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Sustainability Standards for internationally traded Biomass

Sustainable Biomass Production from Degraded Lands

– Summary of Country Studies –

prepared for UBA/BMU

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Any omission, error or misconception of this summary report remains with the authors.

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Background and Aims

The use of biomass for energy production is rising globally in parallel to increasing oil prices, concerns on energy security, and climate change. Many countries recognize biomass as a domestic energy resource, and some see opportunities for exports of liquid biofuels. With political goals of e.g., the EU to increase the use of biofuels in the transport sector from a current rate of 2% up to 10% in 2020, and domestic biofuel quota systems being introduced in many other countries as well, there is little doubt that biomass use for liquid transport fuels, as well as for electricity and heat production, will continue to rise in the future, and that global trade with bioenergy will rise in parallel. This will pose both opportunities and risks for sustainable development for regions, countries, and the world as a whole.

In this context, the Federal Environment Agency (UBA), on behalf of the German Ministry for Environment (BMU), is funding a research project on sustainable global biomass trade (Bio-Global), carried out by Oeko-Institut and IFEU until Spring 2010. The project covers methodical aspects concerning climate protection, biodiversity, water and land use, but also aspects related to bioenergy trade and legal concerns (e.g., WTO, bilateral agreements). A key element in that research is to consider and elaborate on opportunities for sustainable biomass feedstock provision which have no negative or even positive environmental, biodiversity, climate, and social trade-offs.

The cultivation of biomass on abandoned farmland and especially on unused degraded land could safeguard against negative indirect land-use change (ILUC) effects from bioenergy development: As no displacement of previous cultivation occurs, biomass production from these lands will not increase pressure on protected areas and unprotected biodiversity-relevant areas by ILUC (RFA 2008; PBL 2010; Searchinger 2009; WBGU 2009). Hoogwijk (2003; 2004) estimated the amount of degraded land potentially available for energy crop production as a range from 0.43 to 0.58 Gha, resulting in a potential energy supply of 8–110 EJ/yr. Field/Campbell/Lobell (2008) estimated the abandoned agricultural land at 0,386 Gha globally that may provide about 5% of world primary energy consumption (reference year 2006), and ECN (2009) states that the contribution of water-scarce, marginal and degraded lands for energy crop production could be of about 70 EJ/yr. However, Metzger/Hüttmann (2009) give a higher figure of about 2.54 Gha (approx. 19% of total terrestrial areas) of degraded land being available for producing bioenergy. Thus, abandoned farmland and unused degraded land appear to be priority areas for biomass production.

However, it is questionable to what extend these areas are available. Caution is required because some of these unused lands may actually constitute areas of significant biodiversity value (Hennenberg et al. 2009) and because degraded lands are often the base of subsistence for the rural population (Berndes 2003).

In some regions, cultivation of degraded lands may place additional stress on scarce water resources if the crop requires increased irrigation or is characterized by high water use. Furthermore, regeneration of degraded land to natural habitat may be more beneficial in terms of carbon sequestration and biodiversity conservation than any benefits accrued from bioenergy feedstock production.

Prior to cultivation, a thorough evaluation of the effects of shifting degraded lands to cultivation should be included as an integral part of regional or national land-use planning. These evaluations should include the potential costs and yields of bioenergy feedstock production on these lands and assess and mitigate any negative trade-offs for biodiversity, the environment, and local communities (Hennenberg et al. 2009).

Within the Bio-Global project, country case studies in Brazil[1], China[2], and South Africa[3] have been carried out that aim:

- to provide GIS data for mapping of abandoned and degraded land and biodiversity-relevant areas on a national and sub-national scale, and to compare these data with globally available results of mapping (Work Package 1, WP1);
- to identify potential sustainable bioenergy production areas with a focus on degraded land, abandoned farmland as well as natural unused areas (top-down; WP2);
- to identify sustainable cultivation systems for these areas (WP3);
- to check the achieved results of GIS analysis (top-down) with selected data from the field, involving respective stakeholders (bottom up; WP4);

This paper gives an overview on the results of three country studies, separated for the four work packages. Furthermore, the following research questions are discussed on the bases of the presented results at the end of this paper:

- How suitable is the combined top-down and bottom-up approach proposed in this study to identify sustainable bioenergy production areas?
- Are energy crops available for an environmentally friendly and profitable production?
- How reliable are estimations on biomass potentials from degraded areas?

All details of the country studies are given in the reports for WP1 – WP4 of the respective countries.

1 see Ferraz/Alvares (2009), Ferraz/Alvares/Martinelli (2009) and Ferraz/Alvares/Martinelli (2010)

2 see USTB/JNP/NCC/CAAS (2009-2010)

3 see BFAP/GTI (2009a-d)

1 WP1: Availability of Spatial Data

The first task of each country study was the preparation of a brief overview paper on the availability on spatial data regarding the listed topics below considering data on different scales. A focus was set on regional, national and also sub-national data that were compared with global data. Given information covers, e.g., resolution, frequency of updating, data quality, costs and data availability.

Table 1 List of topics considered in the analysis of spatial data

Degradation land
Abandoned land
Unused ("natural") land
Land-use data
Suitability maps for cropping
Soil quality
Biodiversity relevant areas
Other special data that can be used to derive information on the upper categories
Social aspects: data on local people and their livelihoods (subsistence farming, land tenure etc.)

Each of the country reports for WP1 provides a detailed list of analysed datasets in the Appendix. The following main points can be concluded:

- The main *overall result* were that
  - no national datasets for abandoned land was available. Also datasets on unused (natural) land and on land use were mostly not suitable due to low resolution or low reliability of data. This has respective consequences on the identification of potentially suitable production areas under WP2.
  - data on land-use and social aspects are not available with a required resolution
- *South Africa:* Most of the required data with medium resolution (about 30m) are freely available in South Africa (e.g., land cover maps including land degradation and vegetation types of high carbon stock, protected areas, national biodiversity hot spots, soil maps, and land capability maps indicating its suitability for cultivation). The availability of a full set of both, national and global datasets, offers the comparison of the analysis at these two scales.
- *China:* Datasets for most of the topics listed above were available on a national scale. However, due to access restrictions and/or costs that exceeded the budget of this project, national data are not available for the analysis in WP2.
- *Brazil:* Only for some of the topics listed above data are available on a national scale and some data are only available for some parts of the country. Therefore, the Brazilian country study used in WP2 a mixed dataset from national (e.g., land cover) and sub-national (e.g., deforestation in the Amazon) to global datasets (e.g. land degradation).

2 WP2: Identification of Potential Areas for Biomass Production

2.1 Decision tree

The first aim of WP2 was to develop a *decision tree to identify potential areas for biomass production* that is in line with sustainability requirements of EU standards and specified for conditions of each partner country. This was done in co-operation with the project teams in each country and Öko-Institut incorporating the following two steps:

1. Top-down analysis: Making use of suitable datasets to identify potential areas. Considered datasets refer to, i.e., degraded land, areas of high carbon stock and of high biodiversity value and urban areas
2. Bottom-up analysis: Carrying out field assessment for those aspects that are not sufficiently covered by available datasets (e.g., social aspects, land-use pattern, water availability and soil conditions) and ground truthing the top-down analysis.

The general idea of the decision tree is to identify suitable and unused land for biomass production (degraded land, abandoned land and unused natural land) while negative impacts on the environment (greenhouse gas, biodiversity, soil, water) and local people (food security, local land use) are minimised.

Due to the different circumstances in each country, taking into account legal aspects as well as data availability, the decision trees differed between countries. As example, the decision tree from the Brazilian country study is shown in Figure 1.

2.2 Top-down analysis

The second objective of WP2 was to narrow down those areas that are potentially suitable for biomass production on the basis of those datasets evaluated as suitable in WP1. This top-down analysis results in a map of potentially suitable production areas for each country (see Figure 2 to Figure 4). This maps form the basis for the selection of focus areas to carry out field studies in WP4 (bottom-up analysis) to proof the reliability of the applied datasets and to gather further required data.

