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NEW AND EMERGING ISSUES RELATING TO THE CONSERVATION AND SUSTAINABLE USE OF BIODIVERSITY

Biodiversity and liquid biofuel production

Note by the Executive Secretary

EXECUTIVE SUMMARY

Pursuant to its mandate in paragraph (d) of appendix A to annex III of decision VIII/10, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) will be considering new and emerging issues relating to the conservation and sustainable use of biodiversity. In a meeting held by teleconference on 22 September 2006, the SBSTTA Bureau identified, among other issues, the interlinkages between biodiversity and liquid biofuel production as a new and emerging issue for consideration by SBSTTA at its twelfth meeting. The present note, prepared to facilitate the work of SBSTTA, summarizes information from literature and from a six-week electronic forum organized from 29 January 2007.

In recent years, the production of liquid biofuels has been increasing worldwide, mainly in efforts to mitigate greenhouse gas (GHG) emissions and for greater energy security. The main biomasses used to produce liquid biofuels are sugar cane, grain corn and, still in an experimental phase, second-generation feedstocks such as cellulosic materials for bioethanol, and rapeseed and palm oil for biodiesel. The fuel yields, net energy balance, GHG emissions reduction and production costs vary according to the biomass used, production means, production sites and markets. The fuel yields, net energy balance and GHG emissions reduction are generally highest for sugar cane and palm oil, whereas production costs are lowest for sugar cane. Cellulosic feedstocks seem to have even greater yield, net energy balance and GHG emission reduction potentials.

Scientific data indicate that large-scale production of liquid biofuel can contribute to the reduction of GHG emissions, which constitutes an important indirect contribution to the conservation of biodiversity. The potential contribution of biofuel in addressing the climate-change challenges and promoting new and renewable source of energies were considered at the fourteenth and fifteenth sessions

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of the Commission on Sustainable Development. However, large-scale biofuel production can have adverse impacts on biodiversity, including, *inter alia*, habitat fragmentation and degradation, increased greenhouse-gas emissions from degraded carbon sinks and deforestation, water pollution and eutrophication, and overexploitation caused by land conflicts and increase in food prices. For example:

(a) The use of natural lands, such as wetlands and natural forests, for biofuel production is reported as an important threat to biodiversity through the loss of habitats, their biodiversity components and the loss of essential ecosystem services. The use of natural lands can also contribute to greenhouse-gas emissions caused, for example, by deforestation and the degradation of peatlands and soil carbon sinks;

(b) The need for fertile agricultural land to produce biofuels may result in land conflicts and an increase in food prices, which affect indigenous and local communities and small-holder farmers, forcing them to rely more heavily on food from the wild and/or clear additional lands for agriculture;

(c) The increased use of water due to agricultural expansion and water pollution caused by biomass conversion processes can also result in biodiversity loss.

Nevertheless, depending on the land-use change and biomass considered, biofuel production can also have beneficial impacts on biodiversity. For instance, displacing annual crops with perennial grassy crops or restoring degraded lands with tree plantations could lead to greater animal biodiversity and reduce pesticide and net fertilizer use.

Options for promoting sustainable biofuel production exist. They include: (i) the application of guidelines and standards in the framework of the ecosystem approach; (ii) the application of biodiversity-inclusive guidelines on environmental impact assessment and strategic environment assessment; (iii) the development of sound policy frameworks that contribute to both the mitigation of greenhouse-gas emissions and the conservation and sustainable use of biodiversity; and (iv) the promotion of research to improve the economy and yields of energy biomass and develop technologies for second-generation feedstocks and other materials, such as wastes.

To date, comprehensive analyses, including on the socio-economic and environmental impacts, of the complete cycle of production from planting to the use of biofuels are scarce. To promote evidence-based decision-making and good practice approaches on biofuel production, it would be important to carry out such comprehensive analyses for major projects and to share data and experiences through appropriate means.

