Bioenergy policy-makers and producers have highlighted the potential role of bioenergy in reducing global emissions of greenhouse gases; However, bioenergy's contribution to climate change mitigation has also been contested, especially in relation to greenhouse gas emissions resulting from land use change. This raises questions about how bioenergy policies relate to the REDD+ mechanism being developed under the UNFCCC. There is considerable potential for conflict between these two approaches to climate change mitigation; the increasing demand for bioenergy adds to the demand for agricultural land, and thus potentially competes with other land uses, (including for REDD+) and exerts pressure on forest, and REDD+ policies may reduce access to land for bioenergy development. However, the two approaches can also potentially be complementary. Careful and integrated land use planning is needed to maximize effectiveness of climate change mitigation actions and ensure that this mixed relationship between bioenergy production, forestry, and forest conservation has positive outcomes for climate change mitigation, conservation and forest users.

Bioenergy and REDD+: Opportunities and Challenges

UNEP WCMC

Introduction

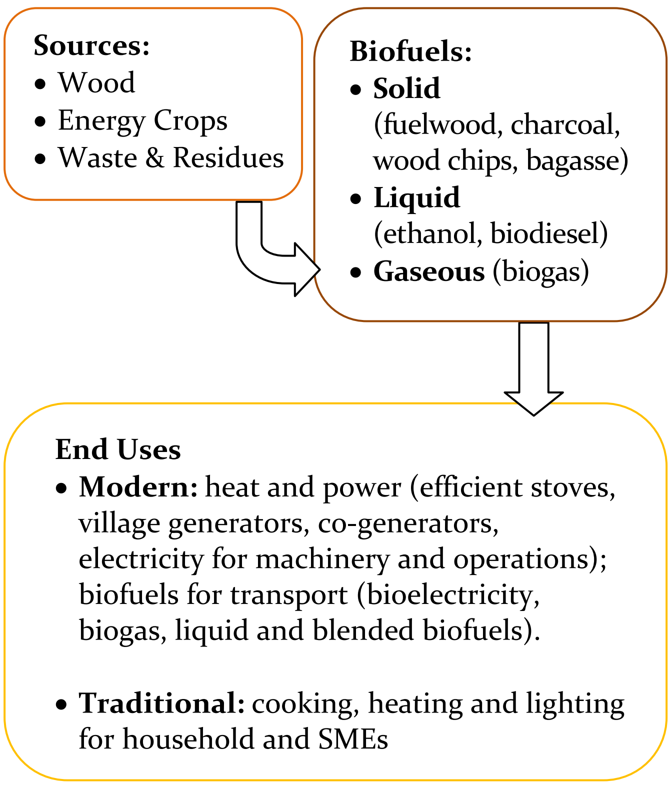
In the context of global concern about mitigating climate change, bioenergy has gained increasing attention for its potential to contribute to reducing greenhouse gas emissions. While attention has so far focused mainly on large-scale biofuel production for transport, modern bioenergy development encompasses a wide range of activities, including increased and more sustainable use of biomass (e.g. fuel wood and charcoal) for energy at both local and larger scales. Any contribution to reducing emissions depends on how such activities are implemented.

The United Nations Framework Convention on Climate Change (UNFCCC) has recognised that land use change makes an important contribution to global CO_2 emissions. Consequently, a crucial part of its efforts to mitigate climate change is limitation of such emissions through the development of REDD+ (i.e. Reducing Emissions from Deforestation and forest Degradation, conservation of forest carbon, sustainable management of forest, and enhancement of forest carbon stocks), a mechanism designed to incentivize efforts to retain and enhance forest carbon stocks in developing countries.

The interactions between bioenergy development and REDD+ and avenues for climate change mitigation are complex because each involves a varied range of approaches. In many cases there may be important trade-offs between them, but there is also some potential for them to be complementary to each other. This paper assesses the current relationships between REDD+ and bioenergy production and use and their implications for climate change mitigation, and concludes with a summary of outstanding questions, opportunities and recommendations.

Bioenergy

Bioenergy is renewable energy derived from biomass, either through direct combustion or through conversion into biofuel. Traditional bioenergy (e.g. fuel wood and charcoal) has a long history of use for domestic cooking, heating and lighting. More recently, new approaches have improved the efficiency of these uses and have opened new uses for bioenergy, including substitution of fossil fuel, in power generation and transport (see figure below).



