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CHALLENGES AND OPPORTUNITIES FOR BIO-FUEL PRODUCTION IN THE AFRICAN COUNTRIES

Table of Contents

I. Introduction

1. Bioenergy and more precisely biofuels have been the topic of discussions around renewed agricultural development for the last few years. Their perceived risks and benefits for the environment, food security and development in general have ranged from panacea to total destruction.

Table 1: Biofuels by source and types

Production side, supply	Biofuel type	User side, biofuel examples
Direct woodfuels	WOODFUELS	**Solid:** fuelwood (roundwood, chips, sawdust), charcoal
Indirect woodfuels		**Liquid**: black liquor, ethanol
Recovered woodfuels		**Gaseous:** pyrolysis gas
Fuel crops	AGROFUELS	**Solid:** straw, stalks, husks, bagasse
Animal by-products		**Liquid**: ethanol, oil diester
Agro-industrial by-products		**Gaseous:** pyrolysis gas, biogas
	MUNICIPAL BY-PRODUCTS	**Solid:** municipal solid wastes
		Liquid: sewage, sludge, pyrolytic oil
		Gaseous: pyrolysis gas, biogas

2. This paper will focus on the African pallet of agrofuels [1], which are biofuels obtained as a product of energy crops and/or agricultural by-products (including animal and agro-industrial by-products) (FAO 2004) and their best choice and development alternatives with benefits to national and rural development. Table 1 illustrates the different types and sources of existing biofuels.

3. Much of the international attention tends to focus on large scale liquid biofuels for transport, which is only a minor fraction of all biofuels. It is however the biofuel most traded on international markets and the most controversial one, as concerns impact on environment and food security. As a result, other types of biofuels and other uses than transport are given less attention and their importance for rural and national development are often simply not valued or not fully understood.

II. Current agrofuel situation in Africa

4. Overcoming energy poverty is one of Africa's greatest challenges and vital to achieving the Millenium Development Goals. Energy consumption characteristics vary widely between African countries, but most per capita consumption is far below world averages, as illustrated in Table 2 (CIFOR 2009). Africa's vast potential of renewable and non-renewable energy sources remains vastly underexploited (OECD 2009). However, the exploitation of these resources needs to be well planned and regulated to avoid large scale destruction and to assure benefits are shared equitably with rural and urban poor and small scale producers and businesses for the improved well-being of all Africans.

[1] According to FAO terminology (FAO 2004):
- *Biomass* is non-fossil material of biological origin, such as energy crops, agricultural and forestry wastes and by-products, manure or microbial biomass;
- *Biofuel* is either biomass used as fuel directly, e.g. firewood, or processed biomass such as charcoal, bioethanol, biodiesel, biogas (methane) or biohydrogen;
- *Bioenergy* is energy derived from biofuels;
- *Agrofuels* are biofuels obtained from non-woody agricultural crops and organic agricultural and agro-industrial by-products
- *Agricultural by-products*: "Biomass by-products originating from production, harvesting and processing in farm areas"
- *Animal by-products*: "... by-products originating from livestock keeping. It includes among others solid excreta of animals"
- *Agro-industrial by-products*: "Several kinds of biomass materials produced chiefly in food and fiber processing industries"

Table 2: Annual energy consumption characteristics of sub-Saharan African and selected countries compared to global trends (World Bank 2009)

	Energy use per capita (kgoe)	Total energy from biomass and waste in %	Electricity consumption per capita (kWh)	Liquid fuel consumption per capita*
World	1796	9.7	2678	751
Sub-Saharan Africa	681	56.3	542	117
Ghana	397	66.0	266	122
Tanzania	530	92.1	61	45
Kenya	484	74.6	138	101
Mozambique	497	85.4	450	39

Source: Compiled from World Bank 2008
* Calculated from 2004 oil consumption and population data at www.eia.doe.gov/emeu/international

5. A recent World Bank report (WB 2010) summarizes IEA and FAO statistics and predicts a large increase in use of primary solid biomass fuels to 2030, larger in total mass than growth in fossil fuel consumption. Solid biomass energy consumption is expected to be equal to production, although it remains mostly subsistence oriented, unhealthy, unsafe and unsustainable in nature (FAO 2009). Its share of total primary energy supply (TPES) decreases from 63.3% of the total in 2005 to approximately 51% in 2030 despite its 27.8% increase in consumption to 377.4 MTOE[2] including fuelwood, agricultural wastes and more modern uses. The same projections assume a production of only 3.2 and 3.5 MTOE of bioethanol and biodiesel, respectively, by 2030 of which about one third may be consumed in Africa. This compares to a production projection for Latin America of 20.4 and 5.9 MTOE bioethanol and biodiesel, respectively, for 2030. The land resources for such production increases seem to be available (see Table 3), although suitable land availability varies greatly from country to country and much more detailed analysis of the type carried out by BEFS (BEFS 2009) is necessary to obtain information reliable enough for local land use planning.

6. The relatively high increase in primary solid biomass consumption (fuelwood) is due firstly to population growth (in 2015 a further 54 million Africans will be dependant on traditional biomass (IEA 2006) and second to a rise in income too small to result in significant switching to other types of fuel. Urbanization and rising urban income are expected to continue the trend towards a higher charcoal portion of overall fuelwood use, thus increasing the overall fuelwood demand due to high transformation losses (WB 2010, p.123). Therefore solid wood biomass will remain the main bioenergy and energy source, in general, for Africa and without decisive intervention this will lead to shortages and severe environmental consequences.

7. Most African countries produce sugar, but few have ventured into sugar ethanol production like Malawi and more recently Mozambique. Jatropha production across the continent is still low, but the oil has also been used in pilot electrification projects, which exhibit a very slow startup period due to the fact that it takes at least 4 years from planting to oil production. Using various waste products for electricity (co-)generation faces large infrastructure (transport) and investment barriers. In general though physical potential for bioenergy production is estimated to be fairly high.(WB 2008).