The Brazilian example shows well how the top-down approach works:

- In a first step, those degraded land that shall be used as priority areas are identified on the basis of global[4] and a sub-national datasets[5].
- In a second step, areas are identified that are already known to harbour protection good like high carbon stock and high values of biodiversity or that are definitely not available for cultivation ("no-go areas").
- In a third step, the "no-go areas" are stamped out from the map of degraded land, resulting in a map of potentially suitable areas for biomass production ("go areas").

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4 Bai ZG, Dent DL, Olsson L, Schaepman ME. 2008. Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC – World Soil Information, Wageningen.

5 MMA (Ministério do Meio Ambiente). 2004. Áreas Susceptíveis à Desertificação no Semi-Árido. Mapa digital. Secretaria de Recursos Hídricos – SRH.

However, it must be kept in mind that this “go areas” are only potentially suitable because the applied datasets may have errors because they are derived from information like remote sensing with no or limited ground truth and because several data show a rather low resolution. Furthermore, not all information required for a final decision is covered by the used data. On the other hand, also the excluded of some areas may incorrect. Thus, the top-down analysis provides a kind of first screening to narrow down potentially suitable areas, but *per se*, a field assessment is needed for final decision.

Figure 1 Flowchart used to identify potential cultivation areas in Brazil

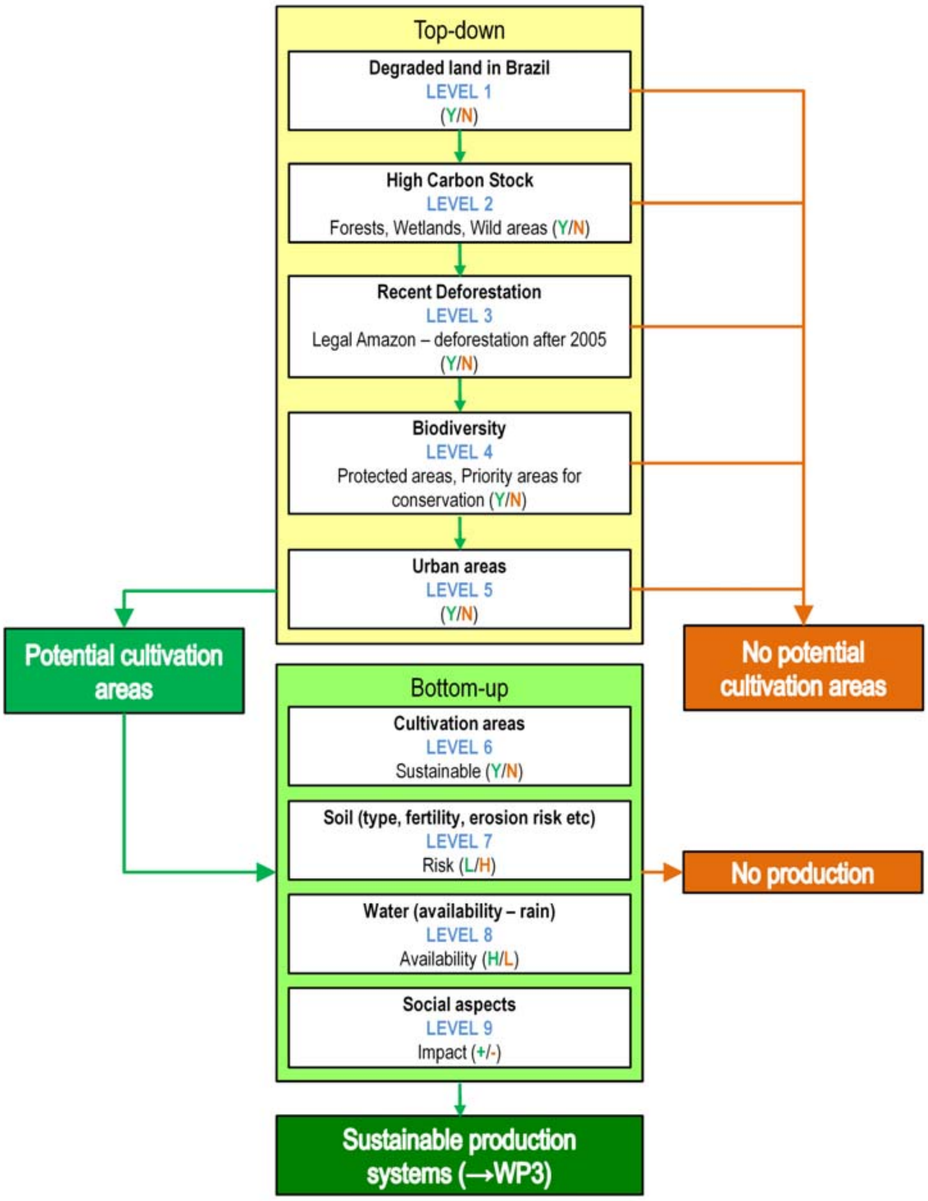
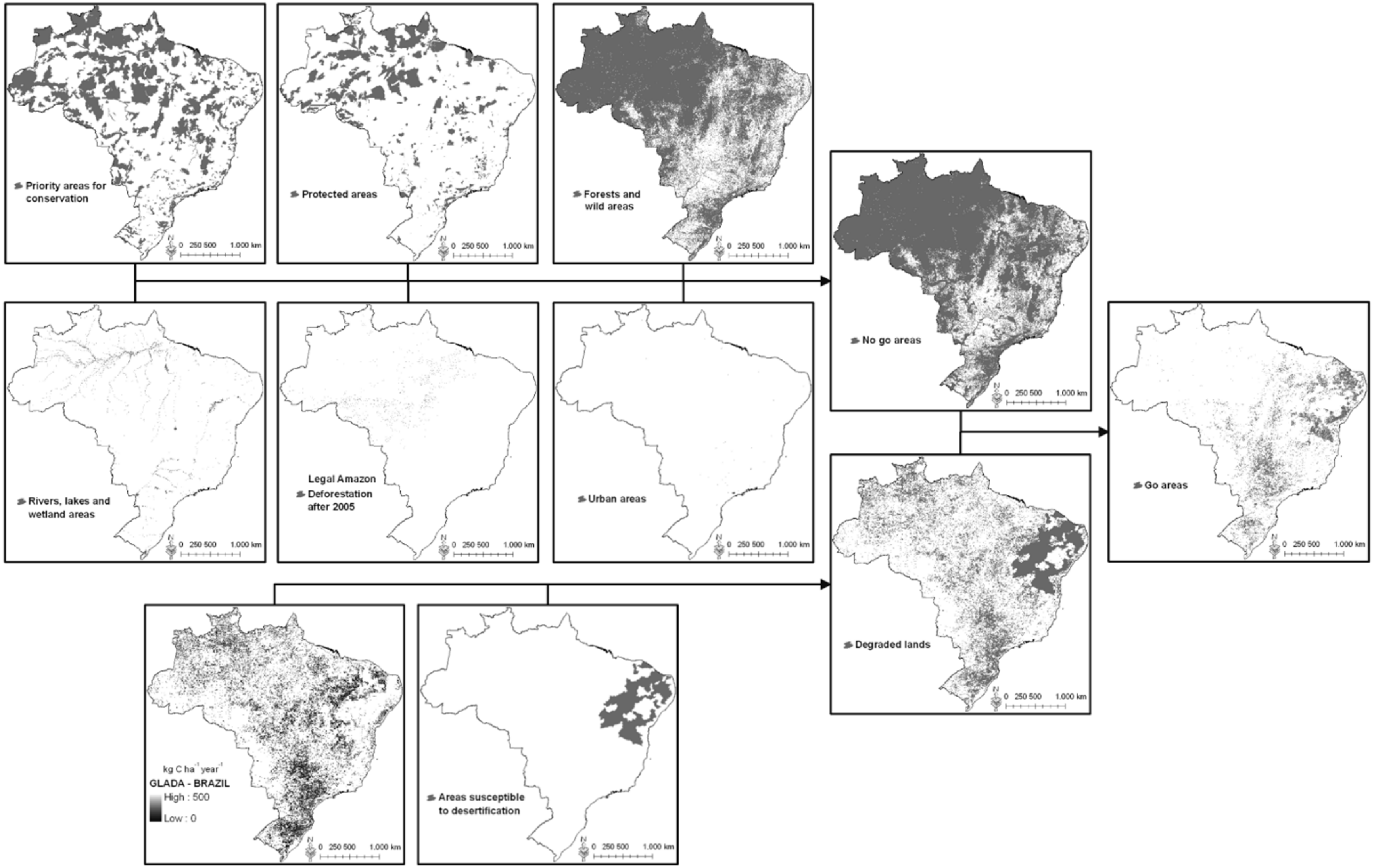


