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COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

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COMPETE WP1 – Current Land Use Patterns & Impacts

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Understanding traditional and modern land use dynamics in the African context

Introduction

COMPETE has identified pathways for the provision of sustainable modern bioenergy in arid and semi-arid regions of sub-Saharan Africa. Different pathways correspond to different geographical localities and land uses, and hence are associated with different suites of policy tenets, bioenergy feedstocks, and practical 'on the ground' implementation and technical considerations.

In order to understand the motivation for the particular pathway identified, it is imperative that land use dynamics within these regions is understood. Gaining such an understanding is however seriously challenged by widely divergent discourses, principally between social and natural scientists, on (a) the drivers, nature and consequences of environmental change, (b) the sustainability of traditional land use practices, and (c) the motivation for and effects of, national and western policies and interventions.

The first section of this paper discusses the influence of these views on concepts such as 'sustainability', 'carrying capacity' and 'irreversibility', and consequently on how overcultivation, overgrazing, deforestation, bush encroachment, land degradation, desertification, etc., are perceived.

The second section examines the use and commercialisation of natural resources, and the management of fire and invasive alien species. These activities cross-cut most land use categories.

With the use of specific examples, the third section explores the threats to and opportunities for sustainable utilisation of modern bioenergy in the following three land use categories:- hunting and gathering, and pastoralism, traditional communal land use to small scale farmer, and large scale commercial agriculture.

The conclusion will highlight dynamics that are particularly pertinent to the successful integration of traditional land use and products into bioenergy policy, and modern bioenergy provision.

Discussion

1. Divergent Discourses

1.1 Drivers, nature and consequences of environmental change

'Plant succession' describes the development of plant communities over time in a series of stages towards a climax which is best adapted to the prevailing biophysiographic conditions. Each stage is dominated by an increased number of species, taller species, increased biomass, and increased representation of and interaction with, animals and other organisms. Excessive grazing and/or browsing, fires, droughts, elephant damage, etc. can arrest communities at a sub-climax stage. There is now general consensus that this gradual continuum or 'equilibrium' paradigm of vegetation change is only applicable to the humid and moist sub-humid regions in Africa. The spatial and temporal heterogeneity and dynamism of ecosystems in the Continent's dry sub-humid, semi-arid and arid regions are better explained by the 'disequilibrium' paradigm. Small scale spatial discontinuities and patchiness reflect local differences in soil nutrients, depth and water availability, and grazing pressure. The spottiness of rainfall events contributes to larger scale differences in biomass. Changes are abrupt and induced by specific events. This 'disequilibrium' behaviour means "that both 'up' in response to growth favouring conditions and 'down' in response to negative factors such as moisture shortages, fire, and heavy grazing, are the norm." (Thomas, 2002, p. 32).

In seeking to identify pathways for the provision of sustainable modern bioenergy in arid and semi-arid regions of sub- Saharan Africa, COMPETE firstly had to re-evaluate the popular interpretation of 'sustainability' as "consisting of continuous processes or conditions that can be maintained indefinitely without progressive diminution of valued qualities" (Holdren *et al*., 1995, p. 3). As Eriksen and Watson (2009) note, understanding the inherent discontinuities and dynamism of these regions recognises that their sustainability is *dependent on change and disturbances* that temporally diminish valued qualities. While some pathways and sections of others, are sufficiently generic as to be applicable anywhere in the African context, others specifically emanate from COMPETE's focus on sub-Sahara's arid and semi-arid regions and may have also been influenced by the eight countries selected for closer study. Therefore before implementing any COMPETE recommendation in a particular locality, it is important to check its applicability by examining biophysiographic data specific to the locality and ground verification thereof, and by carrying out participatory workshops with local stakeholders. The implications of the 'disequilibrium' paradigm on the potential of subsidies to enhance sustainable modern bioenergy in Africa's drylands, is explored further in section 3.3.

The implications of Africa's drylands 'disequilibrium' behaviour in terms of how best to manage them, is hotly contested. The established view predominately represented by natural scientists such as Biggs *et al.* (2004), Hoffmann (1999), Scholes and Biggs (2004), Tainton (1981), and Watson (2002), is that the 'carrying capacity' concept is not only relevant to the 'equilibrium' paradigm. Traditionally stock is accumulated during favourable growth periods, and moved to more favourable areas, or sold or eaten, during less favourable periods. Over the twentieth century most of the Continent's drylands have experienced an exponential decrease in wild ungulate populations and a corresponding increase in both human and

domestic livestock numbers. The latter trend is due primarily to improved access to ground water, healthcare and veterinary medicines. Proponents of the established view believe that (a) the land is excessively overstocked during both favourable and unfavourable growth periods, (b) the off-take of domestic stock during droughts is not adequate to allow for recovery when the rains resume, (c) overstocking and cultivation in marginal lands are the principal cause of accelerated soil degradation (crusting, compaction, salinisation, erosion), (d) bush encroachment reduces an area's carrying capacity and hence is a form of land degradation, (e) land clearance for cultivation and overharvesting of trees principally for use as fuelwood, are the principal drivers of deforestation.