8. Although the future competitiveness of African liquid biofuels is still uncertain, even if expected to be lower than that of other net-exporting regions, Africa has and continues to attract investment for export production. It is those investment pressures, often for large tracts of land,

[2] MTOE – Million tons of oil equivalent

including high biomass forests and grasslands or otherwise good agricultural land, that are making a careful decision making process urgent, before invaluable natural resources or food production potentials are irreversibly lost.

Table 3: Rough estimates on land needed to meet five per cent (two per cent for South Africa) biofuel targets and total fuel needs (based on von Maltitz and Brent 2008 from CIFOR 2009)

	Botswana	Namibia	Tanzania	S. Africa	Mozambique	Zambia
Diesel use in l/yr x 10^6	281	445	667	7 987	381	327
Petrol use in l/yr x 10^6	301	325	202	10 289	107	210
Percent of total land needed to meet transport fuel needs	0.9	0.9	1.2	14.6	0.8	0.8
Land needed to meet biofuel targets in ha	26 078	38 917	53 855	307 375	30 631	56 286
Estimates of jobs created to meet biofuel targets[1]	12 251	18 608	26 399	142 919	15 036	27 046
Estimates of jobs created to meet national fuel usage[1]	245 028	372 160	527 980	n/a	300 712	270 458

All calculations based on sugarcane and Jatropha as feedstock. Values are not linked to specific country or growth conditions and assume suitable land is available.
[1]These figures are based on 0.5 jobs per hectare for biodiesel and 0.33 jobs per hectare for sugarcane as used in Econergy 2008. Most would be low-paying labourer jobs.

2.1 Significance of bioenergy in economic terms (for Africa)

9. To date the most significant value of bioenergy to the African economy is that of solid biomass as fuelwood for cooking and heating. Approximately 603 million m^3 were consumed in 2007 (FAO 2009). An increasing amount is transformed into charcoal for mostly urban consumers. Efficiency of both charcoal and wood fuel can be greatly improved and with it the life quality and contribution to the economy of millions of women and children (two million death per year in developing countries from fuelwood use alone, mostly in unventilated kitchens (UNDP/WHO 2009). Cooking and heating stove improvements have been promoted for decades with only scarce success at occasions where innovative and dynamic local entrepreneurs, with considerable start up support, have commercialized and made attractive low cost stoves. Multiplier effects from improved health and additional household time related to improved use of fuelwood and charcoal are expected to be significant at the household and community level.

10. Agrofuel production is expected to revitalize the agricultural sector and thus has the potential to significantly contribute to better income and food security of a large percentage of the population. In Africa, the majority of the working population relies on agriculture to make a living. Due to their efforts, agriculture contributes 40 per cent of the continent's collective Gross Domestic Product. However, dual subsistence and cash crop production systems in several African countries, while generating significant export earnings, have failed to bring about more sustainable food security, as shown by their import dependence. Thus, without careful policies and regulations, cash crop earnings from agrofuels and especially export earnings, do not necessarily benefit producers or most food insecure people.

11. The permanent loss of natural resources like primary forest and grasslands is likely to be of much higher cost, for replacement, if possible, or as value for future economic benefits. This holds even more weight, if local economic benefits are considered, i.e. particularly if most economic benefits from conversion to plantation or agrofuel crops is exported.

12. A much larger (national and local) benefit is obtained, if bioenergy, including solid biomass, is used to energize rural economies, i.e. be part of an integrated rural development package that includes among other an energy mix of various renewable and fossil energies, increased use efficiency, and opportunities for continued markets. If promoted together with advanced cultivation practices for increased soil fertility (organic matter) and food crop integration (rotation, multiple cropping) there will be simultaneous benefits for greater food production resilience to climate variations, for more stable food security and also for poverty reduction. The latter will allow the fuller development of the human capacities and thus make a very substantial longterm contribution to the development of and quality of life in each nation. The above rationale explains the deliberate choice of UEMOA countries to prioritize bioenergy for domestic purposes (UEMOA 2008).

2.2 Drivers of agrofuel development

13. The main national and international drivers for agrofuel development in Africa have been identified as: 1) international demand caused by policies in major markets and national policies for export earnings, 2) fossil fuel substitution for energy security and reduction of oil bills; 3) concerns about GHG emissions and potential carbon trade. Locally, additional drivers can be identified with rural development targets related to job and income creation, developing opportunities for local business activities, and better access to sustainable energy in rural areas with all its envisioned benefits, including poverty reduction and food security.

14. The first three drivers tend to create large scale industrial agrofuel systems, usually requiring intensive private capital investments plus considerable government incentives and regulatory support like a predictive operating environment and longterm security of assets. These systems have attracted international investment. The international arena is still fairly uncertain concerning total demand and pricing. Expected sustainability standards may raise investment and operating costs and strongly depend on effective local governance. In addition, regularity of supplies and quality assurance are necessary to reach international markets, at least for EU and USA markets. To evaluate how attractive an industry sector is to investment and its competitiveness a COMPETE document may give easy guidelines (COMPETE 2009b).

15. Local drivers like rural development, food and energy security, cash crop diversification, access to affordable energy, tend to foster small to medium scale agrofuel options that contribute directly and indirectly to local economic development, poverty alleviation and consequently greater food security, while bearing less environmental and social risks.