SUGGESTED RECOMMENDATIONS

The Subsidiary Body on Scientific, Technical and Technological Advice may wish to recommend that the Conference of the Parties:

1. *Invite* Parties and other Governments to:

(a) Develop a sound policy framework for liquid biofuel production options that contributes to both the mitigation of greenhouse-gas emissions and the conservation and sustainable use of biodiversity;

(b) Encourage the development and application of guidelines and standards within the framework of the ecosystem approach to reduce the potential negative impacts of liquid biofuel production on biodiversity;

(c) Promote research, especially regarding second-generation feedstocks, that will improve the socio-economics and yields of liquid biofuels and decrease the negative impacts on biodiversity;

(d) Promote international cooperation, including South-South cooperation and the transfer of technologies, on the sustainable production of biofuels;

2. *Request* the Executive Secretary to compile, in collaboration with relevant organizations, socio-economic and ecological information from Parties, other Governments and other sources along the full line of production of liquid biofuels, and use the information for comprehensive assessments of the possible impacts of the production of liquid biofuels on biodiversity and the contribution to the reduction of greenhouse-gas emissions, for distribution to the Parties.

I. INTRODUCTION

1. The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) is mandated under paragraph (d) of appendix A of annex III to decision VIII/10 to identify new and emerging issues relating to the conservation and sustainable use of biodiversity. In a meeting held by teleconference on 22 September 2006, the SBSTTA Bureau identified, among other issues, the interlinkages between biodiversity and liquid biofuel production as a new and emerging issue for consideration by SBSTTA at its twelfth meeting.

2. The contribution of biofuel as a new and renewable source of energy in addressing the climate-change challenges has been addressed by appropriate international forums, including the Commission on Sustainable Development and the Scientific Advisory Panel of the Global Environment Facility. Moreover, the Global Bioenergy Partnership was launched in 2006 to create a global high-level policy dialogue on bioenergy and to promote more efficient and sustainable uses of biomass. In identifying biofuel as an emerging issue pursuant to decision VIII/10, the Bureau of SBSTTA recommended its consideration by SBSTTA at its twelfth meeting from the perspective of the conservation and sustainable use of biodiversity.

3. The present note has been prepared on the basis of findings from scientific studies, reports and other documents to facilitate the consideration of the issue by the Subsidiary Body. Although not a comprehensive review of the issue, it benefited from contributions received through a six-week electronic forum launched by the Secretariat of the Convention on Biological Diversity on 29 January 2007. All contributions to the electronic forum have been compiled in a document for information.

4. After a description of different types of liquid biofuels in section II, the note presents in section III the advantages of biofuel production and use, and in section IV the possible impacts of biofuel production on biodiversity. Section V presents some indicative options for promoting biofuel development consistent with the conservation and sustainable use of biodiversity.

II. DESCRIPTION OF TYPES OF BIOFUELS

5. The impact of climate change on biodiversity is important and there is an urgent need for greenhouse-gas (GHG) mitigation. Current anthropogenic emissions of carbon dioxide (CO_2) principally result from the consumption of energy from fossil fuels (IPCC, 2001). Fuels derived from biomass, called biofuels, including alcohols, vegetable oils, biogas and fuelwood, can be used as substitutes for fossil fuel. Because transportation is a sector that contributes significantly to CO_2 emissions, the present note will focus on liquid biofuels used in transportation.

6. Currently, there are two major types of liquid biofuels that can be used in the transportation industry: (i) bioethanol, which is produced out of plant starch, sugar, and more recently, but still on an experimental basis, cellulose; and (ii) biodiesel, which is made out of vegetables or grain oil and recycled cooking oil. Both bioethanol and biodiesel can be used in existing vehicles when blended with gasoline or petroleum-based diesel or even pure in flex-fuel cars (WI and GTZ, 2006).

7. The major biomass sources currently used are sugar cane and corn to produce bioethanol, and rapeseed and palm oil for biodiesel production. Other sources are also used, such as sunflower seeds, soybean, peanuts, jatropha, castor bean and coconut oil for biodiesel, and wheat, sugar beet, sweet sorghum and cassava for bioethanol (Brown, 2006; GEF-STAP, 2006). The fuel and energy yields vary with the type of plant material used. Fuel yield is generally highest for sugar cane, and palm oil and sugar cane present the highest energy yields (see table 1 below).