The alternative view predominately represented by social scientists in books such as Behnke *el al.* (1993), Bassett and Crummey (2003), Blaikie (1985), Dahlberg (1995), Kinlund (1996), Leach and Mearns (1996), Mistry and Berardi (2006) and Sporton and Thomas (2002b), argues that (a) overstocking during favourable growth periods is economically rational behaviour in disequilibrium environments, (b) overstocking during unfavourable growth periods has been caused by the colonial legacy[1] that favoured sedentary versus mobile land use activities, (c) most pastoralists and subsistence communal land users do not own sufficient stock to sustain their livelihoods, (d) bush encroachment and deforestation are localized around settlements, cultivation and boreholes and do not represent an overall, general trend in vegetation change in these regions, (e) most reductions in biodiversity and biomass are transitory and reversible. Bush encroachment therefore, far from constituting 'degradation', is a stage in the recovery of the system, and (f) far from leading to natural regeneration, restricting the movement of pastoralists has decreased biodiversity.

The established view has predominately informed pre and post independent African environmental, conservation, forestry and agricultural policies. However, the alternative view has become increasingly popular over the last four decades. There are debates about whether Africa is experiencing a fuelwood crisis, widespread deforestation, land degradation and desertification, etc. and the drivers thereof. Promoting the potential benefits of rapid and extensive modern bioenergy production and use in Africa is already challenged by the media bias in the 'food versus fuel' debate. In motivating for the provision of sustainable modern bioenergy in arid and semi-arid regions of sub-Saharan Africa, policy makers should refrain from suggesting that such provision (a) should target marginal lands, wastelands or degraded lands, and/or (b) will ameliorate the environmental problems listed above, thus avoid entering these debates. Without fail, at all of COMPETE's stakeholder workshops, any suggestion that marginal or degraded land should preferentially be used for bioenergy feedstock production elicited negative emotive responses.

[1] In South Africa, this legacy includes that of the Apartheid regime (1948-1994)

1.2 Sustainability of traditional land use practices

Livelihoods comprise the capabilities, assets and activities required for a particular type of living. Assets include natural resources, social networks, skills and knowledge, and financial capital (cash, savings, credit/debit, etc.). Access to assets is determined by institutional arrangements and historically rooted, racial and ethnic systems of social relations. A sustainable livelihood "can cope with and recover from stresses and shocks and manage to enhance capabilities and assets both now and in the future, while not undermining the resource base" (Thomas and Sporton 2002, p.5).

During the 1930s and 1940s soil conservation programmes were implemented in a number of African countries. They were primarily a response to the 'Great Dustbowl' saga in the United States of America and an opportunity to generate employment during the depression. The programmes focused on implementing physical measures such as drainage channels, terraces, and contour bunds. Peasant farmers realised such measures reduced the area of land they had available to crop and hence actively resisted them by constructing them incorrectly and not maintaining them. Blaikie (1985), Showers and Malahleha (1992), Tiffen *et al.* (1994), Kinlund (1996) and others, reveal that this resistance was interpreted as the traditional land users being (a) generally ignorant of and disinterested in environmental processes, (b) being apathetic and lazy, and (c) unwilling to learn from others. This perception of traditional land users reinforced the perception that it was not only their increased population, but *their practices* that were destroying the environment. This perception influenced policies through until the late 1970s. Kinlund (1996) and Rahmato (2003) provide more recent evidence of its influence on land rehabilitation programmes, from Botswana and Ethiopia, respectively. However, most policies formulated (and their associated programmes) since the late 1970s have recognized that traditional land users (both farmers and pastoralists) (a) have a sound and substantial knowledge of their local environment, (b) employ a wide range of innovative practices to conserve and enhance soil quality, improve crop yields, and regenerate grazing and trees, and (c) have willingly adapted or adopted 'modern' practices once the benefits of doing so have been proven to them and provided they can afford to do so. 'Good' cultivation practices such as minimum tillage, planting in depressions, intercropping with nitrogen-fixers, etc., are so integrated and widespread that trying to determine whether they are indigenous or not, is of little practical merit.

Proponents of the alternative view believe that traditional land use practices are inherently sustainable and where this is now not the case, it is due to the legacy of colonial policies that forced traditional land users into marginal areas and discriminated against them marketing their produce. While the local environmental knowledge, adaptive attitude and many practices of traditional land users bode well for sustainability, other aspects of traditional land use dictated by entrenched systems of access to land being dependent on social hierarchy, suggest that it is not inherently sustainable particularly in regard to gender equity. The implications of the requirement that land be used in order to retain claim to it, and of denying women land usage and purchase rights, is explored further in section 3.2. Ironically, section 2.1 examines the overharvesting of fuelwood and medicinal plants attributed to the breakdown in traditional land management and tenure institutions. Policy makers aiming to encourage modern bioenergy crop production and use among traditional land users should

avoid becoming embroiled in debates about the sustainability of what they are currently doing. Section 3.1 motivates why modern bioenergy provision is not yet appropriate in areas predominately used by traditional hunter gatherers or pastoralists. Section 3.2 argues that it should rather focus on small scale farmers on communal and freehold lands. The participatory workshops with local stakeholders motivated for in section 1.1, specifically need to find out *why* people are using a particular range of land use practices i.e. is their use primarily driven by biophysiographic characteristics, or by social systems ?. Many non government organizations (NGOs) and private companies have already found that is quicker and easier to get access to land and labour in areas where the traditional social system is still strongly intact or state lands under direct government control. Sustainability issues arising from taking the shorter path to large scale production of biofuels feedstocks are explored further in section 3.3.

