

## BRIEFING

# BIOFUELS, FOOD SECURITY, AND AFRICA

THOMAS MOLONY AND JAMES SMITH\*

GLOBAL BIOFUEL PRODUCTION TRIPLED BETWEEN 2000 and 2007 and is projected to double again by 2011.<sup>1</sup> This growth reflects a growing interest worldwide in renewable energy alternatives to fossil fuels, especially as a perceived solution to the transport sector's dependency on oil. It also reflects the enforcement in 2005 of the Kyoto Protocol, and the increasing implementation of national biofuels targets. As a result of these and other influences, policy makers and researchers in African countries are giving more attention to biofuels. Yet the rising demand for biofuels has sparked a debate over the threat that energy security poses to food security, and within a few short years biofuels have shifted from being seen as a multi-purpose solution to a range of problems – climate change, energy insecurity and underdevelopment – to what the UN Special Rapporteur on the Right to Food has described as a 'crime against humanity'.<sup>2</sup> The threat is particularly profound for the many African countries where food security is a significant issue, and raises questions in what has become known as the 'food-versus-fuel' debate. This briefing discusses the relationship between biofuels and food security in Africa, and brings in related issues concerning land ownership and livelihoods. As more and more African countries devote land to the cultivation of biofuels, the numerous questions and

\*Thomas Molony (Thomas.Molony@ed.ac.uk) is Senior Research Fellow at the Centre of African Studies, University of Edinburgh, and James Smith (James.Smith@ed.ac.uk) is Senior Lecturer in African Studies and Director of the University of Edinburgh's Global Development Academy. Both work on the Policy Innovation Systems for Clean Energy Security (PISCES) project, a DFID-funded partnership of institutions in Kenya, India, Sri Lanka, Tanzania, and the United Kingdom. PISCES provides policy makers with new information and approaches aimed at unlocking the potential of bioenergy to improve energy access and livelihoods in poor communities (<[www.pisc.es.or.ke](http://www.pisc.es.or.ke)>). The views expressed in this briefing are entirely those of the authors and do not necessarily represent DFID's own policies or views.

1. Rebecca Clements, Joan Kariuki, and Lulu Hayanga, 'Scoping study into the impacts of bioenergy development on land (draft)' (PISCES, Nairobi, 2009); FAO, 'Sustainable bioenergy: a framework for decision makers' (FAO, Rome, 2007).

2. Edith Lederer, 'Production of biofuels "is a crime"', <<http://www.independent.co.uk>> (5 August 2009).

potential conflicts that are addressed here are of crucial relevance to many vulnerable populations, environments, and states across the continent.

### *What are biofuels?*

'Biofuels' are liquid fuels that are directly derived from renewable biological resources, especially from purpose-grown energy crops. Biofuels, and bioenergy more generally, are nothing new to developing countries. An estimated 2.5 billion of the world's poorest people rely on bioenergy every day, and biofuel production has been practised for some decades in Africa, especially in Mali where jatropha has been widely used.<sup>3</sup> Virtually all of the commercially available biofuels are 'first generation' energy crops that are produced from starch- or sugar-rich plants such as sugar cane or maize (for bioethanol), or oilseeds such as rapeseed, soy, palm or jatropha (for biodiesel). Many of these crops are edible – and this, in part, has prompted research into non-edible biofuels that can pose less of a threat to the production of food crops. These so-called 'second generation', or 'advanced', biofuels are created from processes that convert cellulosic agricultural and forestry wastes (for bioethanol) or lignocellulosic substances (for biodiesel) into energy. Second generation biofuels are still at the experimental stage and have not yet reached an acceptable level of economic viability, but they may hold the potential for many more species of plants to be used as sources of energy, and are the most obvious way to avoid future food-versus-fuel resource issues.<sup>4</sup> This does not mean, however, that so-called first generation biofuels are not the target of heavy investment. Quite the opposite.