8. A wide range of cellulosic materials, such as grassy crops, woody plants, by-products from the forestry and agricultural sector (including wood residues, stems and stalks) and municipal wastes, constitute the so-called second generation of feedstocks, for which conversion technologies are under development. Cellulosic feedstocks can yield higher net energy and further contribute GHG emissions reduction because they have a relatively high carbon sequestration potential and their cultivation is less energy demanding than for non-cellulosic feedstocks (Cook and Beyea, 2000; Farrell *et al.*, 2006; GEF-STAP, 2006; WI and GTZ, 2006). Research on low-input high-diversity grasslands shows that biofuels could also be derived, with current technologies, from mixtures of native grassland perennials (Tilman *et al.*, 2006). Even though the cellulosic conversion process is not yet economically competitive, the cost of cellulosic biofuel production is declining (WI and GTZ, 2006) and cellulosic ethanol from certain biomasses is already commercially available. Algae are another source of biomass under consideration for biofuel production and algae biodiesel has recently been successfully tested as a 5 per cent blend biodiesel.

III. POTENTIAL BENEFITS OF PRODUCING AND USING BIOFUELS

9. The energy crisis of the 1970s led countries to seek ways of improving their energy security by decreasing their dependence on fossil fuels and diversifying their energy supplies. While biofuel production has never really been significant due to the low price of oil, the role of biomass as a fossil fuel energy substitute has regained a great deal of interest in the past decade due to: (i) instability in petroleum-producing countries; (ii) the rising cost of petroleum in the past decade, from less than US$ 20 per barrel in 1995 (2006 dollars) to more than US$ 60 in 2006 (WTRG Economics, 2006); and (iii) the adoption and entry into force of the Kyoto Protocol, which requires ratifying countries to reduce GHG emissions. Therefore, biofuel production can bring countries energy security, protect them from energy-pricing risks over which some countries have no control, and result in significant savings in foreign exchange, which can instead be invested in the domestic economy.

10. Derived from renewable sources, biofuels have the potential to be more or less carbon-neutral, since in theory the carbon released during the combustion of the biofuel can be taken up by growing plants. Liquid biofuels have also been reported to release less GHG than conventional fossil fuels (Perlack *et al.*, 1992; Huston and Marland, 2003; Kim and Dale, 2005; WI and GTZ, 2006). The WI and GTZ (2006) reported a 20 to 40 per cent reduction in CO_2 emissions with starches (corn, wheat), a 45 to 75 per cent CO_2 emissions reduction with vegetable oils (rapeseed, sunflower, soybeans), a 40 to 90 per cent CO_2 emissions reduction with sugars (sugar cane, sugar beet) and a 100 per cent CO_2 emissions reduction with second-generation feedstocks, such as wastes (sewage, residues) and fibres (switchgrass, poplar). Use of low-input, high-diversity systems on degraded lands may actually be carbon-negative due to carbon sequestration associated with rising soil organic matter levels (Tilman *et al.*, 2006). However, life-cycle assessments point to many uncertainties, especially with regard to emissions related to by-products, and show that land use is often not taken into account, which can have a significant impact on carbon emissions. Therefore, the total emission reduction potential of biofuels, from production to use, is still under debate and various studies show different figures. The same is true for net energy balance (see table 1 below).

11. In terms of production costs, some biofuels could soon become more advantageous to produce and use than petroleum. According to the WI and GTZ (2006), when petroleum prices are above US$ 50 per barrel, as they were for most of 2005, 2006 and early 2007, bioethanol from sugar cane (Brazil) is significantly cheaper than gasoline. Biodiesel from rapeseed (Europe) and soybeans (United States of America) is comparably priced with diesel, and biodiesel from used cooking oil (Europe and United States of America) is increasingly competitive with diesel. However, price competitiveness depends on the country of production and the biomass used. In Germany, for instance, the oil barrel price at which biofuel becomes more competitive than petroleum is between US$ 95 and $105 per barrel for biodiesel,

US$ 90 per barrel for bioethanol from sugar and starch, and between US$ 120 and US$ 180 per barrel for bioethanol from cellulosic biomass (Agency of Renewable Resources, 2006).