1.3 Motivation for and effects of policies and interventions

There are striking continuities in pre and post independent African environmental, conservation, forestry and agricultural policies motivated by dire predictions of the apocalyptic fate of the environment if contemporary land use practices continue unabated. Most attempts to implement these policies have been actively resisted and hence have failed to change the 'culprit' land use practices. Many have either exacerbated the environmental problems they were designed to remedy, or caused problems elsewhere. Examples from most African countries substantiating the general failure of policy interventions to date are found in Sporton and Thomas (2002a), Bassett and Crummey (2003), and many others. The established view attributes this failure to inadequate empirical data, not accessing and integrating local knowledge sufficiently, and use of an undemocratic 'top down' approach in both policy formulation and implementation. Proponents of this view respect that local knowledge and local participation are prerequisites to contemporary policy making.

Proponents of the alternative view argue that the continuation of environmental crisis narratives despite the non fruition of their dire predictions is evidence that policies to date are political instruments to gain control of local people and their resources. Despite independence movements in many African countries owing their support to rural resistance to colonial policies, independent African government officials became the urban-based elite and continued these policies in order to obtain taxes and resources from the rural populations. The continuation and formulation of some policies were imposed by international aid donors as conditions for receiving further aid (Bassett and Crummey, 2003). Many policy interventions e.g. drought relief, have enabled governments to hide the structural determinants of poverty and their service delivery failures (Solway, 2002). Sporton and Thomas (2002a) argue that in undermining traditional patronage relations and social capital, state intervention has created a dependency culture. Munro (2003, p.203) asserts that "Notwithstanding a rhetorical commitment to local participation, government agencies have not incorporated farmers' ideas into policy design, and have maintained a firm managerial and regulatory hold on resource management institutions".

The 1973 drought in the West African Sahel and subsequent images of the relentless advance of the Sahara led to the proliferation of western NGOs in many African countries. Bassett and Crummey (2003) argue that while NGOs were initially motivated by famine relief, economic development and environmental conservation, their continued control over local people secures their funding. The funding of the recent influx of grassroots actors is similarly secured. Recently there has been a rapid increase in negative and emotive media and web reports claiming that (a) high ranking African government officials have allocated hundreds of thousands of hectares of land to European companies, (b) the allocation has not involved the knowledge of, let alone consultation with communities with long standing rights to use the land, (c) compensation to communities for moving off the land and re-establishing themselves elsewhere is not adequate, (d) the companies will use the land for the large scale production of biofuel feedstocks, (e) the biofuels produced will be exported to the European Union (EU) in order to assist in meeting the EU Renewable Fuels Directive which has mandated an increase in the EU's contemporary use of 2% biofuels in the transport sector, to 10% (by energy) by 2020, (f) in order to obtain economically viable biofuel yields, the crops will have to be irrigated which in turn will have detrimental downstream impacts on poor people's access to water and on biodiversity, and (g) strategic impact assessments have not been carried out to identify the most suitable areas for biofuel feedstock production. Many of these reports are cited by Cotula *et al.* (2008) but are unfortunately very difficult to substantiate. When I visited two areas of major social and environmental concern in Tanzania in May 2009, the relocation of people had not commenced and there was a great deal of uncertainty as to whether the investments had been clinched yet and when they might proceed. Also in Tanzania, Sekab Biofuels Ltd which had established its' sugarcane nursery stock, has subsequently ceased operating. Several of the large bioethanol projects planned for Mozambique and for which land clearance had commenced, are now "on hold" because of the recession. Interestingly, the anti-biofuels in Africa lobbyists have not reacted with such zeal to reports of land allocated for biofuel feedstock production to China in Angola and to South Korea in Zimbabwe.

Given the above background of the scepticism towards the motivation for, and potential of any new policy in Africa to succeed, and the suggestion that EU biofuels policy is now driving a land use change that inevitably will have detrimental effects on poor people's livelihoods, food security and biodiversity, the unique and independent nature of COMPETE, and its' extraordinary approach and contribution needs to be appreciated. Although funded and coordinated by Europeans, its policy recommendations for sustainable bioenergy are specific to the African context and have evolved over three years as a result of opportunities created for world-leading scientists, researchers, funders and practitioners from different fields and across the world to come together to discuss; exchange knowledge; meet with government officials, local authorities and local land users; and see different bioenergy crops being grown at different spatial scales and processed into biofuels for different supply chains and scales of use. Africans comprised the majority at these workshops and they have taken place in African countries. African decision makers should implement COMPETE's recommendations and the sceptics should give them a chance to make a difference.