2.3 Feedstock options

16. The most likely liquid biofuel feedstock crops regarding Africa are for bioethanol: sugar cane, cassava and sweet sorghum, and for biodiesel: oil palm and Jatropha (see also Table 4). Both Sweet Sorghum and Jatropha however, still have large uncertainties to overcome, as concerns yield stability, agronomic practices, local adaptations, and post-harvest treatment. Yet, both have significant advantages when integrated into diversified small to medium scale farming systems. Oil crops, such as oil palm, that may produce pure vegetable oils for direct use in diesel engines have additional advantages under many rural energy scenarios since no further processing (estherification) is required. Moreover, by-products obtained during or after processing often determine the profitability of the fuel production and need to be planned into the supply chain development.

Table 4: Main agrofuel feedstock crops and their by-products, not including woodfuel for electricity and household use

	1st Gen. Ethanol		**2nd Gen. Ethanol**		**Biodiesel**		**Biogas/Pyrolisis**	
Production scale	Crop species	By-products[1)]	Crop species[2)]	By-products[1)]	Crop species[3)]	By-products[1)]	Crop species	By-products[1)]
Large scale	Sugar cane, Sweet Sorghum, Cassava, [Maize, Grains] Algae	1 – 5 3	Wood, coppice, org. waste, cane, grass, whole plants of maize & grains	3 & 5	Oil palm, Jatropha, Soya, Sunflower Algae	3 – 5 3 & 6	Org. waste, starch & sugar crops, oil crops, animal waste *Wood & its wastes for pyrolisis*	3 & 5 *Biochar*
Large with small scale integration	same as above Algae	1 – 5 3	Coppice, grasses	3 & 5	same as above Algae	3 – 5 3 & 6	Unlikely contribution from small scale crops	3 & 5
Small scale	limited scope	limited scope	---	---	Oil palm, Jatropha, Rizinus, Sunflower, Moringa, minor crops & trees Algae	3 – 5 (fencing, shade, mulch, medicine, food) 3 & 6	Animal & human waste *Crop waste, coppice for pyrolisis*	3 *Biochar*

1) 1 - electricity, 2 - heat, 3 - fertilizer, 4 - feed, 5 - other, 6 - nutrient extracts
2) - organic waste may comprise urban, industrial and/or agricultural waste
3) - although Jatropha has been planted on a large scale, sufficient agronomic experiences are not yet available to risk large investments

17. Improvement of existing local crops and varieties is faster and more affordable to small scale farmers than efforts to introduce alien crops and varieties with all their economic, genetic and environmental risks. The diversity created and preserved by local farmers is essential to the resilience to increasing climatic variability, particularly for those multi-purpose crops which can serve for food, feed and energy.

18. With the exception of some tree crops (for oil and solid biomass) other bioenergy crops are likely to yield better on soils that are also good for food production and with high agrochemical inputs. In the absence of well implemented regulations this is likely to create land use conflicts or impacts on social, food and environmental security. Thus trade-offs need to be carefully weighted and reasons for apparently unused or degraded land areas need to be thoroughly scrutinized, to avoid production failure or negative environmental or social impacts. Regulation or guidance on what agrofuel can be used under what conditions should be important considerations in land use planning.

19. Sustainable agriculture production or even good agricultural practices (GAP) require knowledge based farming, be it food or energy crops. Therefore choosing crops known to local farmers brings many advantages for rapid implementation, acceptance, efficiency, yield and more. Since sustainable solutions are favoured by intercropping or rotations between food and energy crops, even more knowledge is required. If such knowledge has not been able to penetrate to the farmers until now, careful evaluation of the cost and funding sources, capacities and political will to

promote such farming practices needs to be part and parcel of any sustainable agrofuel development programme.

20. Many new technologies like pyrolisis/biochar or 2nd and 3rd generation liquid biofuels are still under testing or development and/or will require investments and technologies at a scale beyond many local capacities. These technologies, while allowing for the processing of organic waste material, may also put additional pressure on woodfuel resources, because of their effective energy conversion from cellulosic raw material.

21. Government interventions have generally had little impact on the traditional uses of solid biomass for energy or its sustainable production, with the exception of some fuelwood plantations and few improved charcoal systems (FAO 2001, WB 2010). Most of the solid biomass fuel sector is informal or for subsistence use, with low investment, using few tools and often little to no management. Increasing urban demand is leading to more charcoal conversion, with very simple technologies and low conversion efficiency (WB 2010, p. 65).

22. The introduction of efficient cookstoves could easily reduce fuelwood consumption in half, even up to 10%, but programmes have struggled to make an impact. The entry of commercial players into the cookstove market for the poorest and creative new business models have recently brought promising innovation into the perspectives of scaling cookstove adoption. They start making inroads in skilfully addressing the most vexing challenges of: user motivation, affordability and level of engagement, which often entails significant changes in lifestyle. A GVEP (2009) study shows how entrepreneurs have overcome these challenges, but subsidies for the poorest are still required.

23. The most pressing resource and impact problem is currently associated with unsustainable solid biomass fuel use and the resulting biodiversity, forest and soil degradation. In some cases liquid agrofuels may successfully and sustainably substitute some fuelwood uses. This is more often the case where people have a higher purchasing power (e.g. urban centers) or where liquid biofuel cookstoves are granted under special circumstances, such as refugee camps located in areas with scarce biomass resources. However, without reducing poverty significantly this may remain only a temporary phenomenon.

24. Careful biophysical and socio-economic evaluations, as proposed by the FAO Bioenergy and Food Security Project (BEFS - see Box 1), are key to final crop and fuel choices that fulfill the chosen purpose of sustainable bioenergy development.

2.4 Scale matters

25. Large scale, usually monoculture industrial liquid biofuel, systems are necessary to compete on the international bioethanol market. But they bear their own negative impact risks and mitigating requirements. Small scale farmers can be included in such production systems through contract farming schemes. Current models usually include at least a large land holding under the direct control of the industrial investor and sometimes an additional varying percentage of production sourced from smaller producers. Under carefully monitored conditions, such out-grower/contract farming schemes can be successful in allowing adequate benefits sharing for small scale farmers from these industrial cash crops. Whether they significantly improve food security for all those living in the affected areas or further away depends on a number of additional factors.