Table 1. Selected characteristics of liquid biofuels

Biofuel	***Fuel yields[a] (L/ha)***	***Net energy balance[b]***	***CO_2 emissions reduction[c] (%)***	***Source (for columns 3 and 4)***
Corn grain ethanol	~3000	1.25	12[d]	Hill *et al.*, 2006
		1.03 (worst-case scenario) 1.12 (best-case scenario)	32	De Oliveira *et al.*, 2005
		1.67 (with by-products) 1.06 (without by-products)	N/A	Shapouri and McAloon, 2004
		~1.5	N/A	WI and GTZ, 2006
Sugar cane ethanol	~6000	3.14 (worst-case scenario) 3.87 (best-case scenario)	67	De Oliveira *et al.*, 2005
		5.82	72 to 75	Sadones, 2006
		~8	N/A	WI and GTZ, 2006
Sugar beet ethanol	~ 5000	1.25	31	Sadones, 2006
		~2	N/A	WI and GTZ, 2006
Wheat ethanol	~ 2500	1.35	45	Sadones, 2006
		~2	N/A	WI and GTZ, 2006
Cellulosic ethanol	N/D	2-36	N/A	WI and GTZ, 2006
Soybean biodiesel	~ 500	1.93 (with by-products) 3.67 (without by-products)	41[d]	Hill *et al.*, 2006
		~3	N/A	WI and GTZ, 2006
Rapeseed biodiesel	~ 1100	2.23	68	Sadones, 2006
		~2.5	N/A	WI and GTZ, 2006
Sunflower seed biodiesel	~ 1000	~3	N/A	GEF-STAP, 2006
Palm oil biodiesel	~ 4500	~9	N/A	WI and GTZ, 2006

a. Source: WI and GTZ, 2006
b. The ratio of energy contained in the biofuel to the non-renewable energy used to produce the biofuel.
c. Emissions reduction in percentage compared to the use of energetically equivalent amount of gasoline
d. Crop harvested from land already in production (no conversion of natural habitat)
N/A: Not available
N/D: Not determined

12. Biofuels also have domestic economic appeal. When produced locally, they can create employment and add to the domestic product (Brown, 2006). Local biofuel production can foster the local economy by increasing business opportunities and income for farmers. In this context, the increased production of raw materials for biofuels in rural areas is expected to contribute to poverty alleviation

(Coelho, 2005). As highlighted during the fourteenth session of the Commission on Sustainable Development, South-South cooperation and development could be strengthened with regard to biofuel production. However, the economic efficiency and even the environmental effectiveness of biofuels vary with the location of production and the feedstock used. For instance, according to the German Agency of Renewable Resources, bioethanol produced from sugar beets in Germany is reported to save 7.2 t/ha of CO_2 and costs 24 Euro/GJ, whereas bioethanol produced from sugar cane in Brazil can reportedly save 15.5 t/ha of CO_2 and costs 9.5 Euro/GJ (Agency of Renewable Resources, 2006). Hence, in promoting local biofuel production, there is a need to take into full consideration opportunities to realize potentially more economically efficient and environmentally effective regional or global outcomes.

13. As a substitute for oil, biofuel is also considered a practical solution because it keeps the premium value of liquid fuels for which a distribution infrastructure is already available (e.g. gas stations) and no significant modification of existing vehicles is needed if oil is mixed with biofuel (WI and GTZ, 2006).

IV. POSSIBLE IMPACTS OF BIOFUEL PRODUCTION ON BIODIVERSITY

A. Overview

14. The scale of the biofuel industry and the number of countries involved in its production and use are expanding at an accelerated pace (WI and GTZ, 2006). While global oil production increased by 7 per cent between 2000 and 2005, bioethanol production expanded nearly threefold and biodiesel production increased more than threefold (Brown, 2006; WI and GTZ, 2006). In 2005, the production of biofuels represented nearly 2 per cent of global gasoline use (Brown, 2006). Bioethanol accounts for 90 per cent of global biofuel production and biodiesel makes up the remaining 10 per cent (WI and GTZ, 2006). Brazil, the leading country in bioethanol production, uses sugar cane as the main feedstock. Brazil is the only large-scale example of a mature biofuel industry that makes bioethanol economical for consumers, satisfying 40 per cent of its vehicle fuel needs (Brown, 2006; WI and GTZ, 2006) and currently operating without direct subsidies. The United States is the second largest bioethanol producer. Their bioethanol is made from corn grain and provides slightly under 2 per cent of total automotive fuel needs (Brown, 2006; WI and GTZ, 2006). These two countries represented about 71 per cent of bioethanol production worldwide in 2004 (calculated from Brown, 2006, and WI and GTZ, 2006). In biodiesel production, Europe is the leader, with Germany providing about 55 per cent of total biodiesel production in 2005, followed by France, with a 15 per cent share (calculated from WI and GTZ, 2006). Both countries use rapeseed as the main feedstock (Brown, 2006).

