An assessment of the potential of drylands in eight sub-Saharan African countries to produce bioenergy feedstocks

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This paper synthesizes lessons learnt from research that aimed to identify land in the dryland regions of eight sub-Saharan African study countries where bioenergy feedstocks production has a low risk of detrimental environmental and socio-economic effects. The methodology involved using geographical information systems (GISs) to interrogate a wide range of data-sets, aerial photograph and field verification, an extensive literature review, and obtaining information from a wide range of stakeholders. The GIS work revealed that Africa’s drylands potentially have substantial areas available and agriculturally suitable for bioenergy feedstocks production. The other work showed that land-use and biomass dynamics in Africa’s drylands are greatly influenced by the inherent ‘disequilibrium’ behaviour of these environments. This behaviour challenges the sustainability concept and perceptions regarding the drivers, nature and consequences of deforestation, land degradation and other factors. An assessment of the implications of this behaviour formed the basis for the practical guidance suggested for bioenergy feedstock producers and bioenergy policy makers.

Keywords: sustainability; bioenergy feedstocks production; Africa’s drylands

1. INTRODUCTION

This paper synthesizes the lessons learnt while carrying out 4 years of field-based research in sub-Saharan Africa to investigate how biofuel feedstocks production could interact with current land use and practices. The research was conducted under a project entitled ‘Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems—Africa, abbreviated as COMPETE and comprehensively described at http://www.compete-bioafrica.net. The work aimed to identify land in the dryland regions of Botswana, Burkina Faso, Kenya, Mali, Senegal, South Africa, Tanzania and Zambia, where well-managed intensification of, or conversion to, bioenergy feedstocks production has a low risk of causing detrimental environmental and/or socio-economic effects. The study countries were chosen because they already had several different bioenergy initiatives in place. The work primarily involved using geographical information systems (GISs) and a wide range of datasets. Areas considered unavailable for feedstock production and those agriculturally unsuitable for such production were filtered out. Areas were considered unavailable on the basis of their importance in terms of biodiversity, carbon stocks, environmental services, food security and rural livelihoods. They included all categories of protected areas, biodiversity hotspots, forests and wetlands outside of protected areas and cropland and pasture land. The development of ‘site selection’ tools and methodologies for parties that want to identify areas for sustainable feedstock production, which took place subsequent to this work by McCormick et al. [1], Dehue et al. [2] and Dragisic et al. [3] and others, resulted in the phase ‘responsible cultivation areas’ to describe these areas and broadly used the same approach to identify them.

In order to understand the implications of ‘on the ground’ land-use dynamics on the (i) likelihood and desirability of converting land to bioenergy feedstocks, (ii) appropriateness of contemporary relevant policies, and (iii) best choice of feedstocks and production systems, information was gleaned from a wide range of other sources. These included an extensive review of relevant literature, use of Google Earth to get a closer examination of and field visits to a sample of areas deemed low risk for bioenergy feedstocks production, and from project partners, workshops and field study tours. The workshops created opportunities for world-leading scientists, researchers, funders and practitioners from different fields and across the world to come together to discuss, exchange knowledge and meet with government officials, local authorities and local land users. Most workshops took place in the African study countries and consequently were predominately...
attended by Africans. The field study tours gave the opportunity to see different bioenergy crops being grown at different spatial scales and processed into bioenergy for different supply chains and scales of use.

The lessons learnt are described in four sections. The first explores the challenges posed by the inherent ‘disequilibrium’ behaviour of Africa’s drylands to the sustainability concept and to perceptions regarding the drivers, nature and consequences of deforestation, land degradation and other factors. The second shows the findings of the GIS work and describes lessons learnt from the ‘filtering out’ approach used. The third provides the basis for good practices for bioenergy feedstock producers and bioenergy policy makers. The final section highlights key lessons learnt.

2. SUSTAINABILITY IN AFRICA’S DRYLANDS

There is now general consensus that the spatial and temporal heterogeneity and dynamism of ecosystems in the continent’s dry sub-humid, semi-arid and arid regions, collectively known as the drylands, are best 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. The dynamic flux also reflects past and current disturbance regimes. Changes are commonly abrupt and induced by specific events. This disequilibrium behaviour means that both ‘good’ conditions favouring growth and ‘bad’ conditions when plants struggle to grow and die off are normal [4].