### *Growing interest*

Two main interest groups of countries and companies are jostling for a favourable position within the global energy market. On one side are fossil fuel-importing nations that are seeking to reduce their growing energy expenditures. Tanzania, for example, currently spends US\$1.3–1.6 billion per year, some 25 percent of its total foreign exchange earnings, on oil

3. Environmental Development Action (ENDA), 'Biofuels development in Africa: illusion or sustainable alternative?' <[www.compete-bioafrica.net/publications/publ/ENDA%20Biofuels%20Africa.pdf](http://www.compete-bioafrica.net/publications/publ/ENDA%20Biofuels%20Africa.pdf)> (16 April 2008).

4. ENDA, 'Biofuels development in Africa'; Arthur Mol, 'Boundless biofuels? Between environmental sustainability and vulnerability', *Sociologia Ruralis* 47, 4 (2007), pp. 296–315; Peter Hazell and Rajendra Pachauri, 'Bioenergy and agriculture, promises and challenges' (Report, International Food Policy Research Institute (IFPRI), Washington, DC, 2006); Vineet Raswant, Nancy Hart, and Monica Romano, 'Biofuel expansion: challenges, risks and opportunities for rural poor people' (Report, International Fund for Agricultural Development, Rome, 2008).

imports.<sup>5</sup> On the other side are countries that are currently biofuels exporters or seek to be so in the future. The United States is a powerful actor among the fossil fuel-importing nations; Brazil, Mexico, and Malaysia are key players among biofuels exporters. Several African countries are considering joining the ranks of substantial exporters of biofuels, most notably Angola, Ethiopia, Kenya, and South Africa.

Many oil-importing developing countries with tropical climates that are suitable for growing energy-rich biomass now seek to produce biofuels on a large scale, as part of a strategy for either export-led or rural-based development. Part of the rubric of biofuels thinking is the somewhat geographically deterministic perspective that these tropical countries have a comparative advantage given their greater solar exposure and can thus benefit from producing biofuels that satisfy Northern demands.

Accordingly, a growing number of African countries have now enacted new, pro-biofuel national strategies, among them Malawi, Mali, Mauritius, Nigeria, Senegal, South Africa, Zambia, and Zimbabwe<sup>6</sup> – although criticism has been levelled, such as that towards Mozambique's World Bank-funded National Biofuel Policy and Strategy, which allegedly blocked civil society participation in its formulation process.<sup>7</sup> A number of countries have joined the Pan-African Non-Petroleum Producers Association, aimed in part at developing a robust biofuels industry for the continent.<sup>8</sup> Mauritius is seeking to reach 40 percent of its energy needs through cogeneration using bagasse coming from the commercial production of cane sugar, and is also aiming to develop the processing of sugar cane for bioethanol production. Nigeria, the world's largest producer of cassava, aims to work with Brazil to produce US\$150 million worth of cassava ethanol annually, and to establish a US\$100 million 'biofuel town' near Lagos where 1,000 bioenergy experts – primarily from Nigeria, but also from other African countries and Brazil – will work on novel technologies to improve bioenergy production. The Brazilian influence is also apparent in Mozambique, which is developing a sorghum- and sugar cane-based biofuel sector funded by US\$700 million set aside for biofuel research, production and promotion.<sup>9</sup>

Some African countries are participating in joint ventures with investors. In an initiative that is touted to boost the livelihood of 5,000 smallholder

5. Emmanuel Sulle and Fred Nelson, 'Biofuels, land access and rural livelihoods in Tanzania' (Report, International Institute for Environment and Development (IIED), London, 2009).

6. ENDA, 'Biofuels development in Africa'.

7. D. Ribeiro and N. Matavel, 'Jatropha! A socio-economic pitfall for Mozambique' (Report, Alliance Sud *et al.*, Berne, 2009).