2. Activities cross-cutting land use categories

2.1 Use and commercialisation of natural resources

Traditionally people through out Africa utilise a wide range of natural plant and animal resources for a variety of purposes. Grass is used for livestock grazing, and harvested for livestock bedding and roof thatch. Shrubs are used for livestock browsing, and are harvested for fencing, and fuelwood if wood from trees is scarce. Trees are used for shade under which to meet and rest, are grown as wind breaks, barrier and fodder plants, and their wood is harvested for fuel, fence and house construction, making cups, buckets, mortars and pestles, etc, making furniture, musical instruments, canoes, trailers, and craft for the tourist trade. Many trees have fruit that is used as food and/or to make alcoholic beverages. The bark and roots of many trees are used as dyes and medicines. Various above and below ground parts of herbs and tubers are used as a source of food and fiber, to make beverages, cosmetics and floristic displays, and as tannins, resins, dyes and medicines. Where fuelwood is scarce, extensive use is made of both animal dung and crop residues. Many households supplement their income by selling fuelwood many in rural areas, or by making charcoal for sale in urban areas. Animals are gathered and hunted for food, cultural ceremonies, and to supplement income in the bushmeat and traditional medicine trades.

Research in many African countries particularly over the past three decades has repeatedly shown that natural resources make a very significant contribution to food security and income generation, particularly for poor rural and especially female headed households. Their value to poor households is generally equivalent to the value from livestock and arable cropping combined. The returns to labour in harvesting them are generally greater than wage labour in the agricultural and domestic sectors. The enormous value of natural resources to rural livelihoods and the urban poor in South Africa for example, is substantiated in all contributions to Lawes *et al*. (2004). Watson (2002) reveals that the sustainability of these resources in certain areas of southern Africa are threatened by excessive selective removal, bush encroachment, degradation, total removal, invasive alien plants and by conflicting and inadequate information on them. Some species of plants used in the traditional medicinal trade have become endangered in most countries with South Africa having the longest list of such plants. Despite a rapid and widespread increase in the number of commendable initiatives such as cultivating medicinal plants in community nurseries, woodlots, agroforestry, drives to encourage use of fuel efficient stoves, and access to electricity etc., the reliance on and quantity of natural resources consumed has increased exponentially over the past 50 years. This trend is likely to escalate for decades to come because it is primarily driven by increased population, poverty, urbanization and HIV/Aids.

Given that these resources are so valuable, it is imperative that the clearance of land for biofuel feedstock production does not come to constitute an added stress in areas where their sustainability is already threatened. Research including local stakeholder consultation, is needed to verify that land that appears to be unoccupied and unutilised actually is. The reliance of people on such land in south-east Botswana for example, only becomes apparent in November when the caterpillars of the emperor moth (*Imbrasia belina*) hatch to feed on the leaves of mopane (*Colophospermum mopane*) trees before pupating. Several studies cited in

Greyling and Potgieter (2004) have found that the “mopane worms” (or phane as they are known locally) are picked, smoked and sold by most surrounding inhabitants. They are sold at prices equivalent to prime cuts of beef as far away as Johannesburg and Harare. Botswana’s Central Statistics Office (2000) claimed that trade in mopane worms is second to agriculture as a source of livelihood and that the cash income it provides is particularly important to women – “a poor harvest means a poor Christmas”. Partial land clearance where grazing and access to valued trees continues, as is the case of with the Jatropha plantation shown below, is a good compromise.

2.2 Management of fire and invasive alien plants

Traditionally people through out Africa have deliberately ignited fires to (a) drive wildlife into more accessible areas where they are easier to hunt, (b) encourage wildlife into open new growth areas where they are easier to hunt, (c) encourage new growth for grazing and browsing their domestic stock, (d) reduce ticks, and (e) arrest bush encroachment. Contributions in Booysen and Tainton (1984) and well as many other studies, reveal that fire is only effective in reducing ticks in soils devoid of a surface crust or seal, and in killing the seedlings of woody species if it is hot enough. Overgrazing encourages bush encroachment. Overgrazed grass does not provide enough fuel for the high intensity fires needed. Once the woody species become established they shade out grasses beneath them. Even if the grass between them recovers sufficiently to support hot fires, the fire will not be able to reach and kill them. Overgrazing is generally well represented in both commercial and communal rangelands especially around boreholes, and on routes used by nomadic pastoralists.

The general decrease in wild herbivores elsewhere, a decrease in the frequency of fires in fire managed conservation areas, and restrictions on use of fire by hunter-gatherers and pastoralists, means that after good rainfall years there is typically a large, dead biomass of standing grass (Perkins *et al*. 2002). Many of the fires whether deliberately or accidentally ignited, that occur at these times get out of control due to the lack of control facilities and poor firebreak maintenance and end up affecting vast tracks of land. Estimates of the total areas burnt annually are substantial (Watson, 2002).