In seeking to ensure that biofuels feedstocks production in Africa’s drylands is sustainable, the popular interpretation of ‘sustainability’ as ‘consisting of continuous processes or conditions that can be maintained indefinitely without progressive diminution of valued qualities’ [5, p. 3] needs to be re-evaluated. As Eriksen & Watson [6] note, understanding the inherent discontinuities and dynamism of these regions recognizes that their sustainability is dependent on change and disturbances that temporally diminish valued qualities.

Africa’s drylands disequilibrium behaviour challenges proponents of modern bioenergy development who suggest it will ameliorate Africa’s fuelwood crisis and rampant deforestation. It also challenges those who suggest that marginal lands, wastelands or degraded lands should be targeted for biofuels feedstocks production as a means of rehabilitating them. The drivers, nature and consequences of these processes are hotly contested. The established view predominately represented by natural scientists, such as Biggs et al. [7], Hoffmann [8], Scholes & Biggs [9], Tainton [10] and Watson [11], is that the ‘carrying capacity’ concept is relevant to the disequilibrium 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 (i) the land is excessively overstocked during both favourable and unfavourable growth periods, (ii) the off-take of domestic stock during droughts is not adequate to allow for recovery when the rains resume, (iii) overstocking and cultivation in marginal lands are the principal cause of accelerated soil degradation (crusting, compaction, salinization, erosion), (iv) bush encroachment reduces an area’s carrying capacity and hence is a form of land degradation, and (v) land clearance for cultivation and overharvesting of trees principally for use as fuelwood are the principal drivers of deforestation. This view has predominately informed pre- and post-independent African environmental, conservation, forestry and agricultural policies.

The alternative view predominately represented by social scientists in books such as Bassett & Crumme [12], Belune et al. [13], Blaikie [14], Dahlberg [15], Kinlund [16], Leach & Mearns [17], Mistry & Berardi [18] and Sporton & Thomas [19–20], argues that (i) overstocking during favourable growth periods is economically rational behaviour in disequilibrium environments; (ii) overstocking during unfavourable growth periods has been caused by the colonial legacy that favoured sedentary versus mobile land-use activities; (iii) most pastoralists and subsistence communal land users do not own sufficient stock to sustain their livelihoods; (iv) 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; (v) 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 (vi) far from leading to natural regeneration, restricting the movement of pastoralists has decreased biodiversity. This view has become increasingly popular over the past four decades.

3. LESSONS LEARNT FROM GEOGRAPHICAL INFORMATION SYSTEMS WORK

The methodology and data sources used for the GIS work are detailed in Watson [21–23] and Wicke et al. [24]. The findings of the GIS work shown in table 1 reveal that 34.4 Mha is potentially available and suitable for bioenergy feedstocks production in the drylands of the eight study countries. The total ‘responsible cultivation areas’ and the proportion of the drylands they represent in each country ranges from 1.3 Mha and 1.5 per cent in South Africa to 12.2 Mha and 21.2 per cent in Botswana.

Given that there is so much ‘responsible cultivation’ land, future studies can afford to exclude further land covers for which data were not available at the time.

[1] In South Africa, this legacy includes that of the apartheid regime (1948–1994).
this work was done. Proforest [25] defines a high conservation value (HCV) as a biological, ecological, social or cultural value of outstanding significance or critical importance at the national, regional or global scale. Consequently, HCV areas are critical areas in the landscape, which must be managed to maintain or enhance the HCV. Six different categories of HCV areas are identified. Dehue et al. [2] suggest that all categories of HCV areas should be excluded when identifying responsible cultivation areas. Tool kits have been developed to identify these areas. The Integrated Biodiversity Assessment Tool [26] launched in 2008 now provides a compilation of conservation data that will enable identification of these areas. Muok et al.’s [27] GIS assessment of where 12 different biofuel feedstocks can be produced sustainably in Kenya is leading the way. In addition to protected areas, they excluded the following (not mutually exclusive) outside of them: forests, wetlands, HCV areas, wildlife movement paths 3 km in width and wildlife conflict areas.

In an attempt to ensure that the use of land for bioenergy feedstocks does not cause conflict, areas where there is already conflict, subject to an influx of refugees and designated for land reform, as well as places of cultural significance, were overlaid on the final maps showing responsible cultivation areas in relation to large towns and cities, roads, rail lines and rivers [22]. An example of the map for Kenya is given in figure 1.