8. FAO, 'Sustainable bioenergy'.

9. Kimani Chege, 'Biofuel: Africa's new oil?' <<http://www.scidev.net/en/features/biofuel-africas-new-oil.html>> (15 April 2008).

farmers through contract farming, the Mozambique government has partnered with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Rusni Distilleries Ltd, a private Mozambican company. Their US\$30 million investment will establish a facility capable of producing 100,000 litres of sorghum ethanol annually.<sup>10</sup> Similar partnerships are being set up in countries such as Angola, Ethiopia, Mali, and Tanzania, to name but a few, showing promise for a possible middle way whereby African governments encourage business models that bridge large and small enterprise.<sup>11</sup>

The domestic opportunities that biofuels offer come with trade-offs. In moves that have raised accusations of ‘neo-colonial’ behaviour, some wealthy countries are now rapidly acquiring vast tracts of agricultural land in poorer nations, especially in Africa, to grow biofuels and food for their own consumption. Daewoo Logistics of South Korea, for example, has recently leased 1.3 million hectares of farmland – about half the size of Belgium – from Madagascar’s government to farm maize and palm oil,<sup>12</sup> although the status and details of this agreement are currently unclear and obscured further by political violence in the country, in which rhetoric about the supposed land deal has been employed by the main opposition group. At the same time as trying to manage the political fallout in Madagascar, South Korea is now negotiating the acquisition of 100,000 hectares of farmland with the Tanzanian government – who is also being courted by a United Arab Emirates company seeking a lease on farmland for rice cultivation to help secure food supplies for Gulf countries.<sup>13</sup> Elsewhere in Tanzania foreign companies are growing sugar cane for bioethanol so that European countries can meet their European Union targets.<sup>14</sup>

### *Opportunity and cost*

While there may be some distinct advantages to investment in biofuels in developing countries, especially in rural areas, the sudden interest of wealthy investors can also bring problems. For example, where competing resource claims exist among local resource users, governments, and incoming biofuel producers, these ‘land grabs’ can further marginalize the rural

10. *Ibid.*

11. Sonja Vermeulen, Emmanuel Sulle, and Swan Fauveaud, ‘Biofuels in Africa: growing small-scale opportunities’ (Report, IIED, London, 2009).

12. ‘Daewoo to pay nothing for vast land acquisition’, *Financial Times*, 20 November 2008, p. 7.

13. ‘The next great land sale’, *Africa-Asia Confidential* 2, 12 (2009), p. 6; *This Day*, ‘Gulf firm seeks long-term lease on Tanzanian farmland’, <<http://www.thisday.co.tz/?l=10573>> (26 January 2010).

14. Debora Mackenzie, ‘Rich countries carry out “21st century land grab”’, *New Scientist* 2685 (2008), pp. 8–9.

poor who rely on land for their livelihoods.<sup>15</sup> In some cases the agreement is to grow biofuels on 'idle' or 'marginal' land under the assumption that the unoccupied land is never used, which ignores groups such as nomadic herders who depend on land at certain times of the year. Those with a more permanent presence on the land are also at risk, since they generally have little negotiating power against large private entities. Under pressure from powerful forces offering comparatively large amounts of windfall cash, poor farmers may be tempted to sell their land at low prices or, where land is *de jure* owned by the state, may find that their land is simply allocated to investors.<sup>16</sup>

Issues arise from how 'unproductive' or 'productive' land is categorized. Land may be categorized as unproductive simply if it is not part of the formal economy, but it may still be productive in other terms – for hunting, gathering, or pastoralism. There is also the risk that seemingly sustainable approaches to biofuels investment and plantation might be replaced with less sustainable approaches. Should biofuels production become profitable, one risk is that existing arable land might be turned over to biofuels crop production; and should biofuels crops lead to low yields on more marginal lands, they may instead be planted on better farm lands.<sup>17</sup> Clear land tenure policies are required to guide investments and the proper allocation of land, and must incorporate an understanding of national and local land tenure systems as well as a comprehensive assessment of pastoral practices.<sup>18</sup> There are indications that, because many African countries do not yet have well-thought-through biofuels policies that consider land tenure, *ad hoc* decisions about land use could have longer-term repercussions. In Tanzania, for example, there are concerns over whether the land laws can provide adequate protection against land alienation for biofuel production, and whether compensation payments provided for in the Village Land Act (1999) are sufficient to promote alternative livelihood opportunities.<sup>19</sup> The situation looks little better across the border in Kenya, where early interview data with senior policy makers suggests that while the government is talking about a small-scale, pro-poor focus for its biofuels investment, there is every indication that this would quickly be dropped if there was sufficient commercial interest and investment in large-scale industrial production.<sup>20</sup> The question of scale and sustainability,