Clearly any land, whether small or land scale, under biofuel feedstock production must be adequately protected by firebreaks. Maintenance of the breaks and vigilance must be particularly efficient after good rainfall periods. Subsidies and quotas should respectively allow for instalment suspension and change, in the event of devastation of the crop by fire.

All eight of COMPETE's study countries rate invasive alien plants as one of their key environmental problems. The influx of alien plant species into Africa began in earnest with European colonisation. Most originated from Australia and South and Central America, and most were brought in deliberately for various purposes. In Africa without the natural suite of plant-feeding insects and pathogens that suppress them in their native regions, many of them have out-competed the local plants, formed dense stands, spread rapidly and transformed the landscape. Because the Cape of Good Hope served as a stop over for European ships to and from the Spice Islands as far back as the 1600s, they are best represented and most problematic in South Africa.

Contributions in van Wilgen (2004) attest to the wide range and magnitude of their deleterious environmental and socio-economic effects. In the semi-arid regions in the Western Cape, Mpumalanga and Limpopo provinces up to 80% of quaternary catchments are covered by these plants. In 1995 to stem their threat particularly to biodiversity and water supply, South Africa embarked on the Working for Water Programme (WfWP) which entailed widespread clearance and subsequent control. In order to generate rural employment most the clearance has been and continues to be manual. Although the subsequent control involves manual weeding follow ups, more use is made herbicides and biological agents. Despite local communities being assisted to use the cut plant material to generate an income by making craft, furniture and charcoal, by far the greater proportion of it in most areas is burnt and left in close proximity to where it was felled and/or dug out. Although the WfWP achieves all its objectives, recognition particularly of it's poverty relief role secures it increasingly funding. The Programme is likely to continue for several decades to come and is serving as a model for other African countries. Given this, a concerted effort should be made to utilise the bioenergy potential of the unwanted biomass in the production of briquettes for barbeques and space heating for example. The magnitude of the invasive alien plant problem in South Africa explains its government's cautious approach to authorizing Jatropha as a biofuel feedstock. All countries should adopt a similar approach should potential investors wish to introduce new, non native to Africa bioenergy crops.

3. Threats and opportunities to sustainability

3.1 Hunting and gathering, Pastoralism

Since the southern migration of Nguni tribes in the 16th century, the number, size and spatial range of hunter gatherer communities has progressively diminished. Traditionally these communities moved with the game in response to seasonal and drought induced shortages of water and forage. They now predominately stay in the most marginal of lands bordering protected areas. Their movement has been restricted by erection of fences around commercial farms, the provision of boreholes and the emergence of settlements in close proximity to them, the emergence of mining towns and trading centres, and by the general decrease in wildlife and natural resources. The magnitude of this decrease and its detrimental consequences on the livelihoods of hunter gatherers is particularly evident in the Kalahari in Botswana as a direct result of that country's Beef Protocol agreement with the EU. The agreement gives Botswana preferential access to European markets and has led to a large increase in cattle ranches and in year round livestock pressure in the ranches and overgrazing particularly around boreholes. Perkins *et al*. (2002) document the loss and/or depletion of key veld food resources with increasing stocking rates around boreholes. They also detail the demise of wildlife caused by perimeter and veterinary control fences. The impact of these fences on migratory species was particularly acute. The large populations of blue wildebeest and red hartebeest for example, had crashed by as much as 90% by the late 1980s. Twyman (2002, p.55) describes the stigmatisation of hunter gatherers as "old fashioned, backward and incapable" by settled communities, as well as the loss to hunter gatherer communities of young members in favour of modern lifestyles.

In order to stem the tide against hunter gatherer communities and offer alternatives to poaching, numerous Community Based Natural Resources Management (CBNRM) projects have been implemented throughout Africa since the early 1980s. Most CBNRM areas border unfenced protected areas. Communities are given licences to hunt in these areas. The licence is valid for specific species and age and sex of animal. The number of licences issued is reviewed annually. Communities can generate an income by selling their licence to shoot a coveted trophy species to foreign sports hunters and by assisting them in the hunt. Increasingly they are generating an income from ecotourism activities. There are still a lot of social equity issues in CBNRM areas including women being denied hunting licences and distribution of income generated (Twyman, 2002). While contributions in Hachileka (2003) describing different CBNRM models in Malawi, Namibia, Zambia and Zimbabwe, suggest that a lot of teething problems associated with practical application of the CBNRM concept have been ironed out, they very fragile and sensitive to external forces. While use of more fuel efficient stoves could be encouraged in these areas, it certainly would not be appropriate to try to encourage the planting of biofuel crops. In identifying land available for bioenergy feedstock production, CBNRM areas should be excluded together with the protected areas.