15. Biofuel is increasingly seen as playing a significant role in addressing the growing energy demand while at the same time protecting the environment. Indeed, the 14th session of the Commission on Sustainable Development stressed the importance of renewable energy, such as biofuel, in reducing air pollution and GHG emissions. A growing number of government programmes, partnerships and other initiatives are promoting GHG mitigation and increased biofuel production and use. The European Union (EU) Biofuels Directive, adopted in May 2003, sets a reference value of 5.75 per cent for the market share of biofuels in 2010 (European Commission, 2004). Moreover, at the March 2007 meeting of the Council of the European Union, the 27 EU Heads of State or Government agreed on a 10 per cent increase in the use of biofuels and a binding 20 per cent target for the use of renewable energy sources by 2020 (European Commission, 2007). The United States predicts that 30 per cent of its current petroleum consumption will be replaced by biofuels by 2030 (Perlack *et al.*, 2005). Many other countries have set targets for biofuel production and use (see table 2 below).

Table 2: Present production and forecasted use of biofuels for major producers

Country	*Current production*	*Forecasted use*

	Bioethanol	*Biodiesel*	
Brazil	16,500 x 10^6 L (WI and GTZ, 2006)		Not found
U.S.A.	16,230 x 10^6 L (WI and GTZ, 2006)	290 x 10^6 L (WI and GTZ, 2006)	30 per cent displacement of petroleum by 2030, which will require 1 billion dry tonnes of biomass feedstock per year (Perlack *et al.*, 2005)
China	2,000 x 10^6 L (WI and GTZ, 2006)		15 per cent of transportation energy needs by 2020 (GAIN, 2006a)
European Union	950 x 10^6 L (WI and GTZ, 2006)	3,184,000 tonnes (20 major producers) (European Biodiesel Board)	5.75 per cent market share for biofuels in 2010 (European Commission, 2004) 10 per cent increase in use of biofuels by 2020 (European Commission, 2007)
India	300 x 10^6 L (WI and GTZ, 2006)		The Petroleum Ministry planned to supply ethanol-blended gasoline at 5 per cent across the country by 2006/07, to be increased later to 10 per cent blend. The government also planned for a 20 per cent blend with biodiesel by 2012 (GAIN, 2006b).
Germany		1,920 x 10^6 L (WI and GTZ, 2006)	At least 5.75 per cent of total fuel consumption in energy terms (Government of Germany, 2006)
France	161,172 tonnes (Government of France, 2005)	511 x 10^6 L (WI and GTZ, 2006) 323,720 tonnes (Government of France, 2005)	Percentage of biofuel mixed into usual fossil fuels: 5.75 per cent in 2008, 7 per cent in 2010 and 10 per cent in 2015 (Ministère de l'agriculture et de la pêche, 2006)
Italy		227 X 10^6 L (WI and GTZ, 2006)	Not found
Austria	No significant production	83 x 106 L (WI and GTZ, 2006) 55,000 tonnes (Federal Environment Agency, 2005)	5.75 per cent substitution, based on energy content (Federal Environment Agency, 2004)

16. Given the limited agricultural lands available in certain countries and the better biomass yield potential in countries with favourable climatic conditions, production of biofuels in developing countries is also expected to increase significantly (e.g. Indonesia oil palm to meet China and Europe's biofuel needs). Brazil and the United States signed an agreement in March 2007 to work together to advance biofuel technology and expand bioethanol production in other countries in South America (Ewing, 2007). According to a study on global bioenergy potential to 2050 (Smeets *et al.*, 2004), the most promising

regions for the large-scale supply of bioenergy, assuming best practice agricultural management systems and technologies, are sub-Saharan Africa, Latin America and the Caribbean, and East Asia.