Interest in climate change mitigation, combined with concerns about energy security and the need for expanded markets for agricultural produce, has stimulated development of new policies, such as the European Renewable Energy Directive, and recent increases in biofuel development and use. Between 2000 and 2010 global biofuel consumption grew almost six fold from 17.8 billion litres to 105 billion litres (86 billion litres of ethanol and 19 billion litres of biodiesel, REN21 2011). Policy makers anticipate that bioenergy offers significant potential for emissions reductions as compared with the use of fossil fuels in electricity generation, heating and transportation. However, potential emission reductions can vary significantly between different feedstock, bioenergy technologies and regions. Several studies have raised concerns that bioenergy may not in fact reduce greenhouse gas emissions because of additional emissions due to land use change associated with producing feedstocks (Searchinger et al. 2008; 2009). Other concerns about the effectiveness of bioenergy use in reducing emissions arise when, for example, the short-term emissions impacts of some woody biomass sources are taken into account (Zanchi et al. 2011). Different analysis and accounting approaches provide very different views of the role of bioenergy in reducing greenhouse gas emissions (Bird et al. 2011a; 2011b).

The increase in biofuel consumption has resulted in a higher demand for land to produce biofuel feedstocks. It is estimated that between 2004 and 2008 the amount of land required for biofuel production increased from 13.8 million hectares (Mha, IEA 2006) to 36 Mha in 2008, representing over 2% of global cropland in 2008 (UNEP 2009).

Biofuel production will need to increase still further if countries are to meet the targets they have set for the share of transport fuels to be supplied by biofuels in the future. For instance, the European Union agreed to a mandatory minimum target of 10% for the share of biofuels used in transport, to be achieved by all Member States by 2020 (Commission of the European Communities 2009). This entails an increasing demand for land for feedstock cultivation. While the current main producers, the USA, Europe and Brazil (Table 1), can be expected to retain key roles, plans for the development of bioenergy (especially in China and India) suggest that they too will play a bigger role in the future (Gallagher 2008).

Table 1: Land required for total biodiesel and ethanol production from main crops in selected producer countries in 2008*

Country	**Main bioenergy crops**	**Land required** (Mha)
USA	Corn and soy bean	13.07
Europe	Canola	9.40
Brazil	Sugarcane	6.04
Argentina	Soybean	1.79
China	Corn	1.04
Canada	Corn and wheat	0.49
Indonesia/ Malaysia	Palm	0.33

** calculated based on volume produced, taking into account conversion efficiency and crop yield (adapted from Fargione et al. 2010).*

The likely size of the increase in land requirement is the subject of some debate. Projections vary according to their underlying assumptions, e.g. about the roles of different biofuel crops and their requirements,

Table 2: Projected total land requirements for achieving a 10% substitution of petroleum fuel with biofuels		
Assumptions	**Crop combination**	**Total land requirement** (Mha)
2009 global yields remain unchanged; no contribution of second-generation biofuels. (Ravindranath *et al.* 2009)	Palm oil and sugarcane	118
	Jatropha and sugarcane	243
	Soybean and maize	508
Benefits of co-products avoid some land demand; contribution of second-generation technologies; significant increase in yield (minimum land requirement scenario, Gallagher 2008)	Mixture	56
No benefits of co-products taken into account; no second-generation technology; low yield (maximum land requirement scenario, Gallagher 2008)	Mixture	166

expected changes in yield and the contribution of second-generation biofuels and other technological advances (Table 2). Despite the varied estimates for land required for biofuel production in the future, there is no doubt that there will be a need for more agricultural land for feedstocks. The impacts of this demand on forest carbon, biodiversity and other ecosystem services will depend on which bioenergy crops are prioritized where, and on how sustainable cultivation practices are.

REDD+

Recognition of the large contribution to global carbon dioxide emissions made by deforestation and forest degradation has highlighted the value for climate change mitigation of keeping forests standing and managing forest resources sustainably. As a result, there has been considerable recent progress in the development of a mechanism under the UN Framework Convention on Climate Change (UNFCCC) to provide financial and other incentives for Reducing Emissions from Deforestation and forest Degradation, conservation of forest carbon, sustainable management of forest, and enhancement of forest carbon stocks (REDD+).

REDD+

= Reducing Emissions from Deforestation and forest Degradation

+

Conservation of forest carbon stocks
Sustainable management of forests
Enhancement of forest carbon stocks

Recent progress has included the agreement on a set of social and environmental safeguards, intended to ensure that the risks of adverse impacts from REDD+ are minimized (UNFCCC 2010).

While the details of the mechanism are still under discussion, including the form of financing and the specific actions it will support under different national circumstances, countries are moving ahead with preparing for REDD+, and pilot activities are underway. In most cases REDD+ actions will need to encompass a broad range of interventions and sectors, including establishment of protected areas, development of forest management plans and techniques, and work with local communities to enhance livelihoods and reduce pressures on forests and forest resources.

Many countries engaging with the REDD+ mechanism consider agricultural expansion to be a primary driver for deforestation (Kissinger 2011a; 2011b). For these countries, working with the agriculture sector to find ways to limit expansion of cultivated land may be fundamental, though the relationship between changes in agricultural practice and deforestation is complex (Pirard and Treyer 2010). Drivers that contribute to forest degradation, including traditional fuel wood use, will also need to be addressed.

