertile. pH 5-8	*Tectona grandis Cedrella odorata*
11	Kiwira	2,784	2,739	2 225-2 440	1 707	Thin fine dark volcanic ash with silt and organic matter	*Pinus patula C. lusitanica & P. patula* & others
12	Rondo	2,550	1,100	870-885	1 100	Deep leached highly, porous sand soils	Pines and Cypress spp. *Tectonal grandis Milicia excelsa* Other hardwoods *Pinus caribaea* and others *Tectona grandis* and few others
13	Rubare	2,450	520	1 300	2 100-2 750	Chemically poor and have low pH	*Pinus caribaea*
14	Longuza	2,200	1,750	160 and 560	1 500	Mainly loam soils	*Tectonal grandis Terminalia spp Eucalyptus spp Chrolophora regia C. odorata, C. tona & T. grandis* Natural forests
15	Ukaguru	1,701	760	1 500	1 300	Mostly deeply weathered with a lot of mica	*Pinis patula/elliottii Cupressus lusitanica*
16	Rubya	1,926	1,623	1128	1 614	Generally fertile-deep loams	Pines Mixed pines and cedrela odorata
	Sub – total	**262,054**	**90743**				

(Source: Bakengesa et al, 2011, Ngaga, 2011, Plantation manager reports)

Forests and climate change adaptation

General

The potential effects of climate change on forest ecosystems are complex and not readily understood. At the level of organisms and species, changes in temperature, rainfall, wind, and humidity are likely to affect many processes, including growth, reproduction, pollination, seed dispersal, phenology, pest and disease resistance and competitive ability. In adapting to the existing change, ways to counter effects through Research and development on growth, reproduction, pollination, seed availability, pest and disease are eminent. These are through introduction of other ways for seedling production eg. Introduction of clonal technology, tissue culture, grafting, national tree planting campaigns, species diversification (technical note 3). Climate change effects on species are likely to alter ecosystem balance and composition in unpredictable ways. For example, climate change may both disrupt and improve plant defences against pests and pathogens. Interactions among pests, pathogens and fire may cause either negative feedback loops or destabilizing positive feedback loops. Fires for example, can lead to the outbreak of pests and pathogens, and pathogens can increase the probability and severity of fires; in other instances, fires can reduce pest outbreak and fire suppression may increase epidemic infestations. Habitat fragmentation and exploitation related disturbance also create opportunities for invasive species and the likelihood of reducing species migration in contiguous areas (Seppälä *et al*.2009; Broadhead *et al.* 2009)

Specific instances: an overview A review of management practices shows that most public sector forest plantations are characterised by replanting backlogs, low intensity site preparation techniques, poor quality trees due to use of un-improved seed and low survival due to poor species-site matching and delayed or low intensity weeding. It is also noted that they are generally neglected or have irregular pruning and thinning. (Chamshama and Nshubemuki, 2011).

The quality and productivity of forest plantations will be enhanced by using improved germplasm, site and species/provenance matching, high quality planting stock, appropriate silviculture (site preparation, establishment, weeding, fertilization, pruning, thinning and protection). Further, site productivity must be maintained by adapting appropriate soil and site management practices namely nutrient retention (e.g. by leaving foliar mass on site, retaining post-harvest slash rather than burning it) and use of planned low impact logging techniques by The Tanzania Forest Service Agency.

As we are assessing the impact of climate change on tree planting, it is important to note that vulnerable species will be those species with limited geographical range meaning that they are less tolerant to drought, limited seed dispersal, low germination rates as well as seedlings survival rates. Other factor to consider relates to the soil properties. Noted in plantation forests in Tanzania is the decrease in productivity which is influenced by management practices in establishment, tending and harvesting.(Maliondo and Lupala, 2011). Based on the research recommendations by the former Lushoto silvicultural department and later TAFORI, several tree species were tested and adapted to the sites and can be planted in both public and private forests as indicated in Table 2.