Figure 2. Potentially suitable areas for biomass production in Brazil



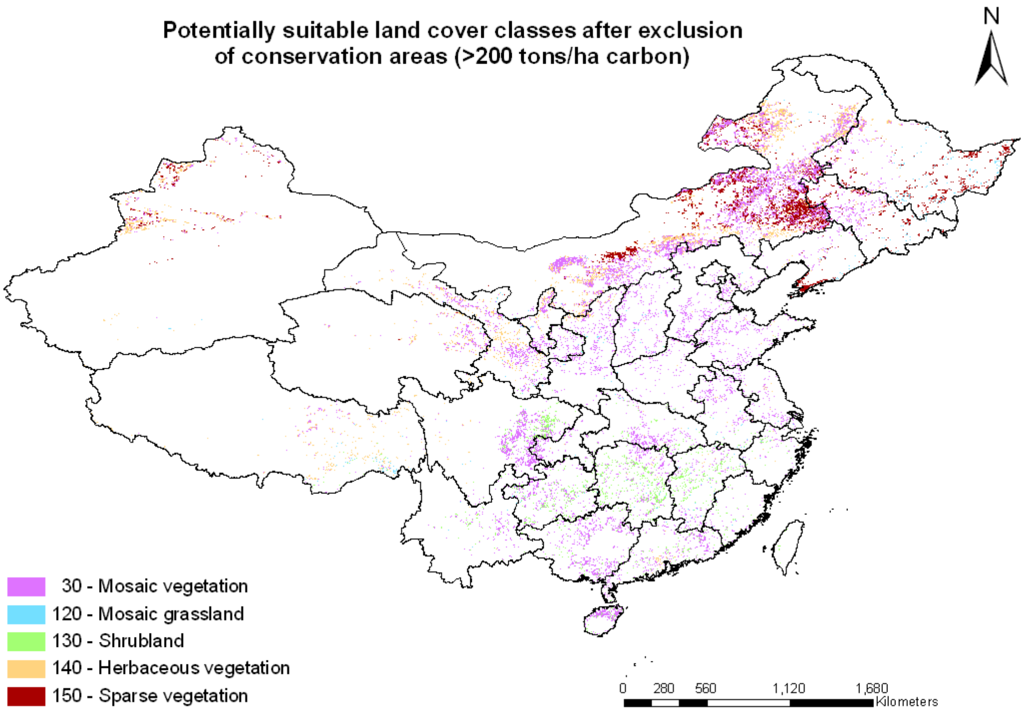
Brazil

In Brazil, the top-down analysis – based on global, national and sub-national data (Figure 2) – revealed that potentially suitable area for biomass cultivation cover about 8.5% of the Brazilian territory. These areas are mainly located in southern and north-eastern region of country, but almost no areas were found in the Amazon region (north-west). The latter results of excluding forested areas. However, in southern regions in Brazil, like São Paulo state, land degradation is strongly linked to expansion of agriculture, and for most identified areas a bottom-up analysis will lead to the exclusion of the areas due to land-use conflicts. This is not the case in north-eastern states. Therefore, the identification of sustainable cultivation systems (WP3) and the bottom-up analysis (two field studies in WP4) focused on this region.

China

The top-down analysis in China was carried out on global data because due to access restrictions and/or costs that exceeded the budget of this project. The Chinese partners focused on degraded land[1] as well as abandoned land[6] while excluding areas of high carbon stock, high biodiversity value and areas of potential land conflict (Figure 3). Depending on included degradation levels and exclusion levels for carbon stock, the amount of potentially suitable areas varies from 6.1% (576,000 Km²) to 1.6% (150,000 Km²) of Chinas territory (see details in the Chinese WP2-report).

Figure 3. Potentially suitable areas for biomass production in China



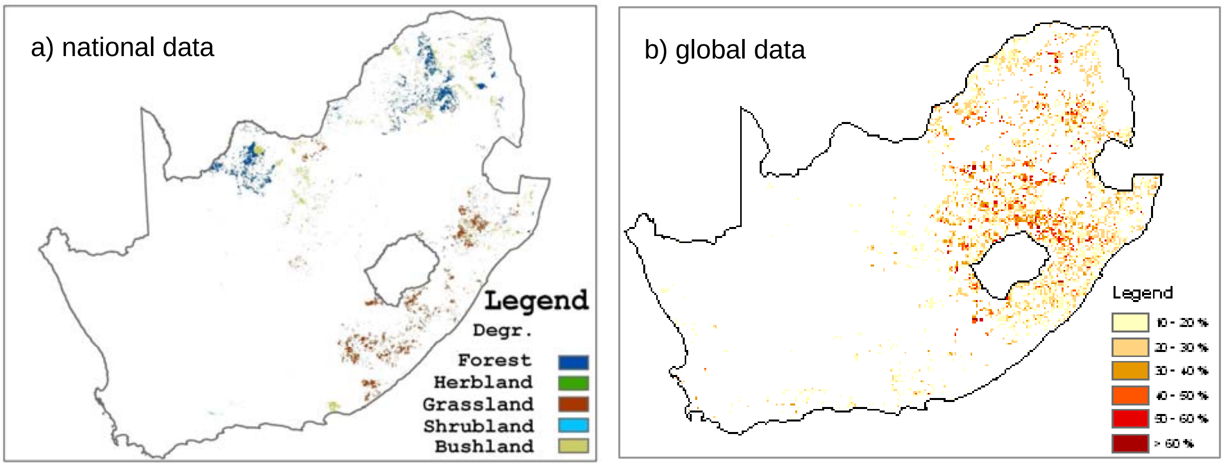
High confidence degrading and abandoned areas coinciding with suitable land cover classes after exclusion of protection areas and carbon stock areas (limit: >200 tons/ha).

6 Field CB, Campbell E, Lobell DB. 2008. Biomass energy: the scale of the potential resource. TREE 23: 65-72

<u>*South Africa*</u>

In South Africa, both, national and global data were available to carry out the top-down analysis, again including degraded areas and excluding areas of high carbon stock and high biodiversity value. This offer the possibility to evaluate to what extend results from global (low resolution) data – that are in principle available for all countries world wide – differ from national data characterised by higher resolution and better ground truth. The respective results are shown in Figure 4 a and b: the amount of potentially suitable land identified on the basis of national data is lower compared to the amount identified on the basis of global data. Furthermore, the location of identified areas differs substantially. From these results it becomes clear that the use of global data is limited and respective results need to be handled with caution.

Figure 4. Potentially suitable areas for biomass production in South Africa



Top-down analysis based on (a) national data and (b) global data considering degraded land and excluding areas of high carbon stock and biodiversity relevant areas.