17. It is generally accepted that the production and use of liquid biofuel instead of fossil fuel could contribute to greenhouse-gas reduction and provide opportunities for the Annex I countries under the United Nations Framework Convention on Climate Change to gain credits, and through climate-change mitigation, contribute to biodiversity conservation. However, the exact potential of greenhouse-gas emission reductions remains uncertain.

18. Farrell *et al.* (2006) noted that with the exception of Brazilian bioethanol production, greenhouse-gas emission savings for most biofuels were lower than their potential and sometimes non-existent. In addition, several non-governmental organizations around the world have expressed concern with respect to the large potentially negative impacts of biofuel production on local and indigenous communities and on biodiversity (Biofuelwatch, 2007; Global Forest Coalition, 2006), calling for a precautionary approach in the production of biofuel. The following is an overview of the possible negative impacts of biofuel production.

B. Competition for land

19. The amount of land that could be dedicated to energy biomass is limited, as most of the suitable land is in use for agriculture, human settlement, covered by forests or locked up in protected areas (FAO, 2003). Therefore, energy biomass plantations may compete with the existing agricultural land uses and/or may lead to the use of the remaining natural landscape that should be kept under conservation.

20. A study from the University of Florida suggests that to replace the entire United States gasoline supply would require 60 per cent of all available cropland (Moreira, 2005). It is also estimated that up to 13 per cent of European Union agricultural land would be needed to meet the 5.75 per cent target of biofuel share in Europe's energy consumption (Biofuels Research Advisory Council, 2006).

21. There is growing concern that replacing an increasing portion of fossil fuels with biofuels will accelerate agricultural expansion. The consequence of energy biomass plantations expanding into the natural landscape will obviously lead to direct biodiversity loss due to habitat destruction and fragmentation. Non-governmental organizations have already raised the issues of deforestation and other ecosystems destruction, including wetlands, due to energy crop expansion (Biofuelwatch, 2007; Global Forest Coalition, 2006). Further biodiversity loss would occur if unsustainable agricultural practices (e.g. overuse of chemical inputs that may lead to eutrophication and water pollution; tillage that can result in soil erosion or compaction) are used when establishing and managing the planted biomass. Given the limited amount of suitable land, energy biomass may also expand into riparian areas, set-aside land or tree lines, which all play an important ecological role. As part of a study performed for the second edition of the Global Biodiversity Outlook (MNP and GLOBIO Consortium, 2006), a scenario has been explored in which bio-energy plays an important role in reducing CO_2 equivalent emissions. In this scenario, major energy consumption savings would be achieved and 23 per cent of the remaining global energy supply would be produced from biofuels in 2050. However, by 2050, the biodiversity gain (+1 per cent) from mitigated climate change and reduced nitrogen deposition, due to less burning of fossil fuels, would not compensate for the natural habitat loss (-2 per cent) for producing biofuel crops in about 10 per cent of the global agricultural area. This would lead to an additional biodiversity loss of around 1 per cent.

22. However, the risks for further environmental degradation caused by growing energy biomass are not the same for every type of energy crop. For instance, Perlack *et al.* (1992) and Cook and Beyea (2000) reported that displacing annual crops with perennial grassy crops, considered a second-generation feedstock, could reduce pesticide and net fertilizer use and lead to greater animal biodiversity as the habitat is improved and natural ecosystems functions are restored. Also, planting energy biomass could be used to rehabilitate marginal and degraded lands (e.g. Tilman *et al.*, 2006).

23. Other issues related to agriculture include: (i) monocultures of energy-efficient crops (sugar cane, oil palm) may be preferred over crop rotations, which may result in the simplification of agro-ecosystems associated with a decrease in crop and farm biodiversity; (ii) the emergence of genetically engineered energy crops for increased yield and energy efficiency could result in cross-pollination of wild relatives, thereby affecting biodiversity; (iii) the potential risks that, in an effort to increase production and meet growing demand for biofuels, energy crops that present many characteristics of a weed, such as jatropha, may become invasive.