Table 2: Tree species for planting in public sector forest plantations

Zone & Major Species	**Alternative Exotic**	**Species Indigenous**	**Climatic factor**
Lake Victoria *P. caribaea*	*Pinus patula Pinus patula var tecunumanii P. kesiya E. camaldulensis E. citriodora (Corymbia citriodora) E. saligna, C. odorata A. fraxinifolius M. azedarach, G. robusta Albizia lebbeck Azadirachta indica, E. alba, E. crebra, E. cloeziana E. melonophlora E.microtheca*	*Antiaris toxicaria Maesopsis eminii Markhamia platycalyx Syn. M. lutea Milicia excelsa Hallea rubrostipulata Trichilia emetica Podocarpus usambarensis Khaya nyasica* Faidherbia albida Acacia nilotica A. polyacantha Miombo species (see Inland plateau)	Suitable for areas receiving more than 1600 mm mean annual rainfall Suitable for areas receiving less than 700 mm mean annual rainfall
Inland Plateau (None)	As for the lake Victoria zone receiving less than 700 mm mean annual rainfall C. equisetifolia *T. grandis* (dry area prov)	*Afzelia quanzensis Dalbergia melanoxylon Julbernadia globiflora Pterocarpus angolensis Vitex keniensis*	Miombo covers 40% of the country. Thus future forestry development depends on this area
Highland Areas *P. patula C. lusitanica E. grandis*	*Casuarina junghuniana Pinus elliottii P. kesiya P. taeda C. odorata C. japonica*	*Beilschmedia kweo Cordia africana Cephalosphaera usambarensis Fagaropsis angolensis* Newtonia buchananii	

E. regnans E. saligna	*C. camphora Grevillea robusta P. radiata* (resistant strains) *E. botryoides E. citriodora E. globulus E. maculata E. maidenii E. microcorys E. paniculata*	Olea capensis P.usambarensis Vitex keniensis *Ocotea usambarensis Olea capensis Juniperus procera Podocarpus usambarensis Acacia sieberiana var. sieberiana, A. seyal Vitex keniensis*	
Eastern Arc Mt. foothills *T. grandis*	*Cedrella odorata Gmelina arborea Grevillea robusta Terminalia superba T. ivorensis C. japonica*	B*rachylaena huillensis Entandrophragma stolzii Khaya nyasica Milicia excelsa Steculia spp Trichilia emetica Sterculia apendiculata Pterocarpus angolensis Dalbergia melanoxylon*	
Coast *Pinus caribaea P. elliottii P. patula ssp tecunumanii*	*Dalbergia sissoo Eucalyptus camaldulensis E. tereticornis C. equisetifolia*	*Dalbergia melanoxylon Rhizophora spp Pterocarpus angolensis Sterculia apendiculata*	Other mangrove species also suitable

Source: FBD (2003)

The late 1980s were characterised by harsh weather conditions notably in Mbeya, and Ruvuma Region districts bordering Malawi. This seems to have paved way for the infestation of *Cupressus lusitanica* plantations and woodlots by the accidentally introduced, *Cinara cupressivora* (Cypress aphid) from Malawi. Infestation firstly occurred in the two regions and later spread to other regions in Tanzania. The fiscal loss sustained at plantation level (Bakengesa *et al.* 2011) has been estimated to be USD 0.103 (TAs. 1.5 billion 1986 prices) Inclusion of other genera in the Cupressaceae family such as *Callitris*, *Juniperus*, *Thuja*, and *Widdringtonia*, also widely used for various purposes, hints on the overall magnitude of the losses experienced. Similar harsh weather conditions in year 2010 are suspiciously believed to have contributed to an insect pest outbreak in 500ha at Itimbo West in Sao Hill Forest Plantation. At stake were some 98,411m^3 of *Pinus patula* and control measures accounted for USD 73,316 (TAs. 95.31 million). *Pinus patula* is the most widely plantation species accounting for 60 per cent and 78 per cent of the total plantation, and planted conifer areas respectively (Nshubemuki *et al.* 1996).