3 WP3: Cultivation Systems and Biomass Potentials

The objective of Work Package 3 (WP3) is to select energy crops that are suitable for cultivation on identified areas for biomass production (WP2) and to develop promising cultivation systems for these areas. These cultivation systems are described regarding their cultivation practices (e.g., cultivated crops, inputs needed, machining), investment and operation costs, their yields and income per area, and their environmental (greenhouse gases, soil, water and biodiversity) as well as social impacts. This description considers cultivation on degraded land as a special focus. Based on this information, biomass production potential are estimated and extrapolated to the each country based on the results of WP2.

While developing cultivation systems it became evident that not only pure energy crops, but also food crops or crops with multiple use options (food, feed or energy) need to be incorporated in these systems to address food security issues as well as to reduce economic risks for farmers.

3.1 Cultivation Systems

Brazil

Following the analysis in WP2, the Brazilian team focused their work in WP2 on the north-eastern region of Brazil characterised by a semi-arid climate (Cerrado and Caatinga). The selected crops covering two oil plants (Castor-oil plant and Jatropha), two food crops (Cassava and Cowpea) and Eucalyptus as silvicultural species (wood and energy) are adopted to semi-arid conditions (Table 2).

Table 2 Proposed cultivation systems on degraded land in Brazil

Area	Type	Crop	Plant description
Cerrado	Oil plant	Castor-oil plant (*Ricinus communis*)	Shrub; high quality oil from seed; 500-1,500mm of annual rainfall; 0.8-2.5 t of seeds/ha; varieties for semi-arid regions and allowing divided harvesting; local markets not yet well developed
	Food crop	Cassava (*Manihot esculenta*)	Perennial; starchy and tuberous root; (400-) 1,000-1,500mm of annual rainfall; deep soils for root development; varieties for food and industry; 10-25 t WM of roots/ha; markets developed (food, flower, feed)
	Silviculture	Eucalyptus *(Eucaliptus* spp.*)*	Fast growing tree; *E. camaldulensis* recommended for semi-arid regions; increments of 10-20 m³/ha/year (about 6-12 t/ha/year); high water consumption; high economic value (fire and construction wood)
Caatinga	Oil plant	Jatropha *(Jatropha curcas)*	Shrub; high quality oil from seed; adopted to semi-arid climate; 0.5-12 t of seeds/ha (no good knowledge on varieties); treatment of poison residues; no local markets
	Food crop	Cowpea (*Vigna unguiculata*)	Annual legume (N-fixation); 250-500mm of annual rainfall needed; varieties suitable for manual harvest; up to 4.5 t DM/ha (lower on degraded land); local markets are developed
	Silviculture	Eucalyptus *(Eucaliptus* spp.*)*	See above

Species selection especially considered that most farmers have no access to improved agricultural techniques like machinery.

Furthermore, all five species have high potential for consortium cultivation such as Eucalyptus and Cowpea, Jatropha and Cassava, Castor-oil plant and Cowpea, and other alternatives of agro forestry systems.

China

The Chinese project gave a detailed analysis of 10 bioenergy crops[7], including their cultivation potential in China. Based this analysis, three energy crops appeared most likely to be of importance in China in the near future: Jatropha (*Jatropha curcas*), Cassava (*Manihot esculenta*) and Cana (*Canna edulis*).

Details for Jatropha and Cassava are already given in Table 2.

Cana is a starchy root crop with historic importance, today mostly used as an emergency food or as feed. It is easy to grow and has no significant pests or diseases. Typically yielding 20-40 t per ha (0.75-1.5 t/ha of starch),

Cana is often grown without irrigation on marginal soils or on slopes where its long crop duration (10-12 months) helps to prevent erosion, and this crop is suitable for cultivation on degraded land.

Based on this selection, three cropping systems were developed. Similar to the Brazilian approach, these systems cover the production of different products (food, feed and wood) and make use of advantages from consortium cultivation (see details in

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7 Crops for biodiesel production: Caper Spurge (*Euphorbia lathyris*), Castor oil plant (*Ricinus communis*), Jatropha (*Jatropha curcas*), Rape seed (*Brassica rapa*), and Tung-oil-tree (*Aleurites fordii*);

Crops for bio-ethanol production: Canna (*Canna edulis*), Cassava (*Manihot esculenta*), Sugar cane (*Saccharum officinarum*), Sweet potato (*Ipomea batatas*), and Sweet sorghum (*Sorghum bicolor*)

Table 3 and Figure 5 as example).

South Africa

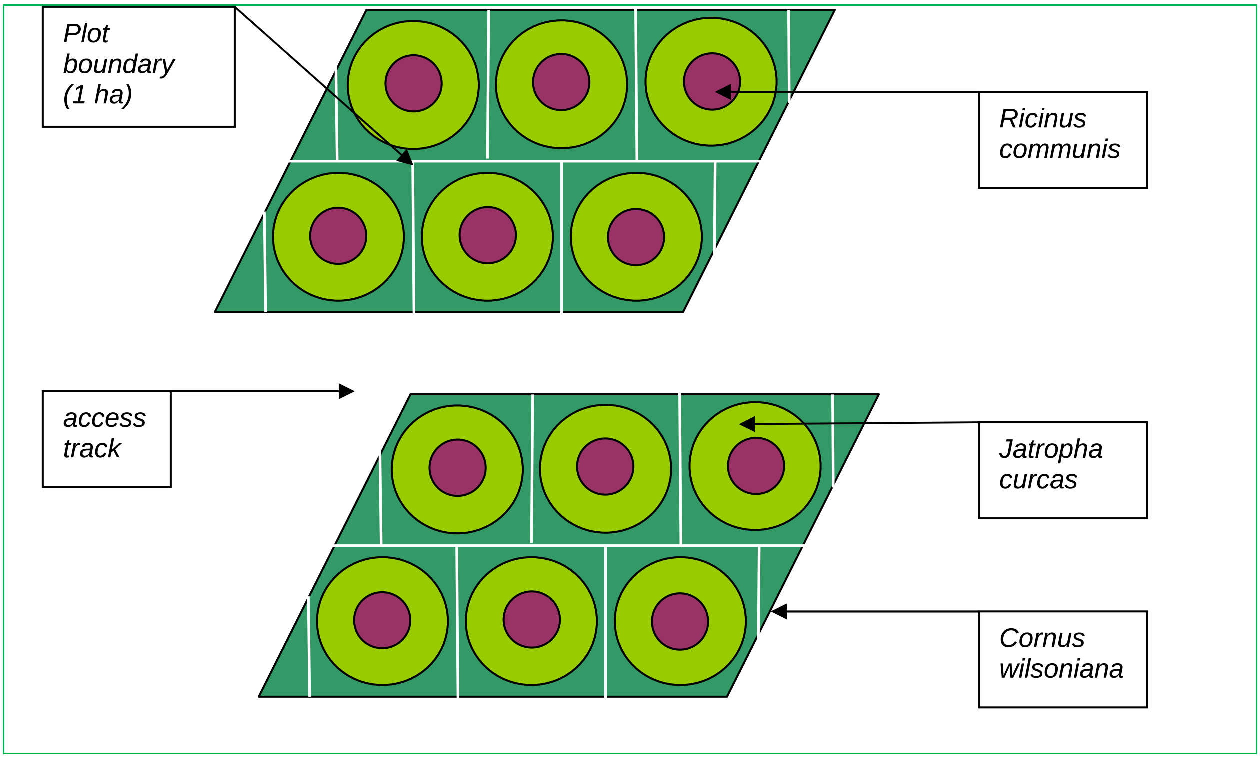
In South Africa, the national strategy excludes maize from bioenergy production for reasons of food security, but also Jatropha that has been recognised as an invasive species. On the other hand, the use of sugarcane, sugar beet, soybeans, sunflower and canola is promoted, but irrigation is not allowed.

Due to this country-specific restrictions and because in many South African regions of maize-maize rotation is on central factor for degradation, the South African team focused their work on improved rotation systems based the annual crops (soybeans, canola and sorghum) – used for energy, feed or food – in combination with maize (food only).