26. Large scale bioenergy projects/investments need to contribute positively to food production, nature conservation, rural market opportunities and better access to sustainable energy.

27. In general, biodiesel feedstock production, lends itself better to small and medium scale developments and local use, with perhaps the exception of oil palm. Oil crops and their processing plants can grow more gradually in size and mechanization, whereas ethanol and especially sugar cane ethanol is more subject to scale based pressures like mechanization, transport and rapid processing needs and requires much larger up-front investment. Both systems are likely to require considerable government support for startup.

28. Small scale bioenergy and more efficient fuelwood use can create new opportunities by reallocating household time and resources and thus starting a snowball effect on a variety of economic and special functions with the freed production capacity. However it may also lead to further marginalization of the role and effectiveness of women.

2.5 Climate variability and impact

29. Climate variability will affect different regions of Africa differently. Some agricultural areas may benefit from increased rainfall and carbon dioxide “fertilization”, while others may experience more frequent or more severe droughts. Estimates suggest climate change will reduce crop yields by 10 per cent over the whole of Africa and even more in localized regions: a 33 per cent reduction in maize in Tanzania; millet down between 20 and 76 per cent and sorghum down between 13 and 82 per cent in Sudan (Tanzanian submission to IPCC quoted in Murray 2005).

30. In a continent where the majority of the working population depends on agricultural activities and where food shortages are already a continuous reality, such foreseeable impacts (increased variability, i.e. uncertainty) require major preparation. Therefore also, it is even more important that any impact possible from integrated agrofuel production is evaluated extra carefully as to assure a positive contribution to more resilient and better yielding production systems. On the other hand bioenegy can increase rural communities’ resilience – hence adaptation to climate change – by making sustainable forms of energy more available at local level.

31. Any effort to make agricultural production, business models and social safety systems more flexible, adaptive or resilient will benefit local progress even if the severity of climatic changes is less than predicted.

III. Opportunities and risks

3.1 Opportunities

32. The mere introduction of a new crop or improved variety to the farmers’ seed basket by itself does neither increase income, nor food security. New seed varieties or crops may actually reduce agro-biodiversity and undermine local seed systems (FAO 2008). Economic, social, knowledge and environmental frame conditions need to be adjusted for changes to take place with such an introduction. Similarly, the increased GDP, as a result of a new export industry like agrofuels, does not necessarily represent a net benefit to the country, considering the many government incentives to investors, increased government debt to service the industry needs (e.g. infrastructure) and global business practices of maximizing profits to their foreign shareholders. Thus, careful planning, adequate participation of local stakeholders, regulation and implementation

and constant evaluation are essential ingredients to harnessing the various opportunities that versatile crop usage, new investment and international demand are offering in the bioenergy sector.

33. That said, the potential opportunities of a well designed and carefully implemented bioenergy programme include a number of areas related to rural and agro-industrial development:

- improved access to transport, cooking and electric energy in rural areas leading to more business and income opportunities, and better education and health services, with domino-like multiplier effect
- improved food security through more available income and more stable, higher productivity, better processing facilities, which, in turn, results from
- revitalized investment in agriculture (incl. research and extension services), and
- more diverse, flexible and resilient integrated agricultural production (food and energy),
- more rural economic opportunities like income from additional jobs with producers and secondary businesses/industries from by-products, newly available energy or from newly generated and locally circulating income,
- fuelwood substitution through increased income to afford alternative fuels and more efficient stoves, resulting in
- reduced health hazards (indoor smoke, better nutrition, cleaner water) and
- reduced environmental impact from better production methods (soil, water & GHG), higher yields (biodiversity – less new land conversions) and fuelwood substitution (less deforestation)
- marginal conditions, in terms of land quality and access, can be improved through available investment resources and better governance
- improved policy planning and dialogue between national and local government and different government sectors (because it is a necessary condition to achieve the above and a benefit to other areas of development)
- additional non-debt financing from Carbon trade (e.g. CDM – C emission reduction and REDD - reduced deforestation).

These more localized opportunities will also impact developments at a national scale.

34. Larger scale bioenergy developments should contribute to local development. But thanks to their scale, they also present opportunities regarding:

- national energy security, including more stable supplies and increased fossil fuel substitution
- improved foreign exchange balances and
- infrastructure development leading to more business opportunities and the resulting chain of development.

35. All this will improve the quality of life, i.e. human well-being, across a wide range of the population, if proper safeguards, regulations and monitoring are in place, and if MDG achievement is an integrated part bioenergy development strategies.

36. The challenge is to create the necessary conditions for these opportunities to be realized. This will require political will, skill and resources. It also needs a clear vision and sometimes the questioning of old assumptions and models, of the present way of “doing business” and of using/employing human and natural resources. And, because most of the listed development

opportunities are connected to agricultural production and products, still the backbone or base of most African economies and of all societies, the question: why all of this has not happened already without bioenergy, needs to be answered after deep and truthful exploration. An open dialogue and reflection might just stimulate enough motivation, insights and awareness to overcome some of the barriers to necessary change.