Cases of needle browning of *P.patula* were noted in 1999 in 7ha at Meru, and have also been noted in about 11ha at Shume, and Meru Plantations in 2002. *Pinus patula* seedlings planted at Rongai Forest Plantation in TAFORI trial plots due to changes in rainfall pattern. Die back of trees in Meru and Ukaguru Plantation forests. The problem seems to be persisting. Worth noting, is the fact that Patula pine had since large scale planting in late 1950s been known to be less susceptible to pests and diseases. A closer look at rainfall variation in planting sites and what has recently been noted, seems to offer insights. Data for Mean annual rainfall (mm) ranges (Nshubemuki *et al.* 1978) show: 900 – 1900 (Sao Hill), 900 -1200 (Shume), and 800 – 1920 (Meru) . Such variation is likely to support successful growth of *P. patula* when exceptionally dry years are infrequent. The minimum rainfall requirement for successful establishment of this pine is 1000 mm. Incidentally, this seems to explain antecedent Patula pine drying problems experienced at West Kilimanjaro Plantations whose mean annual rainfall range is 750 – 900 mm.

Examination of the rainfall pattern in West Kilimanjaro Forest Plantation (WKFP) for the last fifteen years (1999-2013) shows that the plantation gets rain season in January - May and October/November -December with dry season in June – September (Table 3). However, in 2013 like 2001 has shown to have an extended dry season from June to October. This extended dry period probably caused eucalypt trees to experience water stress in the soil hence drying. Literatures reports that *E. grandis* and *E. saligna* grows well in areas with the mean annual raifall of 725 -3500 and 700 -2300 mm respectivelly but the mean annua raifall recorded for 15 years in WKFP (Table 3) ranges from 332.9 – 894.5 mm. There is a very big difference in most of years between the required and recorded rainfall which implies that dying of these two eucalyptus species have been caused by inefficient rain.

Table 3: Fifteen year's monthly rainfall (mm) (1999-2013) in West Kilimanjaro Forest Plantation.

Years	Jan	Feb	March	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total annual rainfall
1999	46.5	19.3	170	168.9	39.9	0	0	8.3	0	23.7	223.5	91.9	**792.0**
2000	2.9	0	101.8	95	30.7	2.8	0	0	0	6.7	61.2	113.1	**414.2**
2001	115.7	56.2	113.1	106.2	14.6	7	0	0	0	0	121.8	73.1	**607.7**
2002	72.6	19.6	121	124.1	13.4	0	0	13	8.9	49	127.4	163.7	**712.7**
2003	51.4	42.9	73	99.2	74.3	13	0	0	0	32.4	77.8	45.7	**509.7**
2004	54.3	58.3	115	181.4	0	0	0	0	0	78.1	95.4	126.1	**708.6**
2005	83.3	15.7	120.8	89.6	65.9	0	0	0	0	53.4	55.6	66.8	**551.1**
2006	61.5	85.4	132.2	152.9	65.8	0	0	0	0	114	175.3	107	**894.5**
2007	0	64.4	56	47.9	34.8	0	0	0	44.6	60.5	101	58.8	**468.0**
2008	52.4	36.8	50.9	98.9	98.7	9.2	0	0	0	17.3	19.3	52.4	**435.9**
2009	22.2	0	0	54	45.4	0	0	0	0	23.3	149.7	38.3	**332.9**
2010	16.7	104	146.1	154.5	0	0	0	0	0	108	111.6	63.3	**704.3**
2011	42.2	72.2	64	110.5	20.9	0	0	0	4	132	115.7	63.8	**625.3**
2012	6	106	9.7	74.3	70	0	0	2.2	29.4	160	110.5	199.8	**768.1**
2013	42.2	3.2	156	118.7	58.2	0	0	0	0	0	89.7		

This seems to suggest that a number of tend to be more vulnerable to the vagaries forest plantations in Tanzania established of climate change while those established on marginal sites (for some tree species) on relatively favourable sites are dragged by the changes to such vagaries. Vulnerability indices will, as expected, differ

In high potential areas such as Rungwe District, decreases in annual rainfall have extended the growing zone of *P.patula* and now seems to be invasive and grows very well at the Mount Rungwe Crater. Similarly, *Eucalyptus pellita* seems to be increasingly invasive in Uchindile Hills in Mufindi District. Late flowering, and flushing has been observed notably in *Tectona grandis* plantations in Longuza as compared to Mtibwa with similar species, this is due to rainfall and temperature pattern. Late flowering is also noted to some n Eucalypts plantations in semi-arid areas such as Malya especially for E. citriodora. Almost invariably, weed growth in forest plantations has intensified implying increased establishment, and tending costs, Rondo forest plantion can cited as an example. It is expected that stressors will most likely intensify as the climate changes.