Table 3 Proposed cropping systems on degraded land in China

Cropping system	**Description**
1. Agroforestry based on Castor oil plant, Jatropha and *Cornus*[8]	- 3-storey system in which *Cornus* occupies the top storey, Jatropha the middle and Castor oil plant the lower one. If necessary, a greater fodder component might be integrated into the system by adding further fodder plants to enrich the diet. - Products: Oil, fodder and wood - - On land with 15–25° slope between 600 and 1,200m
2. Intercropping of Cassava, *Stylosanthes* and Jatropha	- Small-scale rotation of Cassava (4 years, 60% of the area) and *Stylosanthes guianensis*[9] (2 years, 30% of the area), combined with Jartopha hedges (permanent, 10% of the area) - Products: Starch, oil and fodder - - Recommended on degraded land between 5 – 15° slopes from 600 to 1,200m.
3. Crop rotation of *Canna* and grain crops	- *Cana* in rotation with food crops (e.g., maize, soy bean or peanut) or together with maize in a mixed system - Products: Starch, food - - Cultivation on degraded land at the lower end of slopes (0-5°).

Figure 5 Agroforestry crop arrangement (China)



for biodiesel and other products on 15-25° slopes (based on Ricinus, Jatropha and Cornus)

8 The tree *Cornus wilsoniana* grows naturally relatively quickly, mostly at altitudes below 1,100m. Its wood can be used for furniture and its flowers are attractive to bees. *Cornus* provides good quality food oil, high in oleic acid, and its leaves are good fodder.

9 Legumes can be used as forage for ruminants, but are also dried as fodder for pigs and chicken.

3.2 Economic aspects

Each team provided detailed data on production costs for feedstocks, if available (see details in WP3-reports of each country study). Regarding profitability, the results from South African may serve as good a good example how the profitability of feedstock production is strongly linked to yields.

Table 4 reflects low-yield situation on degraded land observed during field trips, resulting in negative profitability-values.

Table 4 Profitability of farms on degraded land (South Africa)

Profitability of farms on degraded land				
Crops	**Maize**	**Sorghum**	**Canola**	**Soybeans**
Average yields (t/ha)	0.4	0.25	0.25	0.5
Estimated local market price (R/ton)	2300	1610	3324	2926
Total turnover (R/ha)	920	402.5	831	1463
Total cost per ha before marketing	**2,866.62**	**2,848.65**	**2,713.43**	**3,522.12**
Total profit / loss for the farm	**-1,946.62**	**-2,446.15**	**-1,882.43**	**-2,059.12**

However, Table 5 indicates the minimum yields that are needed to achieve profitability. These yield improvements appear realistic when agricultural practices (e.g., soil conservation) and rotation systems are improved. However, technical advice and financial incentives are required.

Table 5 Improving the profitability (South Africa)

Profitability of farms on degraded land				
Crops	**Maize**	**Sorghum**	**Canola**	**Soybeans**
Average yields (t/ha)	1.5	2.15	1	1.2
Estimated local market price (R/ton)	2300	1610	3324	2926
Total turnover (R/ha)	3450	3461.5	3324	3511.2
Total cost per ha before marketing	**3,439.94**	**3,418.38**	**3,256.11**	**3,522.12**
Total profit / loss for the farm	**10.06**	**43.12**	**67.89**	**-10.92**

Example from farms in the Eastern Cape.

3.3 Biomass Potentials

The general idea in this project was the estimation of biomass potentials on the basis of identified production areas (top-down, WP2) and the achievable yields on these areas (WP3). However, this up-scaling was mainly limited by the imprecise character of the top-down data. As shown in WP4 (see next Section), it is rather uncertain if an indentified area is available for production or not.

Thus, a rule-of-thumb value of how much of the area may be cultivated by an energy crop must be introduced, giving rather vague results.

For example, the South African team estimated that about 20% of the potentially suitable production areas could be used for bioenergy cultivation.

Assuming yields of 0.3 t/ha and yr for degraded grassland and 1.2 t/ha and yr after rehabilitation of degraded areas, they calculated biomass potentials of 353,000 t/yr and 1.4 million t/yr, respectively.

The Chinese team estimated that for the cultivation of Jatropha, Cana and Cassava about 300,000 ha, 100,000 ha and 100,000, respectively, could be available on a national scale, resulting in a biomass production of about 7 million tons/yr or about 790 million litre/yr of biofuel.

The Brazilian team, however, rejected to carry out calculations due to the limitations described above.

4 WP4: Bottom-up analysis

The aim of WP4 was to carry out a bottom-up analysis on areas that have been identified as potentially suitable for sustainable production of biomass within the top-down analysis in WP2. The bottom-up analysis focuses on two aspects:

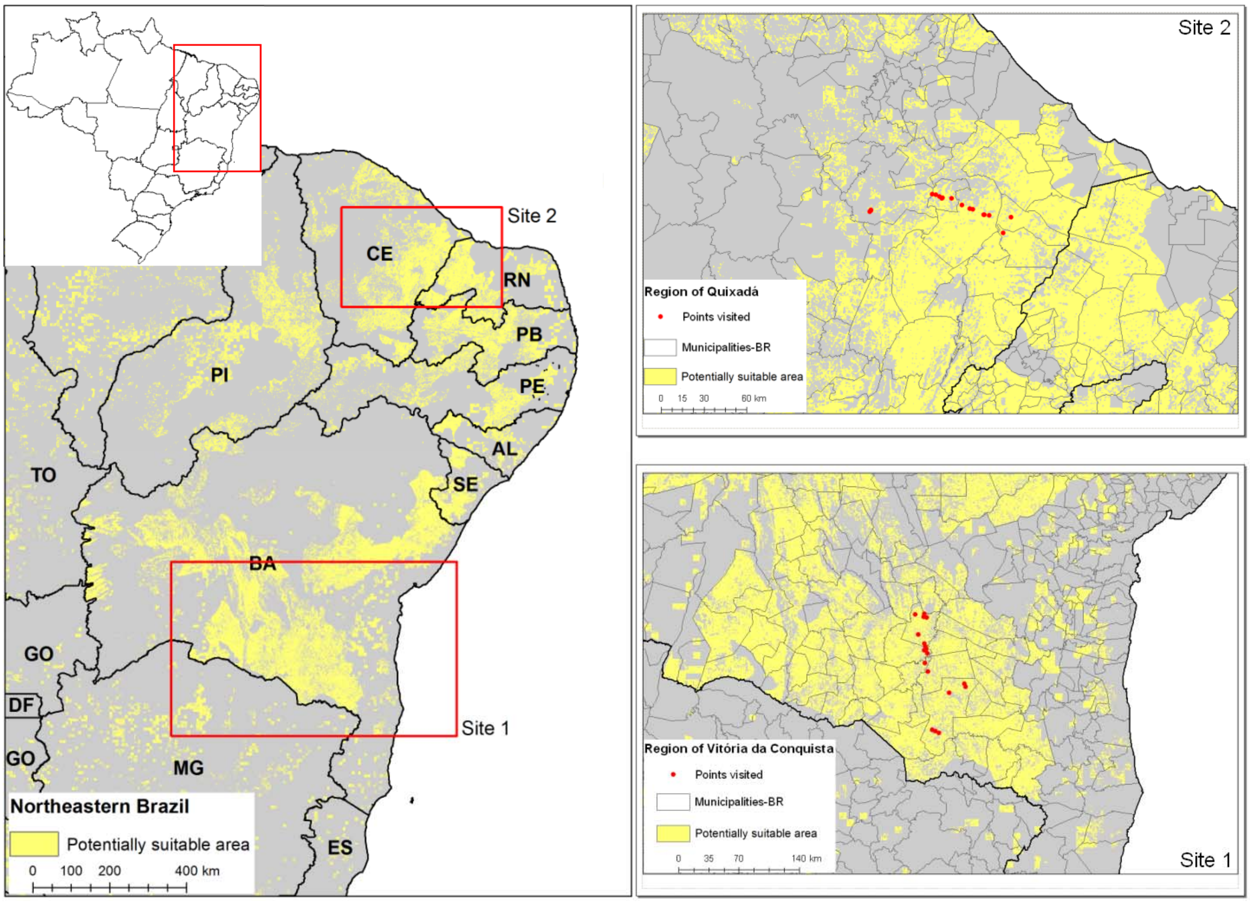
- Ground truth of the results from the top-down analysis
- Field assessment for those aspects that are not sufficiently covered by available datasets (e.g., social aspects, land-use pattern, water availability and soil conditions)

Due to budget restricts, the bottom-up analysis could only be carried out for two focus areas with a minimum size of 1 Km² in each country. However, the variability within each country cannot be covered with this low number of replicates. Thus, it must be noticed that these analyses only can give a first impression to what extent potentially suitable areas are rally suitable and available for biomass production.