3.2 Risks

37. There are several risks associated with agrofuel development, and in particular with large scale liquid biofuel schemes, including:

- opportunistic overexploitation, through intensive industrial agricultural production methods and inadequate land use changes, further depletes soils and water resources, destroys more biodiversity and forests, releases additional CO_2, and leaves farmers and the most vulnerable regions and people unprotected against the exacerbating climate changes and decreasing environmental services
- inadequate local benefits, local labor protection and local investments, leave rural populations poorer due to poverty wages, loss of livelihood skills, less education and health and less opportunities to help themselves
- a resulting increase in value of land which may disproportionately favour land consolidation by large farmers and businesses and further reduce access to productive land by small farmers, women and rural and indigenous communities due mostly to inadequate legal protection
- well-meant or insufficient measures arriving too late or being under-financed after major investments have already created the undesirable impacts and negotiations can no longer mitigate those impacts
- lack of effective control, expertise, and assessments, especially on biodiversity impacts and land use change or water harvesting
- external influences, be they cultural (traditional, gender, religious), environmental (climate), economic (international prices and investor interests) or political (special interests, trade-offs) overpowering local wishes, decisions and actions.

38. One cannot expect that businesses operating as usual will make efforts to reduce the above risks unless obliged to do so. Many of the early investors in bioenergy in Africa were innovative businesses open to higher risk, but not always operating with higher social and environmental values. Tenuous trends toward corporate social responsibility and inclusive business approaches need local consolidation, verification and regulatory demand.

39. How much fossil fuel can be substituted and how much of the rural economy can be fueled with agrofuels is difficult to say and varies from country to country. It is unlikely though that any significant amount of industrialization can be completely fueled with agrofuels or a mix of agrofuels with currently available renewable energies.

40. The BEFS and BIAS tools (BEFS 2009, BIAS 2009) are designed to assess the best interactive optimization of agrofuel and other bioenergy potentials in a safe, sustainable environmental and socio-economic food security context, facilitating part of the analytical needs to plan the best of the above scenarios.

3.3 Mitigation of risks and impacts

41. Actions to deal with negative impacts can be summarized into three basic types:
- offset or mitigation of negative impacts
- prevention of negative impacts
- building resilience to uncertainties (climatic and economic)

42. Most of the production related risks and impacts can be prevented, reduced or offset by the same “good” agriculture and business practices. These include well informed and inclusive planning, priority to rainfed crops and production systems that aim to build soil fertility, climate resilience and water resources and careful integration of food and energy production on-farm or in farmer groups[3]. These, in turn, will benefit from external incentives to intelligent ecological rather than chemical farming, good technical assistance and from support to distinctive markets and regulations.

43. Avoiding or reducing risks from the other non-production related risks (see section 3.2) requires decisive political action and coordination in the social, economic, legal and political arena, including cross-sectoral collaboration, policies, regulations, monitoring, clear openness and participation.

44. A number of risks can be lowered by supporting or stimulating organizational and business models that assist in the diversification and stabilization of production and markets, like: contract farming, full chain development, inclusive and social business models, smallholder inclusion in any large or small scale project, participatory and collaborative local support organizations. In addition to such concrete individual actions, more systemic changes and new development models have been called for at different fora and have been suggested by world leaders in a recent report (NEF 2009).

45 A joint IIED/FAO/IFAD study (Cotula et al. 2009) provides an analysis on the complex and shifting situation of “Land Grabbing” in Africa, laying out key trends, drivers and main features of international land deals, and suggests steps to make the renewed momentum in agricultural investment work for local development and livelihoods. Since many large scale investments, but also small holder projects, are already established, they, too, should be evaluated for their ecological and social performance and, if necessary, improvements be negotiated.

3.3.1 Mitigation of greenhouse gas (GHG) emissions and other environmental impacts

46. Agrofuel production can reduce GHG emissions compared to equivalent fossil fuel emissions and prevent and mitigate most negative environmental impacts, if produced with good agricultural practices (GAPs). However not all GAPs are equal in that respect. Emission balances are sensitive to yields, chemical inputs, soil management, prior land cover and effective by-product uses. Examples for that can be seen in a FAO Sweet Sorghum GHG lifecycle analysis (FAO, 2009c).

47. Optimum practices to aim for are cultivation methods that reduce soil disturbances, avoid chemical inputs, build soil fertility naturally and recycle or add value to by-products (wastes). GAPs fulfill many of these goals, with organic agriculture proven to best perform under most conditions (FAO 2009d, SA 2009). By contributing simultaneously also to more stable, sustainable

[3] Integrated food and energy systems (IFES) have been suggested over time for various reasons. An FAO study on IFES is looking at cases of optimal combinations of food and energy production for achieving a variety of environmental, social and economic goals, and also including other renewable energy sources, i.e. not only bioenergy.

and increased yields, even restoring soils and water tables in East Africa, they also increase production resilience against climate and weather impacts (UNEP/UNCTAD 2008).

48. Combined, where possible (near urban centres or on-farm), with proper organic waste management (biogas for energy extraction plus/or composting for soil fertility and C-sequestration) this is a production system beneficial to GHG balances and possible CDM financing as well as for food yield increases[4].

49. Conversion of biomass-rich habitats to crop cultivation should never be considered for agrofuel production, and likewise pressures that indirectly lead to such conversion by other displaced land users. Their carbon and biodiversity content are not replaceable within reasonable timeframes, if at all.

50. Small-scale farmers, not only in Africa, have demonstrated many times that, by using sustainable production methods, they can reverse environmental damage, reduce GHG emissions and also increase resilience and adaptability to climate change (Practical Action 2008 and FAO 2009). These methods are not exclusive to small scale farmers and can also be adopted by larger production systems and enterprises and still operate profitably. However new business models and ethics may be helpful, if not necessary (IIED 2009, Simms 2005). Table 4 presents a summary suggestion of such business innovations and policy suggestions to stimulate such practices.