Traditionally pastoralists in arid and semi-arid regions of sub-Saharan Africa where rain falls in a single season scheduled their livestock to calve during this season. As a consequence there is a shortfall of milk during the dry season which they are compelled to offset by growing vegetables and crops, fishing and/or hunting (Western and Manzolillo Nightingale, 2004). As they are already accustomed to growing their food, these pastoralists have generally responded well to land allocation programmes to encourage them to change to a sedentary lifestyle. During the early 1970s famine most Sahelian pastoralists migrated south and many stayed. While they still own herds of cattle, in addition to growing vegetables and crops for their own consumption, many also produce cotton as a cash crop (Gray, 2003; Saul *et al.* 2003).

By contrast, the Maasai move across an expanse of land falling under the jurisdiction of both the Kenyan and Tanzanian governments that has a bimodal rainfall distribution. Milk is more efficient than meat in converting forage to human food. With moving to the best grazing pastures facilitated by two rain seasons, the Maasai secure year round milk production and are therefore less dependent on alternative forms of production than pastoralists in areas with a single rain season. The Maasai's zebu cattle compliment their extreme dependence on pastoralism, very well. These cattle are good milk producers, are adapted for walking long distances, and thrive in harsh environments. Traditionally they view wildlife as a 'second cattle' to be used in times when their zebu cattle are decimated by drought, disease or predation (Western and Manzolillo Nightingale, 2004). The Maasai population has increased from a few thousand at the turn of the 20th century to 900 thousand in the early 1990s. They have evolved into quite a significant political entity viz., actively resisting the urging of both governments to adopt a more sedentary lifestyle and securing grazing rights to many national parks in both countries. Both governments have opted for promises to compensate commercial and communal farmers who have lost grazing due to Maasai 'trespassing' on their lands, rather than deal with evicting and punishing the Maasai. Employers at SEKAB Biofuels ltd near Bagamoyo on Tanzania's coast were allegedly threatened by Maasai pastoralists who have been forced by the current drought to seek grazing closer to the coast. In identifying land available for bioenergy feedstock production, routes traditionally used by the Maasai in both 'normal' rainfall periods and severe droughts should be excluded.

3.2 Traditional communal land use to small scale farmer

Traditionally, a male tribal chief grants the following to a male member of the community who wishes to establish a family:- a homestead site, an area of cropping land, the right to graze stock on the communal grazing land, and the right to collect water, thatch grass, and wood for fuel and building purposes. Traditionally, if the husband died, his widow can continue to live in the homestead and use the land and its resources for the rest of her life. Traditionally, family labour is used to produce vegetables and staple crops for their own consumption. Selling only occurs when surpluses are available. Production involves low inputs such as use of chickens and ash to control insects, ash and mulch to maintain soil fertility, and burning diseased crops.

During the colonial period, the spatial extent of the traditional communal lands was substantially decreased and predominately restricted to less arable parts of the colonies. Over the same period, access to western health care and veterinary services resulted in an exponential increase in the populations of the people and their stock inhabiting these communal lands. The overcrowding of them coupled with restrictions on the sale of produce and resources harvested from them, resulted in economically active and particularly male, members of the household leaving to seek employment in the commercial agricultural sector, mining and urban areas.

Households in the communal lands became increasingly unable to produce enough food to meet their subsistence requirements and increasingly reliant on remittances (often irregular) from employed members. There are several reasons why they were unable to produce enough food. Although the average land holding per family is 8 ha, most families have less than 2 ha. Even so, comprised of children, women and the elderly, typically there is not enough labour to work this amount of land productively. Each family requires a herd of at least 20 cattle to meet their subsistence needs, build up a herd, and withstand sale over a short run of bad years. A herd size greater than this, permits an annual take off of one or two beasts for meat, cash, social or religious ceremonies. Families with herds smaller than 20, are reliant on using cows and immature beasts in their plough teams with consequent negative impacts on their breeding capacity. Most families have less than ten cattle and therefore have to hire beasts to plough. They consequently plough when conditions are less favourable to do so, and consequently in turn have poorer and later harvests. Custom dictates that in order to retain the right to use the land, it must be used. Hence more land is cleared and ploughed than can be efficiently used for cultivation.

Since independence a number of general trends have interacted to erode the traditional communal landuse system. Firstly, with increased access to education and urbanization, the influence of the tribal authority is becoming progressively weaker. Consequently women the *de facto* heads of most rural households, are steadily gaining more authority over investment and management decisions relating to land and resource use. Secondly, with the sale of produce and resources from communal lands being legalised, people have an incentive to (a) produce vegetables and crops, and even flowers for marketing, (b) harvest fuel wood for sale or to convert into and sell it as charcoal, and (c) gather plants and plant parts and hunt animals used in the traditional medicine trade to supply booming markets in urban areas. Thirdly, the post independence governments implemented various land reform schemes. Sub-dividing commercial agricultural lands and allocating plots helped reduce the population pressure in the communal areas. Fourthly, the end of civil wars in some countries and structural adjustment and the consequent loss of jobs in urban areas in others, has seen the return of men and young women to rural areas alleviating the cultivation labour shortage problem noted above. Lastly, there have been a large number of government and non-government initiatives to educate and assist people to employ more productive land use and marketing practices. The hardships people face in many rural areas, have been exacerbated by the effects of HIV/Aids pandemic. In some rural areas particularly in South Africa, the introduction of pensions and child support grants, has served as a disincentive to work the land.