<u>*Brazil*</u>

For the bottom-up analysis, two focus areas have been selected in the north-eastern Brazil have been selected that showed a high amount of potentially suitable areas (Figure 6).

Figure 6 Selected focus areas at north-eastern Brazil



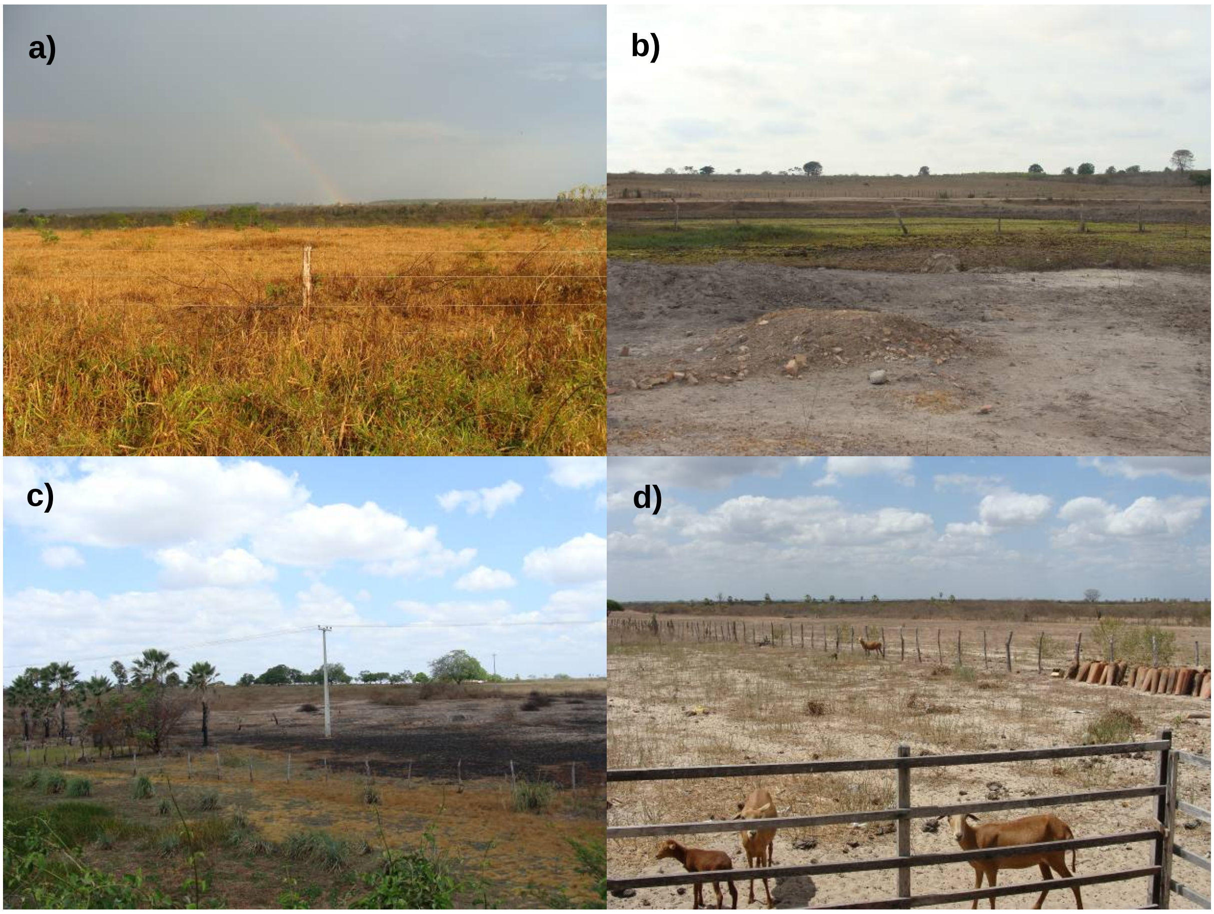
Site 1: Vitória da Conquista region (BA = Bahia state); Site 2: Quixadá region (CE = Ceará state). Red dots illustrate locations visited during the field assessment.

In total, 18 sites have been visited in the Vitória da Conquista region, and 12 sites in the Quixadá region. These sites were characterised by slight to high degradation levels.

The bottom-up analysis revealed that top-down data for *land degradation* and *carbon stock* fit pretty well with field observations. However, this was not the case for the *biodiversity* value of areas: more than 50% of the visited sites in the Vitória da Conquista region were recognized as areas of high biodiversity value, and at sites in the Quixadá region this proportion was one-third. Regarding current *land use*, in the Vitória da Conquista region, about 20% of the visited sites were in cultivated (cultivation of coffee) and 80% were abandoned, whereas in the Quixadá region, all visited sites were in use (agriculture in combination with animal breading on tow third of the sites; cattle breeding on one third of the sites). The *production potential* of in both regions was evaluated as low to medium. The main constrains were related lag of water availability (low amounts and high variability), whereas soil parameters showed values suitable for cultivation.

These two field studies clearly show that the combined top-down and bottom-up approach used in this project is powerful to identify suitable production areas for bioenergy.

Figure 7. Photos from visited sites in Brazil



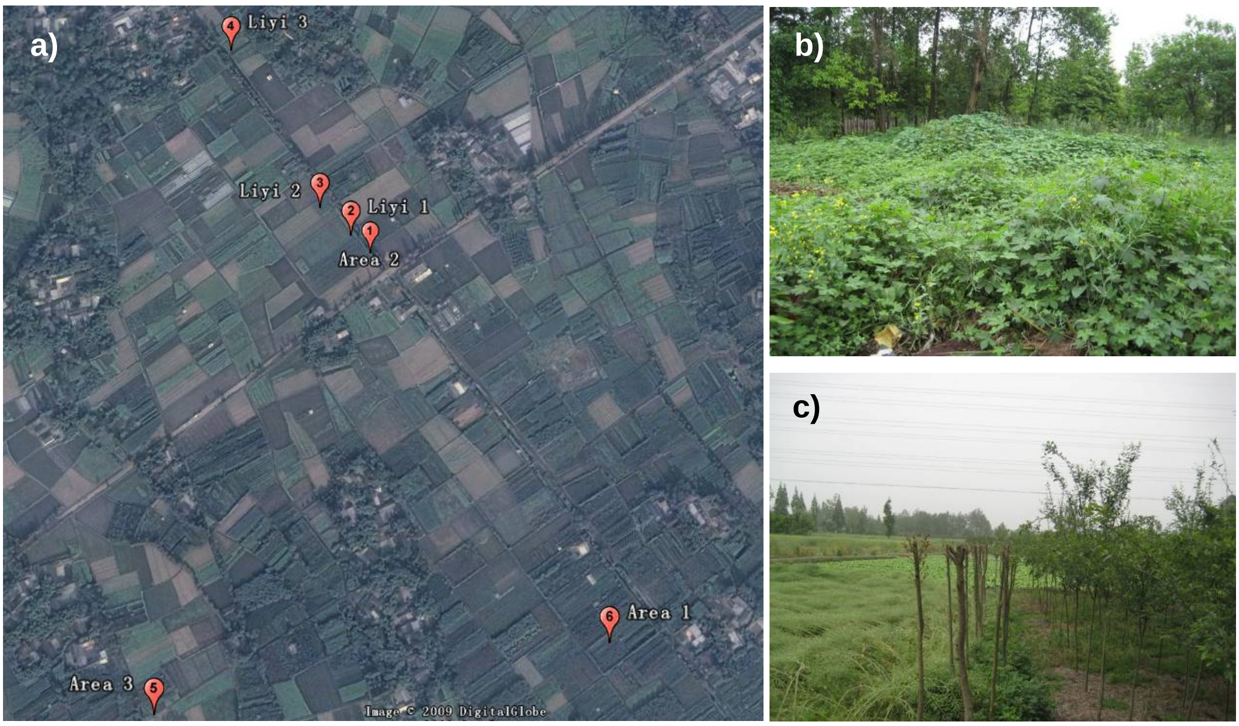
Vitória da Conquista region (a, b); Quixadá region (c, d)