[4] The composting of organic waste material, following certain quality standards and controlled efficiency, has received CDM credits for operations among other countries in South Africa; see: www.soilandmore.com

Table 4: Business model innovations that provide small-scale opportunities in biofuel supply chains (IIED 2009)

<table>
<tr><td>Business arrangements to include small-scale owners and enterprises</td><td>Outgrower schemes

Purchase contracts

Land leases

Sharecropping

Management contracts

Joint ventures (e.g. community land inputs = shares in the business)</td><td>Cooperative mills

Share ownership

Small-scale facilities aimed at local end-uses

Supply contracts with larger refineries and distributors</td><td>Limited options given high capital costs of biorefineries</td><td>Intermediary traders

Transport contractors

Utilizing existing distribution systems (e.g. network of rural retail outlets aimed at farmers)</td><td>Sliding-scale energy pricing

Subsidized multifunction platforms

Subsidized improved appliances

Use of unrefined oil rather than refined biodiesel</td></tr>
<tr><td></td><td>FARMING →</td><td>MILLING →</td><td>REFINING →</td><td>DISTRIBUTION →</td><td>END USES</td></tr>
<tr><td rowspan="2">Options for government policy support</td><td>Support to positive models through regulation, information, model contracts and brokerage

Underwriting community business involvement</td><td>Active promotion of small-scale milling operations, e.g. via supply of prototypes

Range of support to promising joint equity models</td><td>Employment laws

Holding developers accountable to job projections in approved investment contracts</td><td>Local content requirements</td><td>Support to off-grid energy schemes

Subsidies as above</td></tr>
<tr><td colspan="5">Subsidized finance and insurance schemes

Fiscal incentives (e.g. tax breaks, reduced concession fees)

Local supply quotas (e.g. Brazil's Social Fuel Seal)

Active support: information, guidance, research</td></tr>
</table>

3.3.2 Mitigation of food security and poverty impact

51. Well integrated and diversified farming and business methods, like those mentioned in the previous section are built on collaboration, participation and transparency, key concepts and action for improving the production, business and social contributions to food security.

52. By itself the introduction of a new cash crop like agrofuel feedstock will not bring about such changes as are needed to improve food security (FAO 2008). There are concerns about unequal competition to the detriment of food production, particularly for larger scale developments. At the small scale level a shift to cash crops or market orientation often shifts women's traditional control over land- and plant-based resources to men as resources become more valuable. This, in turn, may lead to over-exploitation in the absence of strong systems of indigenous resource control and become a risk to household food security.

53. There has been much talk about the food price changes as a result of international commodity trades, in part influenced by increased demand for maize as agrofuel feedstock in the USA. Such changes are unlikely to be repeated by smaller national or local agrofuel programmes, especially if proper attention is given to possible land use changes that displace food crops and to continued or improved food production for the local population.

54. If measures considered beneficial for sustainable agrofuel production (see section 3.3.1) are extended to regular food production or food and fuel production are closely integrated, food production should increase significantly rather than be affected negatively. That is, even if only part of the previously discussed policy, economic and social action is taken, both agrofuel production, including its secondary business impacts, and food production should lead to wider income generation, i.e. poverty alleviation, the major cause of food security. The suggested sustainable production systems will also lead to more resilient, more stable and more productive energy and food systems, and a more stable market and wider income circulation from better business models, i.e. mitigating part of energy poverty, financial poverty and food scarcity simultaneously.

55. The mitigation of potentially negative impacts on social and economic conditions of rural and urban poor has often more to do with institutional conditions like new business models and social networks and good governance, than with production methods. Equity distribution, clear ownership rights (e.g. land rights), legal recourses, participation, income opportunities, social safety nets are some of the principle measures that can be taken. Of course, also improved productivity and stability of production contribute to poverty and food insecurity mitigation.

56. The explicit inclusion of small to medium scale farmers and businesses in bioenergy policy instruments, large scale licensing and in new business models for downstream supply chains is needed to enable better income distribution and equity participation (see also Table 4).

57. It is paramount that appropriate data collection and monitoring/evaluation procedures and standards are established and used, otherwise sufficiently sensitive monitoring of impacts is not possible. BEFS tools (see Box 1) have been designed to facilitate this multi-sector task.

3.4 Adaptation to climate and economic uncertainties

58. The best way to manage increased uncertainty is through increased flexibility and resilience, more robust environmental and production systems and spare resources, and adequate better management capacities to achieve the above. The production and business systems already discussed include the necessary flexibility and the potential to produce and use spare resources. However, much of the capacity to manage them is lacking, as are many of the mentioned framework conditions needed to stabilize those systems. In their absence, first priority should perhaps be the widest application of the most diverse sustainable agricultural production methods with a high diversity of crops, energy crops being only one part, as described in section 3.3.1. To combine diversification with sustainable yields would require some improved mostly rain-fed agricultural practices such as: locally adapted seeds, cover crops, no-till, building soil organic matter, and integrated pest management with healthy pollinator populations. The resulting improved soil cover and structure will reduce impacts from flooding, droughts, water shortages and desertification, thereby also improving global food and water security (SA 2009).

59. Similarly to more holistic land management, more holistic economic and social management also creates more resilience in social systems that can withstand or "weather" highly variable or more extreme climate and economic conditions. A combination of traditional cultural elements and "new economic" thinking (NEF 2009) is likely to be most successful.

60. Carbon trade is a recent development whose benefits (or not) are still discussed. It may in the future, together with REDD mechanisms, open new financial support strategies for carbon and environment friendly production systems for bioenergy and other agricultural products. The compensation payments may in the future help to reduce certain economic or social uncertainties. More direct and more reliable though will be different business and economy models similar or the same as those mentioned under mitigation.

IV. Why agrofuels in Africa

61. Setting goals or deciding the purpose of a bioenergy programme is of crucial importance, but easier said than done. A large number of people, businesses and institutions across many disciplines are involved in creating the goal and then in building the road to get there. Therefore the vision and the goals need to be clear, have a time frame, be communicated and inclusive, i.e. developed with all and including all in the benefits. It also serves as a benchmark against which to measure progress.