Watson’s [21,23] field visits to, and Google Earth examination of, 100 areas identified as responsible cultivation areas revealed human habitation and/or use of natural resources in a substantial portion of them. Clearly, while the 1 km² resolution of the datasets used in the GIS work is adequate to give a quick, coarse assessment of these areas, their availability and suitability needs to be verified initially using higher resolution satellite data and/or aerial photographs, and then in the field with local stakeholder consultation.

### 4. GUIDANCE FOR BIOENERGY FEEDSTOCK PRODUCERS AND POLICY MAKERS

Overgrazed areas do not provide enough fuel for the high-intensity fires [11]. Perkins et al. [28] observe that while 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. Many of the fires, whether deliberately or accidentally ignited, which occur at these times get out of control owing 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 [29,30]. Clearly any land, whether small or large scale, under bioenergy feedstock production must be adequately protected by firebreaks. Maintenance of the breaks and vigilance must be particularly efficient after good

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**Table 1. Availability of land for energy crop production in semi-arid and arid regions of eight sub-Saharan African countries [24].**

<table>
<thead>
<tr>
<th></th>
<th>Botswana</th>
<th>Burkina Faso</th>
<th>Kenya</th>
<th>Mali</th>
<th>Senegal</th>
<th>South Africa</th>
<th>Tanzania</th>
<th>Zambia</th>
</tr>
</thead>
<tbody>
<tr>
<td>total area (Mha)</td>
<td>57.6</td>
<td>27.2</td>
<td>58.0</td>
<td>124.9</td>
<td>19.5</td>
<td>121.3</td>
<td>93.3</td>
<td>75.0</td>
</tr>
<tr>
<td>semi-arid area</td>
<td>44.9</td>
<td>14.3</td>
<td>22.3</td>
<td>24.5</td>
<td>9.7</td>
<td>37.6</td>
<td>31.5</td>
<td>16.0</td>
</tr>
<tr>
<td>arid area</td>
<td>12.8</td>
<td>0.5</td>
<td>23.1</td>
<td>39.3</td>
<td>1.5</td>
<td>51.4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>other areas</td>
<td>0.0</td>
<td>12.4</td>
<td>12.6</td>
<td>61.1</td>
<td>8.3</td>
<td>32.3</td>
<td>61.8</td>
<td>59.0</td>
</tr>
<tr>
<td>excluded area (Mha)</td>
<td>45.4</td>
<td>13.2</td>
<td>39.8</td>
<td>54.9</td>
<td>10.0</td>
<td>87.7</td>
<td>29.6</td>
<td>14.3</td>
</tr>
</tbody>
</table>

| unsuitable        | 0.7      | 0.0          | 0.8   | 21.6 | 0.2     | 1.0          | 0.3      | 0.2    |
| high biodiversity | 6.0      | 3.0          | 19.3  | 8.4  | 0.8     | 62.6         | 11.5     | 5.0    |
| protected areas   | 18.7     | 1.8          | 3.1   | 2.7  | 2.8     | 5.8          | 6.4      | 5.3    |
| biodiversity hotspots | 0.0 | 0.0 | 11.5 | 0.0 | 0.0 | 17.4 | 6.0 | 0.0 |
| closed canopy forest and wetlands | 3.6 | 0.0 | 2.2 | 0.1 | 0.0 | 7.4 | 11.5 | 4.6 |
| agricultural land | 4.1      | 8.9          | 2.6   | 14.4 | 7.1     | 14.3         | 4.7      | 2.4    |
| cropland          | 21.4     | 3.1          | 15.6  | 20.1 | 3.1     | 47.8         | 13.3     | 5.3    |
| pastureland       | 12.2     | 1.6          | 5.6   | 8.9  | 1.2     | 1.3          | 1.9      | 1.7    |
| available area (Mha) | 12.2 | 1.6 | 2.8 | 3.4 | 0.7 | 1.1 | 1.9 | 1.7 |
| arid area         | 3.8      | 0.0          | 2.8   | 5.5  | 0.5     | 0.2          | 0.0      | 0.0    |
| share of total arid and semi-arid (%) | 21.2 | 10.7 | 12.4 | 14.0 | 10.8 | 1.5 | 6.1 | 10.6 |

*The sum of the different land areas excluded from availability does not equal the total of the excluded area because of overlaps between different categories. This breakdown is presented here to give insight into the importance of the different land categories excluded.*
rainfall periods. Subsidies and quotas should, respectively, allow for instalment suspension and change, in the event of devastation of the crop by fire.