China

Based on the top-down analysis, the Chinese team selected the Wenjiang District (Sichuan Province) and Xingyi District (Guizhou Province) for on-side assessments, because these districts show high amounts of potentially suitable areas for biomass cultivation. Because interviews reveralt that in the Wenjiang District only a low amount of land is not in use, the final selection of a focus area of 1km² (see Figure 8) was guided by local stakeholders to increase the probability that the areas also covers unused land. In the Xingyi District, three areas have been selected for on-side assessments, also guided by local stakeholders.

The focus area in the Wenjiang District was almost completely used for agriculture purposes. On many areas ornamental plants are cultivated that are economically attractive. The area showed slight degradation, but the land is still suitable for cultivation. Because almost all land is in use introducing bioenergy in the area would lead to land conflicts. However, it is not likely that local farmers would be interested in bioenergy cultivation because cultivation of other crops, especially of ornamental plants, is more lucrative. In total, the bottom-up analysis revealed that the focus areas in the Wenjiang District – as well as the whole district – is not suitable for biomass cultivation in the sense of the project.

Figure 8 Photos from visited sites in Wenjiang District (China)



(a) Areal photograph of focus area (1 km²) in Wenjiang District; (b) Photo of Area 1; (c) Photo of Area 3.

In Xingyi District, however, the situation differed. The district is located in a hilly Karst areas characterised by step slops that are often degraded due to human activities.

Many parts of the visited focus areas were classified as degraded and/or abandoned land with low carbon stock and without high biodiversity value. Sustainable cultivation of bioenergy crops would be possible on these areas, especially when adopted cultivation systems – as proposed in WP3 – would be applied. Because the Xingyi District is one of the poverty regions in China, the cultivation and use of energy crops would offer an option to generate surplus income.

Figure 9 Photos of hilly Karst areas in Xingyi District (China)

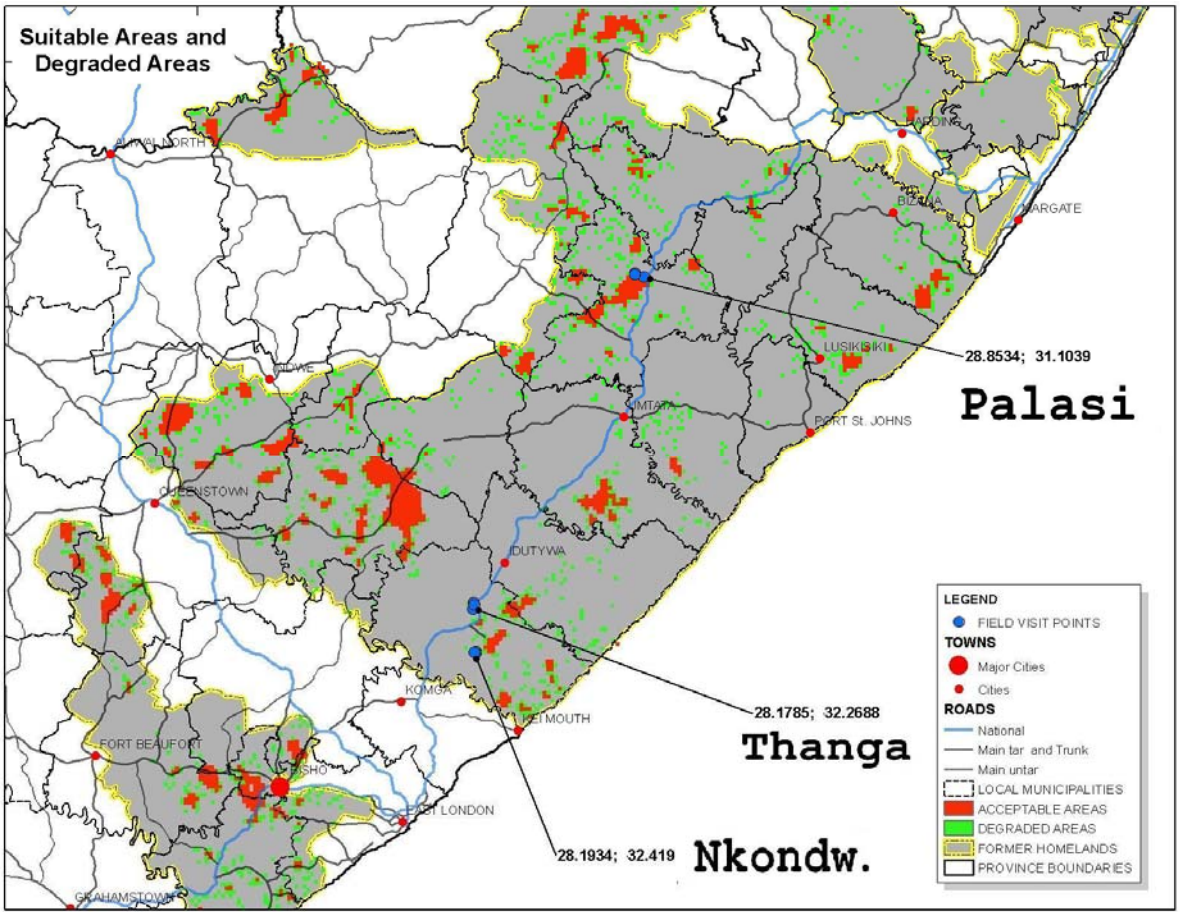
The bottom-up analysis at the two focus areas showed both, the risks of misinterpretation due to the low resolution and low reliability of global data (Wenjiang District) as well as the possibility to identify areas that are suitable for sustainable bioenergy production. However, for future land-use planning on behalf of national and local governments it is recommended to carry out a study with unlimited access to national up-to-date data to identify suitable areas for biomass production in a more reliable way.

South Africa

In South Africa, field studies focused on former Homelands[10] located in the Eastern Cape because the National Biofuels Industry Strategy 2007 promotes to source feedstock from former Homelands or other land where emerging farmers settle and because Eastern Cape was most recommended region in South Africa for sustainable bioenergy cropping (see WP2). Three focus areas located in the local municipalities (LMs) Mnquma and Mhlontlo, near the towns of Butterworth and Qumbu in the Eastern Cape, were chosen (Figure 10). The natural vegetation units of the focus areas are mainly Savanna subtypes and Grassland, with some spots of Mistbelt Forest (see Figure 11).

[10] Former Homeland or Bantustan areas were formed by the white minority government in 1951 to enforce the Bantu Authority Act (the beginning of the segregation or Apartheids policy) in order to separate white settlement areas from black ones.