C. Additional greenhouse-gas emissions

24. Agriculture is responsible for a significant part of the non-energy emissions. According to the Stern Review (Stern, 2006), total agricultural emissions, excluding deforestation and not taking into account increase in biofuel production, are expected to further increase by 30 per cent before 2020. Most of this increase is due to enhanced nitrous oxide emissions due to greater use of fertilizers, particularly in the tropics (IPCC, 2001). Moreover, agricultural practices such as ploughing cause increased soil carbon emissions. Increased demand for biofuels could lead to large-scale ploughing of non-agricultural land and pasture land, which would result in substantive carbon emissions.

25. Similarly, peatland degradation for biofuel expansion can lead to important carbon emissions. The global Assessment on Peatlands, Biodiversity and Climate Change reports that peatlands are essential for biodiversity conservation and support specialized species and unique ecosystems, and are also critical carbon sinks containing as much carbon as all terrestrial biomass, and twice as much as all forest biomass, while covering only 3 per cent of the world’s land area. The report also states that conservation, restoration and wise use of peatlands are essential and very cost-effective measures for long-term climate change mitigation and adaptation as well as biodiversity conservation. Another report (Hooijer *et al.*, 2006) states that 27 per cent of both timber and oil palm concession areas in Indonesia are on peatlands. Therefore, the expansion of biofuel production could actually counter the GHG emission mitigation potential linked to the use of such biofuels. According to the Millennium Ecosystem Assessment (2005) and the second edition of Global Biodiversity Outlook (SCBD, 2006), climate change is one of the drivers of change in biodiversity and ecosystems with the most rapid increase in impacts.

D. Deforestation

26. In addition to the potential loss of forest due to land clearing for agriculture, growing interest in cellulosic biomass (second-generation feedstock) may increase the existing pressure on forests from fuelwood harvesting (particularly in developing countries) and worsen the already alarming loss of biodiversity in these ecosystems. Moreover, similarly to agriculture expansion, harvesting forest resources to produce biofuel can work against the goal of greenhouse gas reduction, as between 25 and 30 per cent of the GHGs released into the atmosphere each year (1.6 billion tonnes) is caused by deforestation. Primary forests in Indonesia have been found to hold on average 306 tonnes of carbon per hectare in the above ground biomass and litter, whereas mature oil palm plantations hold only 63 tonnes per hectare and are not expected to live more than 25 years at the most (Palm *et al.*, 1999).

27. However, Cook and Beyea (2000) reported that forest or tree plantation for biofuel production can have a beneficial impact on biodiversity as long as it does not replace natural stands and especially if it replaces row crops or helps restore degraded lands (bird population recovery and under-story vegetation favouring habitat for small mammals). Moreover, the negative impact of forest harvesting can be mitigated through the use of residues from logging, which can constitute about 60 per cent of the total harvested trees left in forests (Parikka, 2004).

E. Land conflicts and food prices

28. Some organizations, such as the Forest People Programme and Sawit Watch, have raised concerns regarding the alleged imposition of biofuel production, such as oil palm plantations, on indigenous and local communities, as well as plantation workers and small-holder farmers, without concern for their rights, livelihoods or welfare (Colchester *et al.*, 2006). Moreover, as global demand for food is ever rising, agricultural land use changes from food crops to energy biomass production may result in higher food prices, which in turn may force indigenous and local communities to clear additional lands for food production (subsistence agriculture) or grazing, and to rely more intensively on food from the wild, thus having a negative impact on biodiversity.

F. Water-related impacts

29. Expanded production of biomass for biofuel production may increase the need for water, especially for crops with high water demand. Water is already scarce in many areas and constitutes the major resource constraint on further agricultural expansion. This aspect is a serious concern, in that biodiversity loss from inland water is occurring faster than for any other major ecosystem, and pressures on water resources are already rapidly increasing through the direct drivers of food production and urbanization.

30. Water use and pollution in the processing phase of biofuel production should also be considered. Water pollution can be caused by untreated oil palm mill effluent that contains chemicals (European Commission, 2006). The conversion of biomass to liquid fuels consumes little water compared to evapotranspiration losses in energy crop production. However, the effluent production from fermentation processes to produce bioethanol may be substantial (Berndes, 2002). Therefore, in addition to water pollution linked to agriculture, further concerns about water pollution and consequent biodiversity loss can arise if water used in processing technologies is not treated properly before returning to the environment.