While all eight study countries rate invasive alien plants as one of their key environmental problems, they are best represented and most problematic in South Africa. Contributions in van Wilgen [31] 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 per cent 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 of the clearance has been and continues to be manual. 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. Recognition of the WfWP’s poverty relief role has secured increased 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 use the bioenergy potential of the unwanted biomass in the production of charcoal and briquettes. The magnitude of the invasive alien plant problem in South Africa explains its government’s cautious approach to authorizing *Jatropha curcas* L. as a biofuel feedstock. All countries should adopt a similar approach should potential investors wish to introduce new, non-native to Africa bioenergy crops. A number of trees indigenous to Africa’s drylands produce large quantities of seeds with as much as 65 per cent being contributed by oil. Watson [23,32] calls for prioritization of research into (i) whether the oil can be used raw in electricity generators, or processed into biodiesel for vehicular or aviation use, (ii) the ecological role and range of traditional uses of these trees, and (iii) the effects of cultivating them or harvesting the wild resource on rural livelihoods.

Cotula *et al.* [33] cite numerous reports of very large areas of land being allocated for bioenergy feedstock production in African countries without environmental impacts assessments and community consultation having been carried out, and consequently having, or having the potential for, detrimental effects. These reports are very difficult to substantiate. Field visits in 2009 to many of the areas mentioned in Cotula *et al.* [33] revealed that 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. Several of the large bioethanol projects planned for Mozambique and for which land clearance had commenced were ‘on hold’ because of the recession.

Figure 1. Showing areas in Kenya’s drylands excluded from biofuel feedstocks production consideration in relation to rivers, roads and railroads, towns and locations with social constraints.
While non-government organizations (NGOs) and private companies may find it quicker and easier to get access to land in areas where the traditional social system is still strongly intact, numerous references cited in von Maltitz & Brent [34] and Diaz-Chavez [35] express concern about whether peasants living within these systems will benefit more than a minimal income from selling their labour for land clearance, planting, pruning, harvesting, as well as concern that this may well be at the expense of their ability to meet their subsistence needs. As von Maltitz & Shackleton [36] note there are several entrenched reasons related to both custom and historical legacy why most households are unable to produce enough food and are reliant on remittances sent by economically active, and particularly male, members of the household who have left to seek employment in the commercial agricultural sector, mining and urban areas. Traditionally, the right to use land is granted by a male tribal chief only to male members of the community. Colvin [37], and many others since, have found that although most households have less than 2 ha, being composed of children, women and the elderly, there is not enough labour to work this amount of land productively. Most households have less than 10 cattle and consequently use cows and immature beasts in their plough teams, which has a negative impact on their breeding capacity. Many households are forced to hire beasts. They consequently plough when conditions are less favourable, and therefore have poorer and later harvests. Arntzen & Veenendaal [29], Kgathi et al. [38] and Central Statistics Office [39] describe the effect of the tradition that, in order to retain the right to land, it must be used. 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 land-use system. As evidenced by Tiffen et al. [40] and contributions in Bassett & Crumley [12], Wigdren & Sutton [41] and others, the system that appears to be evolving to replace the traditional communal land-use 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. 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 [42, 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 or emergent 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 [43] and cotton in Burkina Faso [44]. They farm between 9 and 20 ha [45,46]. Based on field visits to them and inputs from their representatives at the project’s workshops, they appear to be very optimistic about the future and aware of the role modern bio-energy 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.

Takavarasha et al.’s [47] assessment of Angola, the Democratic Republic of Congo, Mozambique, Tanzania and Zambia indicates that this optimism is not unfounded. They found that these countries have more than enough arable land 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 (table 2). They concluded that ‘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’ [47, p. 21]. Case studies on Kenya, Mali, Mozambique, Senegal, Tanzania and Zambia in Diaz-Chavez et al. [48] concur that there is enough land for a significant increase in both energy and food crops and that food production can be increased by increased biofuel feedstocks production by combining projects with improved agriculture management practices and investment.

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 [49] describes how the introduction of loans left small-scale farmers in Botswana worse off than they were before. Together with

### Table 2. Comparative areas (1000 ha) highlighting the biofuels potential in five SADC countries [47]. DRC, Democratic Republic of Congo.