Figure 10 Map of the focus areas in the Eastern Cape

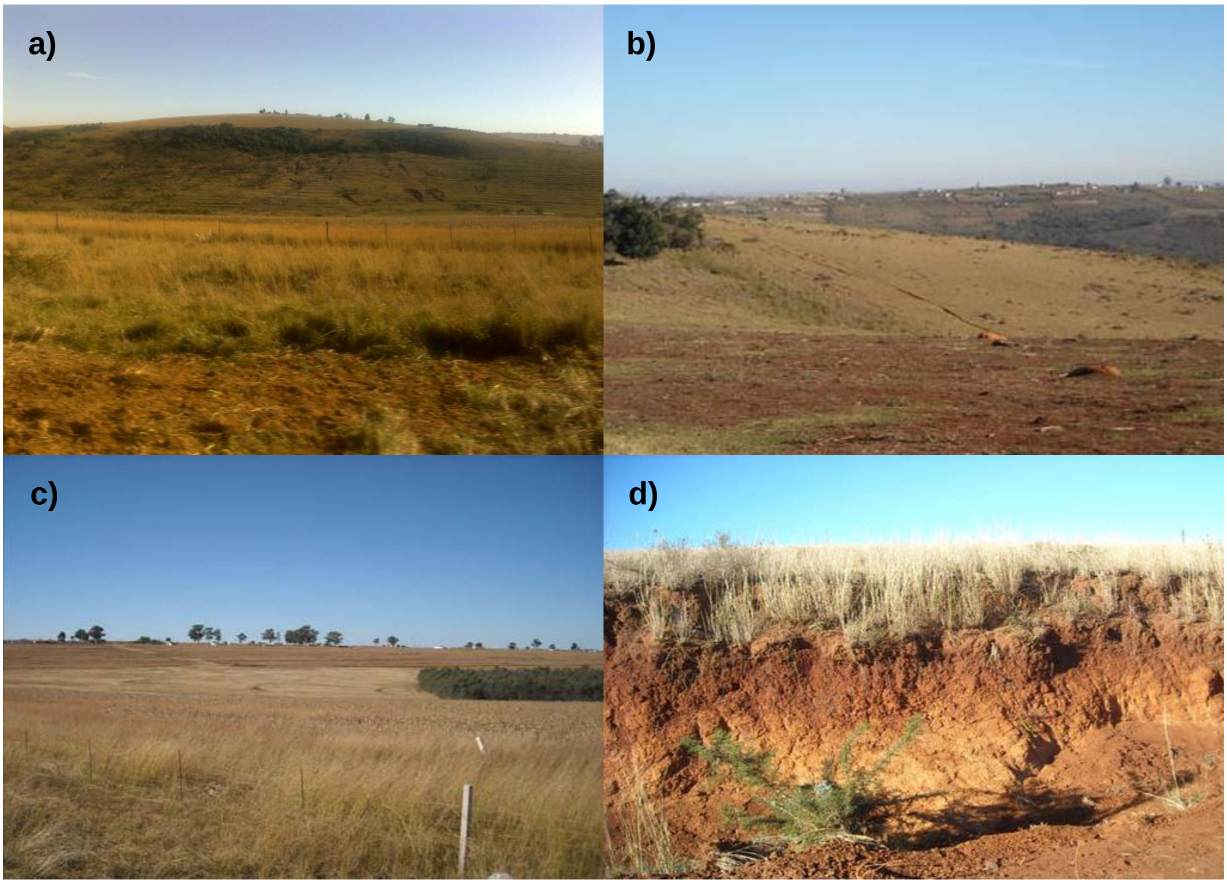


Acceptable areas (degraded areas with high land capability) are stamped out, while national parks and reserves, protected and highly biodiverse areas are excluded. Focus areas are marked with dots (Mnqume and Mtlonthlo local municipalities).

The bottom-up analysis revealed that all three focus areas showed *land degradation* related to both, vegetation and soil. Degradation, however, was mainly caused improper cultivation systems. The investigated areas mainly showed a low *carbon stock*, except of some forested parts (tree savannah and riverine forests), and all three focus areas showed no high *biodiversity* value. In total, the ground truth of information from national datasets used in the top-down analysis showed a high reliability of the data.

Many areas in the focus areas Thanga and Nkondwana are unused. These areas show sufficient conditions for bioenergy cultivation regarding *soils* and *water*, availability, especially when soil conservation measures are applied. However, *land availability* is restricted due to customary rights for grazing and cultivation. In the focus area Palasi, the area is already designated for food production, but cultivation did not started yet. Here, bioenergy production would conflict with food security issues, but improved cultivation systems as proposed in WP3 may solve such conflicts and increase overall benefits for local farmers.

Figure 11 Photos from visited sites in Brazil



(a) Thanga focus area (plot 1) with fenced off maize field and unused terraces for maize cultivation; (b) Focus area near Nkondwana village with eroded top soil and slopes; (c) Focus area near Palasi village with a large scale maize project, forest areas and neighbouring grazing land; (d) Soil profile in Thanga.

In general, the national GIS data, which was used in the top-down analysis (WP 2), are adequate to identify and narrow down valid target areas for sustainable biomass production in South Africa. However, despite being of good technical quality (resolution, scale), the informative value of the used GIS data is sometimes limited as values are based on prescribed definitions for e.g. degraded land, land capability, biodiversity etc. As a consequence, due to shortcomings in the data, the findings are sometimes open for interpretation or are even biased.

Furthermore, GIS data is not suitable for sensing complex criteria, such as the social impact, but can only depict individual aspects of that complex such as infrastructure. Therefore, the findings of a bottom up approach did contribute to a more complete picture of the situation or even to correct information displayed in GIS maps.

5 Discussion and Conclusions

1. How suitable is the combined top-down and bottom-up approach proposed in this study to identify sustainable bioenergy production areas?

The overall result of the country studies is that the applied approach of a combined Top-down and Bottom-up analysis to identify suitable areas for sustainable biomass production is in general feasible. However, the hit-rate of suitable areas depends on the quality of the used Top-down data, especially visible in the comparison of national and global datasets in South Africa. Furthermore, one must be aware that additional suitable areas can and will exist outside of the preselected areas.

The country studies clearly showed that the Bottom-up analysis is evidentially needed. Information from Top-down data is sometimes incorrect (e.g., degraded land and carbon stock) or not complete (e.g., biodiversity), and important aspects are not sufficiently covered by available data (e.g. land use).

An important point is that the used approach can be applied on the bases of globally available data as proven in the Chinese country study. If more appropriate national data are available, global and national data can be combined (see Brazilian case) or a complete national dataset may be use (see South African study).

2. Are energy crops available for an environmentally friendly and profitable production?

In each country study, promising energy crops and cultivation systems have been identified that can be used for cultivation under the environmental and political circumstances in the respective country. Thus, from a technical point of view, production on the degraded land is possible. However, economic feasibility may be questionable in several cases, mainly caused by low achievable yields on the areas.

3. How reliable are estimations on biomass potentials from degraded areas?

The Bottom-up analysis – though repetition was rather low – showed clearly that Top-down data alone do not allow a reliable estimation of the amount of potentially available degraded land for biomass cultivation. Estimations on available degraded land of 0.43 to 0.58 Gha (Hoogwijk et al. 2003) up to 2.54 Gha (about 19% of the total terrestrial areas; Metzger and Hüttmann 2009) based on Top-down data very likely overestimate potentials. It was not possible in this project to evaluate a realistic correction term of these estimations, but the amount of available degraded land appears to be at least 10-times lower than the estimations of Hoogwijk et al. (2003). Here, further ground truth is needed to give serious figures.

But, nevertheless, the country studies also showed that there are potentials to produce bioenergy on unused and degraded lands. If managed well, this bioenergy production can achieve the promised positive impacts, i.e., the reduction of GHG emissions, rehabilitation of degraded areas and opportunities for rural development including access to modern energy.

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