62. The different stakeholders will see different goals and pathways; that is the nature and strength of their sectoral characters and some of these may be conflicting. Unifying these goals into a common purpose without loosing their individualities is the first step and needs to be revisited periodically to maintain strength,

Box 1 — Bioenergy, Food Security and the Environment

The impact of large scale bioenergy development on access to food (e.g. increased food prices) and food production (land competition) and thus on food availability (including also equitable or functional markets) was one of the main concerns, next to increased pressure on already largely reduced and sometimes even threatened environmental services. Since this latest wave of interest in bioenergy, FAO has been working to 1. mainstream food security concerns into bioenergy strategies (BEFS 2009) and 2. make available information and tools to facilitate the inclusion of food security and environment concerns in policy making and investment decisions (BEFS 2009, BIAS 2009, UN-Energy 2010).

The BEFS and BIAS projects established analytical frameworks for the analysis of the food security and bioenergy nexus and the evaluation of impact on environmental resources and services, respectively. BEFS also implemented a complete analysis with trained partners in Tanzania, Peru and Thailand, whereas BIAS tested a partial application of its framework on sugar cane ethanol production in Tanzania and evaluated the greenhouse gas balances of Sweet Sorghum bioethanol production. The analysis in Tanzania was performed on Cassava, sugar cane, palm oil, Jatropha, sweet Sorghum and sunflower with maize, cassava ad rice as the most important food security crops.

The BEFS framework provides powerful tools to generate information based on evidence, analysis and evaluation necessary to underpin policy by analyzing two key elements:

- Feasibility of producing bioenergy (potential areas, technical and competitive viability, integration of smallholders - Where? and How?)
- Viability in view of food security and the national economy (bioenergy contribution to: economic growth, poverty reduction, agricultural markets, household level food security and vulnerability, land competition for food, identification of tradeoffs - impacts on policy, economy and households?)

Finding reliable indicators that can be measured with limited human and financial resources is not an easy task and is receiving considerable global attention (GBEP, RSB, BEFS and World Bank). It is expected that these will soon be translated into standards that allow the management and evaluation of sustainability of production methods and whole supply chains, whether certified or not.

Future market conditions as well as resource limitations will perhaps sooner than later require the reliable application of such standards to bioenergy, industrial and food crops. Just in case, following the most sustainable practices will not only safeguard future human and natural resources but also assure early market advantages in a more socially and environmentally conscious world.

motivation, dedication and a direction to the programme.

63. Bioenergy development cannot solve all problems and do everything, but it can be an important element to support many different goals and be a catalyst for inter/multi-disciplinary collaboration. This process can already be observed in many countries where perhaps for the first time a number of different ministries talk to each other for collaboration and even other stakeholders are involved. Similar processes can be observed between national and international business communities, civil society and government. It is a sign of our times and of the need to deal with the speed of developments, their interactive scale and immense knowledge requirements. The necessary flexibility and capacities can only be obtained through much broader pooling of resources than at anytime in the past.

64. The nature of bioenergy is in part an engine for rural development (as energy is a basic requirement), in part a synthesizer of different interests (need of cross-sector collaboration), in part an attractant for finance (fulfills very basic need, is versatile, storable and transportable) and is also part of several sectors: agriculture, environment, trade, transport and energy and therefore also policy.

65. Thus a higher level goal of developing bioenergy could well be the development of this collaboration, and the resulting pooling of a community's, nation's or region's strength for bringing well-being to all its members. At the global international level there is GBEP, UN-Energy, Roundtable on Sustainable Bioenergy (RSB) and many private initiatives. At national level, the collaboration between government and all of its constituents should decide.

66. The following visions could provide guiding principles for bioenergy policy development in African countries (COMPETE 2009)

- Rural development and improved livelihoods for the rural population in African countries;
- Increased energy access and income generation opportunities;
- Successful transition from traditional biomass to modern biomass;
- Sustainable large-scale production of biofuels involving communities, smallholders, cooperatives and local enterprises;
- Support to rural production and marketing of bioenergy;
- Reduced dependence on imported expensive fossil fuels;
- Achievement of the Millennium Development Goals (MDG).

67. The road towards this vision benefits differently from different fuel types, crop choices, production systems, business models, policy, legal and regulatory conditions, biophysical and social conditions. To work out the optimum combinations, conditions, potentials and needs, the FAO BEFS and BIAS projects (BEFS 2009, BIAS 2009) as well as other initiatives have worked out guidelines for decision makers. Considerable amounts of data are necessary to feed this decision making process. Careful prior assessment and later monitoring and evaluation are essential for project success and assuring fulfillment of the many requirements and expectations (goals?) attached to bioenergy development.

V. What is needed now?

68. The outlook for bioenergy development in Africa is different from that of other regions, because traditional biomass use is likely to increase in importance and the prospects for liquid biofuel developments on a wider base remain very unclear (WB 2010). Thus any development programme and particularly an integrated energy programme needs to include measures to improve sustainability of traditional biomass use or measures to substitute it.

69. Agrofuel programmes will have to partially aim at reducing traditional biomass use and policy strategies have to be developed jointly across sectors (agriculture, forestry, environment, rural and small business development, finance, child and adult education). Dedicated cookstove programmes are an essential part of any such initiative.

70. Although agricultural land is still abundant in Africa, there are limitations to its use based on cultural, climatic, environmental and political conditions. To protect some of these conditions (environmental and cultural) and overcome the other conditions (climatic and political) land use planning and land access regulation is a priority. The latter is mired with special interests, hazy legal interpretations and parallel, often conflicting, traditional and legal land tenures. This situation needs to improve dramatically if increased value creation from bioenergy development and investment keep on growing. Otherwise it will be difficult if not impossible to assure more fairness in equity and income distribution.