Implications

Stated in plain language, climate change is an alteration of water availability scenario to components of the ecosystem – disrupting the core of ecosystem health. In managing forest plantations, this implies a revisit of current management regimes to the extent of even subjecting the sacrosanct (Chamshama and Nshubemuki 2011), best management practices to climate change's mitigation and adaptation peer review. This might culminate into examining species/provenance selection and possibly testing, plantation establishment, tending, including policy, legislation and utilisation adjustments in current practices. Yet this may not serve as a suitable response to water considerations pointed above let alone the time needed. In forest plantations, the major water users are trees. Inspired by the work done in dry areas in Australia, Philips (1977), urges relating the number of suitable tree species in a given area(spacing in m) of the selected site to rainfall (in mm) given the worst/near worst scenario:

Spacing (m) = 2450 ÷ Mean annual rainfall (mm)

Applied to the various ecological zones of Tanzania, emerging spacing regimes vary between 2.0 x 2.0 and 6.0 x 6.0 metres. This range covers what has been approved by FBD (2003) for an array of end products. However, this management for adaptation approach seems to be at variance with management for mitigation. Increased spacing implies fewer trees and reduced carbon sequestration. This brings us face to face with a dilemmatic question. How does management for adaptation differ in practical terms from management for mitigation? Are demarcation lines clear or are there areas of overlap between these approaches? Are existing national management specifications flexible such that changes evoked by climatic change can be accommodated? It is prudent to cognize that even when forest management is directed to the concept of sustainable forest management (SFM), there has always been a number of constraints. It follows therefore that in outlining the challenges to be faced it is useful to look at plantation forestry management in Tanzania from the perspectives of climatic change adaptation, and mitigation as additional considerations in ongoing sustainable forest management practices. Most fundamental, is to assist plantation forests to maintain forest health and resilience. A wealth of experience exists in forest monitoring. This need be intensified particularly in extensive forest plantations such as Sao Hill. Furthermore, experiences gained in effective fire management, and forest rehabilitation after disturbances such as fire and wind throw need be shared and tailored to suit local conditions. The number of habitats such as wetlands within plantations, need be recognized as areas where specific management prescriptions are needed, and so on.

Forests and climatic change mitigation

Forests are reservoirs, sources and sinks of carbon, thus reducing greenhouse gas emissions. This is what makes plantation forests potential for climate change mitigation. Carbon is stored in above, and below ground vegetation components notably in trees; and in forest soils. Insightful estimations of carbon storage capacity in two miombo woodlands, a lowland, and montane forest in Tanzania, are given by Zahabu (2008). The amount stored is influenced by: climate, the level of management, variations in tree growth, soil type, species composition and age of the stands such that observed low end rate of biomass increment is typically 0.5 tons/ha/yr for managed forests. Biomass increments for other forests varied from 1.7 -5.2 tons/ha/year, corresponding sequestration rates varied from 3.2 -9.8 tCo_2/ha/yr. As expected, biomass increments in plantations under the same conditions are far higher in forest plantations than in miombo woodlands and the other forests mentioned above. It is estimated that forest plantations in Tanzania hold about 8.8 million tons of carbon, and 15.9 tons Carbon/ ha giving Co_2e 58.2tons/ha (Malimbwi, pers. com). However, factors influencing increment and storage are generally the same. Thus degradation of forests through logging, fire, pests, diseases, contributes to Co_2 emissions. When sustainably managed, forests supply products that have life-cycle emissions of GHGs considerably lower than alternatives such as fossil fuels, plastics, etc. In Tanzania, a National Framework for Reduced Emissions From Deforestation and Forest Degradation (REDD) has been launched (URT 2009). This followed a Bali roadmap which included the emission reduction from deforestation and forest degradation to including sustainable forest management of forests in REDD+. The relevance of REDD+ in Tanzania, stems from the fact that the country has abundance of land. It is also notably that the study by Ngaga (2011) indicated increasing demand on wood products is far below the supply. At country level a number of establishments and projects has been qualified as CDM projects(Makundi, 2011). And other projects are still under pilot studies.. Essentially, achieving climate change mitigation employing plantation forestry implies managing them in ways that fundamentally reduce carbon emissions. A number forest plantation related practices are currently in use, include:

- Maintaining or increasing land under plantation forestry as annually carried out by managers
- Management of wildfire,
- Increased use of wood products from known sources, and monitored movement by use of Transit Passes, etc.

For forest plantations to be a net source of carbon emissions, deforestation and or forest degradation must occur without corresponding afforestation, and other forest regrowth efforts. Noting that this is at variance with the concept of SFM, it seems unlikely that forest practices for climate change mitigation would be substantially distinct from SFM. Furthermore, the core objective of climatic change mitigation is to reduce emissions of GHGs. It seems evident that adaptation activities will differ from mitigation activities only where interventions do not reduce emissions; for example thinning, and increased spacing (Broadhead *et al*. 2009).

SUSTAINABLE FOREST MANAGEMENT AND CURRENT FOREST MANAGEMENT

The latest comprehensive study of SFM and current management of forest plantations in Tanzania has been undertaken by Ngaga (2011). Excerpts from the picture painted are as follows:

1. Age structure of the plantations is skewed towards the young age (27.4 per cent), and for older classes (28.1 per cent). This is partly explained by the period spent without meeting annual planting targets as required for normal forests.
2. Sao Hill is supplying over 85 per cent of raw materials consumed by forest industries. Given the structure and harvesting levels, it is predicted that after 2017, there will be a deficit for some 10 years. Only after 20 years from then the harvesting may come back to current levels.
3. Individual private plantations/woodlots are currently supplying an estimated 200,000 – 300,000 m^3 of round wood.
4. Supply forecast of round wood from plantations until 2030 is estimated at 2.2 million m^3. In 2010, public plantations

supplied over 70 per cent of raw material, whereas by 2020 only 40 per cent is to be supplied and private forests are expected to provide the balance.

5. Forecastsof demand for wood from plantations in the base scenario indicate that demand will outstrip supply by about 400,000 m^3. However, if the economy, population, and urbanisation grow at the same pace as now, demand for wood for plantations will exceed supply by about 2.2 million m^3 by 2030. This gives an annual planting deficit of about 7,000 – 8,000. When demand and supply factors from natural forests are taken into consideration, demand will surpass supply by about 39 m^3 by 2030.

Evidently, even when routine adjustments for coping with scarcity are taken into consideration in the absence of painstaking efforts, the contribution of forest plantations in combating climate change effects will be at stake. Because some of the seven thematic elements which are accepted as key components of SFM, have not been upheld. Furthermore, the premise for establishing plantations is to relieve utilisation pressure from indigenous forests. If plantations are not managed sustainably, the reason for their establishment is undermined! There is therefore a pressing need for changing this trend. It is proposed that since the area under public forest plantations is not increasing as fast as the area in private hands, the establishment of private/private public is encouraged. Furthermore, interventions in primary production, processing, and market chain are proposed as stimulators for modernisation. Major management interventions focus on: enforcement of existing guidelines and regulations regarding harvesting of forests, use of improved germplasm, regulation of growing stock and adjustment of allowable cut to reach sustainable levels while availing time for industries to adjust, and fire control.

Conclusion

Incidences of climatic change manifested by changes in long term rainfall patterns have been observed in Tanzania. These changes have, among other ecosystems, adversely affected parts of the country's 250,000 ha of forest plantations having Co_2e 58.2 tons/ha. Insect and or disease outbreaks, changes in phonological cycles, instant invasive characteristics by some species denote such changes. It has been pointed out that adaptation and mitigation efforts to combat these changes have elements of sustainable forest management (SFM). Recent investigations indicate that in the near future, it will be apparent that plantations are not sustainably managed. There is a pressing need for changing this likely development.

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