15. Lorenzo Cotula, Nat Dyer, and Sonja Vermeulen, 'Fuelling exclusion? The biofuels boom and poor people's access to land' (Report, IIED and FAO, London and Rome, 2008).

16. Raswant, Hart, and Romano, 'Biofuel expansion'.

17. Joseph Fargione, Jason Hill, David Tilman, *et al.*, 'Land clearing and the biofuel carbon debt', *Science* 319, 5867 (2008), pp. 1235–8.

18. Clements, Kariuki, and Hayanga, 'Scoping study'.

19. Sulle and Nelson, 'Biofuels, land access'.

20. Matteo Vianello, *Biofuels and Development: Exploring the Kenyan reality* (University of Edinburgh, unpublished MSc dissertation, 2009).

so often an issue in alternative energy development, is a serious one. Locally attuned small-scale production may easily be replaced by externally oriented, interest-driven large-scale production if the opportunity presents itself.

Lack of transparency and paucity of regulation in foreign biofuel investment is evident in Tanzania, where there appears to be no consistent strategy regarding biofuels investment or how to regulate it. Oxfam reports that the emerging picture is one of investment for export with seemingly no requirements on companies to maximize value-addition within country, supply national markets, form links with local companies, adopt production models likely to maximize opportunities for poor people, or work with local communities to increase access to energy.<sup>21</sup>

Rather than diversifying income and profit-making potential, Tanzania's experience seems to be a well-trodden path that bends to navigate global agricultural trade realities.

#### *Livelihoods and food-versus-fuel*

Notwithstanding the experience of countries such as Tanzania thus far, cultivation of biofuels may be instrumental in long-term poverty reduction in developing countries that have a high dependence on agricultural commodities, with benefits in the form of employment, skills development and the nurturing of secondary industries.<sup>22</sup> If developed correctly, there may be real opportunities to bring sustainable benefits to countries and communities that invest in biofuels production. A more positive recent study from Tanzania, for example, shows that with due recognition of local contexts, biofuel companies using outgrower and other contracted smallholder arrangements have little direct negative impacts on land access and represent a more positive model for the environment and local livelihoods.<sup>23</sup>

The employment opportunities range from highly skilled science, engineering and business-related jobs, to medium-level technical staff and unskilled agricultural work in farming, transportation and processing in rural communities.<sup>24</sup> These opportunities are often associated with large-scale plantations owned by private companies that aim at gaining economies of scale, but which are sometimes accused of displacing people and of poor labour conditions.<sup>25</sup> There are certainly likely to be trade-offs between the

21. Oxfam, 'Another inconvenient truth: how biofuel policies are deepening poverty and accelerating climate change' (Briefing paper, Oxfam, Oxford, 2008).

22. Cotula, Dyer, and Vermeulen, 'Fuelling exclusion?'

23. Sulle and Nelson, 'Biofuels, land access'.

24. FAO, 'Sustainable bioenergy'.

25. ICRISAT, 'Pro-poor biofuels outlook for Asia and Africa: ICRISAT's perspective' (Report, ICRISAT, 2007); FAO, 'Sustainable bioenergy'.

types of jobs created and lost, and the backgrounds of the people who stand to gain and those who have the most to lose.