Bioenergy and REDD+ can conflict

Bioenergy development and REDD+ are fundamentally linked through their relationship to demand for land and resources. Increasing the area of land used for biofuel production can require that land not currently used for agriculture is converted (i.e. direct land use change). Alternatively, crops on existing agricultural land may be replaced by bioenergy crops, potentially displacing the original crops onto former non-agricultural land (i.e. indirect

land use change, iLUC). In both cases, biofuel expansion can exert pressure on forest land and lead to deforestation.

Palm oil production, mainly for food but also for biofuel, has become a major driver of deforestation in Southeast Asia. For the period 1990 – 2005, an estimated 55-59% of the expansion of oil palm in Malaysia and at least 56% of that in Indonesia occurred at the expense of forest (Koh and Wilcove 2008). In Argentina, the area harvested for soy bean has increased from about 5 Mha in 1990 to more than 16.7 Mha in 2009 (FAOSTAT 2011). Hotspots of deforestation coincide with areas for biofuel production in the country's north, mainly affecting the forests of the Dry Chaco (Gao *et al.* 2011). In Brazil, projections for the likely future expansion of cultivation to meet national biofuel production targets suggest that an additional 5.7 Mha will be required for sugarcane and 10.8 Mha for soybean (Lapola *et al.* 2010). While Brazil has developed Agro-ecological Zoning (AEZ) and other policy approaches to limit the expected direct conversion of natural ecosystems to biofuel productions, it has been estimated that iLUC (displacement of previous land uses) may lead to as much as 12.2 Mha of pastureland expansion into forest areas of the Amazon and the Cerrado (Lapola *et al.* 2010). Thus in at least some cases, expansion of biofuel cultivation can be a significant driver of deforestation; planning and implementation of REDD+ will need to take this into account, and in addressing this driver may limit options for further expansion.

A further factor affecting the interaction between bioenergy and REDD+ is the financial incentive associated with each land use. At current carbon prices, conversion of forest for oil palm would be more profitable to landowners than conserving the forest under a REDD+ scheme (Butler *et al.* 2009), though this may change if a future climate agreement changes the ways carbon credits can be traded. While REDD+ financial incentives may represent a welcome support to local communities, they are likely to be less effective where economically attractive prospects arise, such as some types of bioenergy development. The long-term success of REDD+ will depend on how opportunity costs compare with the incentives generated through conservation of carbon stocks.

Bioenergy development and use based on forest biomass can lead to emissions from forest degradation and may also contribute to deforestation. These problems can arise in traditional use of fuel wood and charcoal, and also for those forms of modern bioenergy that are dependent on woody biomass, either directly harvested for the purpose or in the form of residues from the harvest of other forest products. In many countries, actions under REDD+ are likely to target harvest and consumption of woody biomass.

In many cases, therefore, planning and action under REDD+ may create barriers to bioenergy development by constraining the use of land and forest resources. In other cases, however, sustainable bioenergy development and REDD+ may support each other.

Bioenergy and REDD+ can potentially be complementary

Although bioenergy development and use can contribute to land conversion as outlined above, there is also some potential for it to make a positive contribution to reducing emissions from deforestation and forest degradation. Modern bioenergy approaches may play a role in reducing pressures on forests by reducing demand for wood fuel by providing alternative fuels, such as ethanol or biogas, and/or by improving the efficiency with which traditional fuels, such as wood and charcoal, are produced and used (see case study). Furthermore, advances in agricultural practice that are associated with the development of modern bioenergy, such as improved soil management methods and the use of new varieties, can foster similar improvements in other agricultural sectors and related increases in yields that may help to reduce demand for agricultural land.

Sustainable bioenergy development and REDD+ may support each other

When sustainable forest management techniques are used in the production of biomass they help both to assure a continued supply and to maintain ecosystem services, including carbon storage. The ecosystem services provided by forests, such as regulation of water supply, soil conservation and pollination services also support production of biofuel crops. Finally, development of sustainable production of woody biomass can contribute to reclamation or restoration of degraded forest, and in some cases to the establishment of new forest on lands not previously forested. These impacts could potentially contribute to 'enhancement of forest carbon stocks' under REDD+.

Case study – The CWCS Improved Fish Smoke Houses Project in Cameroon

The UNEP Programme CASCADe (Carbon Finance for Agriculture, Silviculture, Conservation and Action against Deforestation) aims at enhancing expertise to generate carbon credits in land use, land use change and forestry (LULUCF) as well as bioenergy activities in Sub-Saharan African countries (see www.cascade-africa.org).

One of the Programme's pilot projects aims at reducing deforestation in the coastal mangrove forest of the Douala-Edea Reserve in the South-West of Cameroon. Villagers in the area extract large quantities of wood from the surrounding mangrove forests. The wood is used for smoking of fish, a major source of local income, using energy-inefficient smoking rafts. This practice is a significant deforestation pressure on the mangrove forest.