As evidenced by Tiffen *et al.* (1994) and contributions in Bassett and Crummey (2003), Widgren and Sutton (2004) and others, the system that appears to be evolving to replace the traditional communal landuse system is one similar to that found on redistributed land where small scale freehold farmers grow most of their own food crops as well as cash crops. While labour is still predominately provided by the family, shared labour arrangements and hiring of labour are common. A wide range of soil conservation measures as well as agroforestry practices are well represented. While use of the traditional inputs noted above are still common, income from the cash crops enables them to purchase fertilizers and pesticides. A substantial proportion of the fields are ploughed by tractor. The tractors are either share owned or hired. These farmers have fewer livestock of better quality. Where land is available communal grazing is still typical but in areas where it is in short supply, animals are kept in a kraal and fed fodder specifically grown and/or collected for them. In the dry season animals feed on stalks in the fields and deposit their manure. Gray (2003, p.85) notes that "where farmers cannot claim individual permanent control over land, they use investments in soil quality to create rights in land. By improving soil quality, they increase the length of time they can farm a field. The longer a farmer cultivates a field, the harder it is for him to be asked to leave it, and the easier it becomes for him to put it down to fallow and then reclaim it."

Small scale farmers on both communal and freehold lands, already contribute a substantial proportion of the national production of food and cash crops, leading examples being sugarcane in South Africa, and cotton in Burkina Faso. These farmers appear to very optimistic about the future and aware of the role modern bioenergy can play in it. Many of them in a number of countries, have already planted Jatropha as a barrier plant around fields and kraals and/or have intercropped with it. Many more have plans to do so. Takavarsha *et al.'s* (2005) assessment of the five countries shown in Table 1 below indicates that this optimism is not unfounded. There is plenty of suitable cropland – more than enough to allow for more farmers in the future as well as a substantial expansion of both food and biofuel crops, for both domestic and export markets. The proportion of suitable cropland required to be converted into biofuels feedstocks to meet domestic biofuels targets is shown in brackets in the bottom row. It ranges from 0.44% in the DRC to 2.40% in Angola.

Table 1: Comparative areas (1000 ha) highlighting the biofuels potential in five SADC countries (Takavarsha *et al*, 2005)

Country	DRC	Angola	Tanzania	Zambia	Mozambique
Total land area	227 000	124 670	87 869	74 339	78 409
Suitable cropland	45 000	25 000	18 000	15 000	16 000
Under crops	8 000	4 000	5 000	5 000	3 000
Needed to meet domestic biofuels targets	200 (0.44 %)	600 (2.40 %)	300 (1.67 %)	200 (1.33 %)	200 (1.25 %)

Takavarsha *et al.* (2005, p. 21) argue "these countries can easily satisfy their current energy needs by allocating a part (< 10%) of their cropland to energy crops. The income generated by this would allow farmers to buy fertilizers and to increase food production on the remaining land. Farming for energy will thus contribute to the national food security. The five countries can also choose to increase their cropland up to 100 million hectares. This would allow these countries to produce sufficient bio-fuel for the entire SADC region, which would today require 11 million hectares of energy crops. It would even allow for exports abroad."

Modern bioenergy clearly has the potential to enhance the livelihoods of small scale farmers and the time to support its rapid and widespread provision is ripe. Such support involves access to loans, extension services and markets. Solway (2002) describes how the introduction of loans left small scale farmers in Botswana worse off than they were before. Together with cash derived from selling their oxen, they used their loans to purchase tractors. Banks reclaimed these tractors during severe droughts when they were unable to meet their loan repayments. When the rains returned they had to resort to hand hoes to prepare the soil for planting food and cash crops.

The key lesson of this COMPETE deliverable is that biomass productivity in the arid and semi-arid regions of sub-Saharan Africa is explained by the 'disequilibrium' paradigm. The setting of loan repayments and quotas must take the implications of this paradigm into account viz., in poor rainfall periods they must be reduced or even suspended.

3.3 Large scale commercial agriculture

As noted in section 1.3, most of the anti-biofuels lobbyists' hype about corrupt government officials recently handing over hundreds of thousands of hectares to foreign biofuel investors and the rural poor being driven off their lands, has been difficult to substantiate. However, most of the deleterious environmental and socio-economic impacts noted by this lobby have accompanied large scale commercial food and cash crop agriculture in both pre and post independent Africa. In the arid and semi-arid regions of sub-Saharan Africa, large scale sugar cane production is one of the main culprits. This is because it can not be grown in these regions without irrigation. With reference to 10,000 hectares under sugar cane on the Bérégadougou plain in Burkina Faso, Saul *et al.* (2003, p.139) note that detrimental impacts of moving people and taking water, need to weighed against the fact that "the fields and the sugar factory and distillery created many jobs, especially for women". Most sugar cane currently produced in the arid and semi-arid regions of sub-Saharan Africa is used for sugar. Where ethanol is produced, it is sold to the pharmaceutical, agro-food and beverage industries. Plans to expand areas and put new areas under cane in these regions, is a real concern.