VI. INDICATIVE OPTIONS FOR PROMOTING BIODIVERSITY-FRIENDLY BIOFUEL PRODUCTION

31. Biofuel production raises several concerns with regard to biodiversity conservation and sustainable use. However, there are a number of options proposed in the literature to reduce negative impacts and promote positive impacts on biodiversity.

A. Application of guidelines or standards to reduce negative impacts on biodiversity

32. Several organizations have thought about possible actions to mitigate negative impacts and develop sound biofuel production systems and related tools. The Roundtable on Sustainable Palm Oil, for example, was set up to bring together the commercial sector, conservation organizations, civil society groups, governments and other stakeholders and has devised principles and criteria for sustainable palm oil production and a broad code of conduct for its members (RSPO, 2006). The code includes principles related to best practices for growers and promotes environmental responsibility and conservation of natural resources and biodiversity.

33. The Oeko-Institute has produced a document, published by the World Wide Fund for Nature-Germany, on sustainability standards for bioenergy (Fritsche *et al.*, 2006). Greenpeace has developed criteria for assessing bioenergy production technology and a framework for sustainable agriculture. Other non-governmental organizations such as Friends of the Earth-Brazil have also developed criteria for sustainable biofuel production (Moret *et al.*, 2006).

34. Certification and labelling of bioenergy have also been proposed by the World Wide Fund for Nature to promote the production and use of environmentally friendly biofuels (Denruyter and Earley, 2006).

35. The ecosystem approach, which is the primary framework for action in the Convention, and other tools adopted by the Conference of the Parties, such as the biodiversity-inclusive environmental impact assessment and strategic environment assessment, would assist in planning and implementing plans and programmes for biofuel production

B. Promoting research to develop sustainable option

36. Second-generation feedstocks and associated conversion technologies are promising in terms of savings of greenhouse-gas emissions and biodiversity conservation. Use of low-input, high-diversity grasslands biomass, and focusing biofuel production in lands already available to agriculture, in particular degraded lands, can result in carbon-negative biofuel production systems, have negligible impacts on water use and water quality, and contribute to the conservation of agricultural biodiversity (Tilman *et al.*, 2006). Therefore, research is crucial to develop the potential of these second-generation feedstocks. Finally, there is room for improvement in the economics and yields of energy biomass. This can be achieved through breeding and genetic engineering, which trigger the need for more genetic research and development.

C. Putting in place a sound policy framework

37. All of the current liquid biofuel initiatives have depended on government interventions for their establishment, and most continue to rely on subsidies and other incentive schemes. In this context, biofuel production options that contribute to both the mitigation of greenhouse-gas emissions and the conservation and sustainable use of biodiversity could be promoted by appropriate incentive frameworks (Farrell *et al.*, 2006).

VII. CONCLUSIONS

38. The impact of biofuel production on biodiversity will depend on the feedstock used, management practices, land-use changes and energy processes. Although GHG emission reductions can be achieved through the use of biofuels, it is feared that deforestation, land-use changes and the loss of major carbon sinks such as peatlands can in certain cases offset the energy benefit of biofuel. Several participants in the electronic forum on biofuels were concerned that biofuel expansion would accelerate both climate change and biodiversity loss through deforestation, ecosystem destruction, peat drainage and the wider effects of increased fertilization.

39. Moreover, the potential for biofuel production needs to be forecasted based on ongoing climate changes. The 2007 summary report for policy makers of the Intergovernmental Panel on Climate Change (IPCC) predicts significant drying in South America, Africa and much of South-east Asia, which will predictably reduce agricultural production in those countries where the potential for biofuel production is greatest.

40. Expansion of biofuel production is largely driven by government intervention. It is important for public policy—and the associated incentive structure—to be developed in such a way that this expansion not only contributes to mitigating greenhouse-gas emissions but is also consistent with the conservation and sustainable use of biodiversity. In addition, since it may be too early to fully understand the impacts of biofuel production on biodiversity, it would be useful to carry out, in accordance with national requirements and procedures, assessments of the socio-economic and ecological impacts of biofuel production for large-scale projects.

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