The project will help villagers install more efficient fish smoke houses that require much less wood. This more efficient use of bioenergy should significantly reduce deforestation in the area. While local traditions are maintained, the project will help communities preserve ecosystem services that are critical to their livelihoods, reduce the time spent for wood collection, and mitigate dangerous indoor smoke pollution caused by traditional smoke-houses. The estimated annual emission reduction/ sequestration that will be achieved amounts to 9,023 tons of carbon dioxide equivalents per year. The resulting carbon finance enables the construction of the smoke houses (UNEP *et al.* 2010).

Conclusions

Although there is a mixed relationship between REDD+ and bioenergy production, there currently appear to be more significant trade-offs than potential synergies between the two. While REDD+ may offer some opportunities to incentivize certain types of bioenergy production, action under REDD+ may also limit expansion of bioenergy production on forest land (Table 3).

The future balance of the relationship between REDD+ and bioenergy will be affected by the interpretation and application of the social and environmental safeguards for REDD+ referred to in the UNFCCC's Cancun Agreement (UNFCCC 2010). These are intended to ensure, among other things, that REDD+ funding is not used to subsidise replacement of natural forest with plantations, although such areas technically remain "forest" under the definitions adopted by the UNFCCC in 2001 (Sasaki and Putz 2009). The safeguards help to address concerns that REDD+ funding could otherwise be used to support the already subsidised bioenergy sector. They also aim to ensure the continued provision of the multiple benefits of forests. Where biofuel production areas and natural forests occur side by side, this may require coordinated management to ensure the multiple benefits provided by the forest are not constrained by biofuel crop cultivation in adjacent areas. On the other hand, bioenergy projects aiming to increase the sustainability of fuel wood management at local scale may present opportunities to enhance other environmental benefits provided by forests, such as biodiversity conservation, soil protection and provision of other non-timber forest products, and may thus be consistent with social and environmental safeguards for REDD+. The influence of the safeguards on the relationship between bioenergy and REDD+ will depend on their interpretation at national level.

Sustainability standards and criteria, such as those included in the European Union's Renewable Energy Directive (Commission of the European Communities 2009) also aim to avoid the conversion of natural habitat and areas of importance for biodiversity and carbon for the production of biofuels. These should help to limit conflicts between biofuel crops and REDD+, but do not currently address indirect land use change and its impacts.

Table 3: Potential synergies and trade-offs between REDD+ and bioenergy		
Potential synergies	Potential trade-offs	
	Bioenergy impeding REDD+	REDD+ impeding bioenergy
• Bioenergy development reduces pressure on forests o increasing efficiency or reduction of traditional biomass use o provision of alternative fuels o improved forest management • Improved forest management under REDD+ improves overall stocks of woody biomass • REDD+ funds support improved forest management for bioenergy production	• Demand for bioenergy increases intensity of forest biomass use and causes forest degradation • Demand for bioenergy increases conversion of forest for agricultural production of feedstocks • Bioenergy production displaces other land uses and/or extractive activities, increasing total emissions from forests (indirect land use-change)	• REDD+ interventions reduce access to forests for biomass harvest • REDD+ interventions reduce availability of land for cultivation of bioenergy feedstocks

The complexity of the relationships between bioenergy and REDD+ means that planning these and other approaches to climate change mitigation needs to be coordinated amongst several sectors and also needs to form part of wider integrated land use planning to ensure the continued provision of food, energy and ecosystem services to support sustainable development.

Improved smoke houses can help reduce pressure on mangroves

References: For details of references cited or further information on the UNEP Issue Paper Series, please see: http://www.unep.org/bioenergy/Issues/UNEPIssuePaperSeries/tabid/79387/Default.aspx

AVENUES FOR SUSTAINABLE BIOFUEL PRODUCTION

LOOKING AHEAD

- Recognise that one kind of mitigation can affect another, either adversely or positively;
- Make use of safeguards and sustainability standards to help limit conflicts between mitigation approaches, taking into account that their effectiveness has yet to be proven and will depend on national interpretations and application;
- Coordinate planning and implementation of REDD+ and bioenergy development as climate change mitigation actions in order to ensure as much synergy as possible among, and avoid adverse impacts on, outcomes from these and other mitigation approaches;
- Develop incentives and policies for REDD+ and/or bioenergy in the light of full assessment of opportunity and other costs associated with these and other land use choices;
- Integrate planning for REDD+ and bioenergy into wider land use planning, addressing the needs of all sectors, biodiversity, ecosystem services and people;
- Identify and disseminate any successful experience in which bioenergy development has been shown to reduce pressures on forests.
- Prioritize those bioenergy approaches that are likely to be most effective in reducing pressure on forests.