Serious consideration should be given to accepting Johnson and Matsika (2006) suggestion that the new areas put under sugar cane to meet biofuel demands should be confined to regions with sufficient rainfall to avoid the need for irrigation. In the arid and semi-arid regions in southern Africa, Watson (2009) notes that the surface and ground water resources are

already seriously depleted and that the scarcity of water in them is likely to be aggravated by climate change. Increasing recognition that sweet sorghum is a more appropriate feedstock for bioethanol production for fuel use in these dryland regions, and the recent upsurge in research into its potential as such a feedstock is encouraging. While large areas have and will being planted up with Jatropha, most such operations are joint ventures between foreign investors, governments and groups of small farmers. The farmers benefit from bank credit, inputs and extension services. However, the need for repayments and quotas to be flexible enough to accommodate below average yields as noted in section 3.2 above, is also applicable here. The potential for biodiesel production of a number of trees indigenous to Africa's drylands especially *Pappea capensis* and *Ximenia caffra* in southern Africa and *Croton megalocarpus* in East Africa, has attracted research interest. These trees produce large quantities of seeds, and between 30 and 65 percent of the weight of the seeds, is oil. Research into (a) the properties of oil from these trees as suitable to be used raw in electricity generators, or to be processed into biodiesel for vehicular use, (b) the ecological role and range of traditional uses of these trees, and (c) the effects of cultivating them or harvesting the wild resource on rural livelihoods, is still in its infancy. Research into the above aspects must be prioritized particularly as there is already an initiative to plant up large areas of Tanzania with *Croton megalocarpus.*

4. Conclusion

COMPETE identified pathways for the provision of modern bioenergy in Africa's arid and semi-arid regions. In order to assess if these are appropriate for and hence likely to succeed in different land use categories, this deliverable sought to understand the dynamics within them. Land use dynamics in all categories is greatly influenced by the inherent 'disequilibrium' behaviour of these dryland environments. An established view and an alternative view have evolved to explain the dynamism of interactions between traditional people and these environments. The established view blames bad land use for land degradation, and has predominately informed policies to date. The alternative view blames bad policies for bad land use, questions the reality of a fuelwood crises, deforestation, etc. and believes land degradation is transient and reversible. The first section of this paper discussed how these views influence the conceptualization of processes well represented in the dryland regions. It concluded that given the increasing popularity of the alternative view and anti-biofuels bias in the media, African bioenergy policies should avoid controversy by not promoting bioenergy's potential to reduce deforestation, rehabilitate degraded land etc.

The second section examined activities that cross-cut most land use categories. A wide range of plants and plant parts, and animals are collected and hunted for a wide range of purposes. Rural households and those of the urban poor are particularly dependent on these natural resources for food security and income generation. The reliance on and demand for these resources is likely to continue to increase. There is therefore a need to verify that land that appears to be unoccupied and unutilised actually is, before it is cleared for biofuel crops. In the case of tree crops like Jatropha, partial clearance which allows for grazing and access to valued trees to continue, should be encouraged. Communal and commercial rangelands and routes used by nomadic pastoralists are typically overgrazed and burnt too frequently.

Elsewhere the general decrease in wild herbivores and fire restraint, means that after good rainfall years there is typically a large, dead biomass of standing grass which when ignited frequently gets out of control affecting vast tracks of land. All land under biofuels must be adequately protected by firebreaks especially after good rainfall periods. Despite commendable efforts to eradicate and control invasive alien plants, they are likely to continue to pose a major threat to surface water, biodiversity and grazing. A concerted effort is needed to exploit their bioenergy potential. All countries should adopt a cautious approach before authorizing the cultivation of any new, non African bioenergy crop.

Lastly, the threats to and opportunities for sustainable use of bioenergy in different land use categories were explored. It was concluded that modern bioenergy is premature for hunter gatherer communities inhabiting CBNRM areas and for the Maasai pastoralists. By contrast, it is already beginning to improve the livelihoods of small scale communal and freehold farmers. The time for active support in the way of loans, extension services and markets among these farmers is ripe. Given that biomass productivity in these dryland regions is explained by the 'disequilibrium' paradigm, loan repayments and quotas must be reduced or even suspended during poor rainfall periods.

Adoption of the COMPETE Declaration on Sustainable Bioenergy for Africa will ensure that the deleterious environmental and socio-economic impacts associated with large scale commercial agriculture in the past, are not repeated. Sugar cane can not be grown in Africa's arid and semi-arid regions without irrigation. Given this, areas proposed for it to be grown on a large scale as a biofuels feedstock, need to be assessed by a competent multidisciplinary team. Research into the potential for biodiesel production of a number of trees indigenous to Africa's drylands must be prioritized.

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