<table>
<thead>
<tr>
<th>Country</th>
<th>DRC</th>
<th>Angola</th>
<th>Tanzania</th>
<th>Zambia</th>
<th>Mozambique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total land area</td>
<td>227,000</td>
<td>124,670</td>
<td>87,809</td>
<td>74,339</td>
<td>78,409</td>
</tr>
<tr>
<td>Suitable cropland</td>
<td>45,000</td>
<td>25,000</td>
<td>18,000</td>
<td>15,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Under crops</td>
<td>8000</td>
<td>4000</td>
<td>5000</td>
<td>5000</td>
<td>3000</td>
</tr>
<tr>
<td>To meet domestic biofuels targets</td>
<td>200 (0.44%)</td>
<td>600 (2.40%)</td>
<td>300 (1.67%)</td>
<td>200 (1.33%)</td>
<td>200 (1.25%)</td>
</tr>
</tbody>
</table>

*Interface Focus*
cash derived from selling their oxen, they used their loans to purchase tractors. Banks reclaimed these tractors during severe droughts when farmers 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 learnt from the COMPETE project is that the biomass productivity in Africa’s drylands is explained by the disequilibrium paradigm. The setting of loan repayments and quotas must take the implications of this paradigm into account; namely, in poor rainfall periods they must be reduced or even suspended.

Furthermore, the COMPETE project produced guidelines for ‘implementing certification and standards for a sustainable biofuel production’ [50] and on ‘good practices and sustainability assessment for biofuels projects’ [35]. These good practices showed through stakeholders’ input that agroforestry mapping and land-use rights are considered essential for a sustainable bioenergy crops production.

In both pre- and post-independent Africa, the conversion of land to large-scale commercial food and cash crop agriculture has generally been associated with deleterious environmental and socio-economic impacts [12]. In Africa’s drylands, sugarcane cannot be grown without irrigation. Saul et al. [44, p. 139] note that detrimental impacts of moving people and taking water to cultivate 10 000 ha of sugarcane on the Beregadougou plain in Burkina Faso need to weighed against the fact that ‘the fields, sugar factory and distillery created many jobs, especially for women’. Most sugarcane currently produced in Africa’s drylands 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 sugarcane in these regions are a real concern. Serious consideration should be given to accepting the suggestion made by Johnson & Matsika [43] that the new areas put under sugarcane to meet biofuel demands should be confined to regions with sufficient rainfall to avoid the need for irrigation.

In southern Africa’s drylands, Watson [32] 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 be 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, given the inherent dynamic nature of biomass production in drylands, loan repayments and quotas must be flexible enough to accommodate below average yields.

5. CONCLUSION
Land-use and biomass dynamics in Africa’s drylands are greatly influenced by the inherent disequilibrium behaviour of these environments. The implications of this in terms of conceptualizing key management concepts, the principle of which is sustainability, and of interpreting the causes, nature and effects of processes well represented in these environments, are contested. The preamble of African bioenergy policies should therefore avoid promoting modern bioenergy’s potential to redress deforestation and rehabilitate degraded land. The methodological approach used in the GIS work is sound. It revealed that Africa’s drylands potentially have substantial areas available and agriculturally suitable for bioenergy feedstocks production. The 1 km² resolution of the datasets used in the GIS work is adequate to give a quick, coarse assessment of these areas. However, their availability and suitability need to be verified initially using higher resolution satellite data and/or aerial photographs, and then in the field with local stakeholder consultation.

Research into constructing a database of areas where bioenergy feedstock production is constrained by social, cultural, political and archaeological factors should be prioritized.

Other lessons learnt from the project provide practical guidance for bioenergy feedstock production and bioenergy policies, including the need for (i) areas under bioenergy feedstock production to be adequately protected by firebreaks especially after good rainfall periods, (ii) a concerted effort to exploit the bioenergy potential of invasive alien plants, (iii) a cautious approach before authorizing the cultivation of any new, non-African bioenergy approach, and (iv) research into the bioenergy potential of plants indigenous to Africa to be prioritized. The time is ripe for active support of small-scale communal and freehold farmers in the way of loans, extension services and markets. However, given the disequilibrium nature of biomass productivity in dryland regions, 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. Sugarcane cannot be grown in Africa’s drylands without irrigation. Given this, areas proposed for large-scale biofuels production need to be assessed by a competent multi-disciplinary team.

REFERENCES


Watson, H. K. 2009 *Contesting views and changing paradigms: linking people with nature*. Pietermaritzburg, South Africa: CSIR.