71. Another challenge, one of creative innovation, is that of establishing a variety of new ethically and socially responsible business models, using different economic parameters and profitably match them with the most advanced ecological farming systems in an environment of extreme financial poverty, low health and declining basic farming knowledge. Relying on strong basic traditional values and social networks may be just a good foundation for such innovation.

72. Box 2 describes some of the main points that need to be addressed with programme activities. The guiding principles below draw on the final COMPETE Declaration and several years of discussions, workshops and papers to orient policy formulation for sustainable biofuel production (from COMPETE 2009):

- Aim for clear, longterm, stable policies that encourage sustainable bioenergy development at many scales and by local people for local people
- Interlink bioenergy goals, policies and actions with those of other sectors like trade, economy, agriculture, energy, environment, and climate change
- Participatory work through committees and task forces to faster generate inclusive policy and business strategies
- Determine and clearly state and communicate the objective(s) and regulatory requirements for national biomass use, e.g. energy security, electricity provision, rural development, transport requirements, job creation
- Develop national sustainability standards in collaboration with international organizations such as the Roundtable on Sustainable Biofuels (RSB)
- Seek responsible economic investment, payments for environmental services (CDM and REDD) and north-south and south-south cooperation
- Determine land use and land use change after thorough scientific and practical analysis
- Establish or recreate a regulatory and institutional framework that can regulate and provide incentives for development and growth of a sustainable biofuels industry.

- Identify and facilitate new, inclusive sustainable business models suitable for the African framework conditions
- Prioritize national market needs and observe global market developments for: accessibility infrastructure development, standards, fair trade and environmental labeling
- Set regulatory requirements for the use of traditional environmental tools such as strategic environmental assessment to review policies, plans and programmes related to biofuels and to enhance and enforce environmental and social impact assessment
- Create conditions for wider application of sustainability objectives beyond biofuel production to general development for the local area and region including social, economic and environmental considerations (possibility to link with MDGs).

73. The challenge is that the demanded fair benefit distribution requires new economic models, new business structures and ethics, holistic (care of all elements) farming practices and a supportive stabilizing policy and institutional framework with well educated, informed and empowered people. A daunting task, but one that promises much better results and to be less costly in lives and dollars than continuing with business as usual, the end result of which we can easily foresee.

Box 2 Key Programme Actions

1) Africa has land available to support biofuel production, but availability varies widely from one region and country to another and competing uses need to be considered. Where land is available, it is important to ascertain that biofuels are the most appropriate land use and will provide greater benefits to the current land users and owners.

2) The land rights and resource rights of indigenous people and disadvantaged groups need to be protected. No land should be allocated without adequate provisions for ensuring existing land users capture benefits from biofuels and without free, prior and informed consent. Such practices have proven extremely difficult to operationalise in practice (Freeman *et al*. in press).

3) Africa has huge potential for agricultural intensification. Intensified bioenergy initiatives should also activate other agricultural activities. A key concern is why this is not occurring with food crops, which almost always are more valuable than fuel crops and should be a first priority.

4) Biofuels in Africa must be for Africa's benefit. Africa must not be used to meet global biofuel demand unless the development has social and economic benefits for Africa. For instance, African countries should be fuel self-sufficient before they export excess feedstock for international use. Policies should also support production models with greater gains for smallholder producers.

5) Biofuel projects must balance local and national benefits. Economic or production efficiency might have to be forfeited to maximize local benefit, for instance through small local processing rather than large central processing.

6) Deforestation and loss of biodiversity remain key concerns. Checks and balances are needed to protect against both social and environmental bad practices.

7) A national cap on land available, a set of land allocation criteria for biofuels and monitoring systems to ensure these standards are respected need to be developed in each country to limit food-fuel conflicts, ensure social sustainability, and keep biodiversity loss within acceptable limits.

8) The implications of second generation biofuel technologies need to be considered as they may affect the economics of first generation projects in the future.

(Cifor 2009)

VI. Conclusions

74. It is quite clear, from common sense and scientific studies, that business as usual, including bioenergy, will neither solve our carbon limitations (energy resource depletion and CO2 release into the atmosphere) nor will it bring about economic changes for alleviating poverty and food insecurity. Thus thinking only in terms of bioenergy development as another means to reduce fossil fuel dependency or GHG reductions will not lead to any sustainable development nor will it leave enough of a positive social impact to aid in poverty reduction or related food insecurities, less still in view of pending production stresses resulting from climate variability.

75. When focusing on bioenergy as a means of improving natural resource use (improving soil, water and biodiversity resources) and as an opportunity to reduce rural and possibly also urban poverty, then bioenergy programmes will take on shapes and contents which may contribute to increased resilience and productivity in African agriculture and thus in the livelihood support of still the largest portion of Africa's population, the rural communities and farmers. The multiplier effect shows it may make a lot of national economic sense to invest in small scale bioenergy development.

76. Sustainable (rural) development is no small task, to be clear, particularly under current economic trends, but one that can be tackled with clear and visionary leadership. In this the African continent faces a more challenging, but also a more rewarding opportunity.

77. There is an unbreakable link between adapting to climate change, poverty reduction and access to food and energy; neither can be solved without the other. To approach solutions, systemic change and new development models need to be implemented. They have been tried and, by their nature, they need further experimentation. The risk of not experimenting is guaranteed failure at national and global scale.

'A new model of development is called for, one in which strategies to increase human resilience in the face of climate change and the stability of ecosystems are central. It calls for a new test for every policy and project, in which the key question will be, "Are you increasing or decreasing people's vulnerability to the climate?" Above all, the challenge calls for a new flexibility and not a one-size-fits-all approach to development. Just as an investment portfolio spreads risk by including a variety of stocks and shares, so an agricultural system geared to manage the risks of changing climate requires a rich diversity of approaches in terms of what is grown, and how it is grown.'

Simms A. (2005)

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