Large-scale and small-scale biofuels production can co-exist and even work together to maximize positive outcomes for rural development.<sup>26</sup> The technologies involved in modern biofuels production are basically simple oil-pressing and alcohol distillation processes that are well known at the village level and are easily replicable. Foreign firms can contract local small farmers to grow crops for them, providing farmers with more security and predictability than from simply selling crops on open markets. Price squeezes by middlemen or large-scale processors will probably still apply, however, and small-scale farmers may need to form commodity associations and cooperatives to protect themselves. New pro-poor contract-farming relationships are emerging that may better serve small-scale farmers, but these will only succeed if they are designed to be cost-effective and competitive.<sup>27</sup> It is likely that there will need to be strong and thoughtful state regulation if biofuels are truly to be pro-poor. Evidence suggests that while poorer communities have benefited from investment in ethanol production from sugar, for example, other problems have arisen over access to land and poor labour conditions.<sup>28</sup>

Most compellingly and most visibly, the rising demand for biofuels has sparked a debate over the threat that energy security poses to food security. There are three main (interrelated) threads to the food-versus-fuel debate. The first is that there is less food available to eat because crops that would otherwise be used for human consumption are being diverted for processing into biofuels – usually for transportation. The second is that demand for biofuels has increased competition for land and water resources that would otherwise be used for cultivating edible crops (and that also runs the risk of heightening conflicts over water use, particularly in Africa's drier areas).<sup>29</sup> A result of these two concerns is, thirdly, that more production of biofuels will force food prices up and make it more difficult for poor people to purchase food.<sup>30</sup>

Food price increases have seemingly kept pace with oil price rises (and certainly they are linked in some respects), rising by 140 percent between January 2002 and February 2008, and staples such as grains have doubled in price in just the past year. Several reasons have been cited, including the price of oil; changes in food production and consumption; the exchange

26. Cotula, Dyer, and Vermeulen, 'Fuelling exclusion?'

27. ICRISAT, 'Pro-poor biofuels'.

28. Oxfam, 'Another inconvenient truth'.

29. Elizabeth Cushion, Adrian Whiteman, and Gerhard Dieterle, 'Bioenergy development: issues and impacts for poverty and natural resource management' (Report, World Bank, Washington, DC, 2009).

30. Clements, Kariuki, and Hayanga, 'Scoping study'.

rate of the dollar (and related world macro-economic factors); and growth of the world population.<sup>31</sup> Biofuels have been cited as another factor, although published analysis diverges widely on the extent of the effect of biofuels on food prices, which again underlines how little we really understand the impacts.

In May 2008 the US Secretary of Agriculture claimed that analysis showed that biofuel production contributed only 2 to 3 percent to increases in food prices.<sup>32</sup> However, in July 2008 a World Bank document leaked to *The Guardian* calculated that biofuel production was responsible for 75 percent of the increase in food prices between 2002 and 2008. Increased biofuel production was said to have led to increased demand for so-called feed crops (from which fuel can be derived), which in turn led to large-scale land use changes which reduced supplies of crops such as wheat.<sup>33</sup>

According to a 2008 World Bank report, rising food prices have forced approximately 100 million more people into poverty and the recent Food and Agriculture Organization (FAO) report on food insecurity in the world (2009) estimates for the first time that over one billion people are undernourished worldwide.<sup>34</sup> Meanwhile, the United States and Europe have made efforts – with varying degrees of fortitude – to progressively increase the portion of biofuels that are blended into petrol. Some African governments are now also making moves in this direction.<sup>35</sup>

The assumption in all of these arguments, however, is that there will be no increase in the total amount of land cultivated. The earlier point about ‘unoccupied’ land notwithstanding, untapped and potentially cultivatable land does exist – depending on the definitions of ‘idle’, ‘under-utilized’, ‘barren’, ‘unproductive’, ‘degraded’, ‘abandoned’ and ‘marginal’ lands. There are, of course, huge costs in developing ‘barren’, ‘degraded’ or ‘marginal’ lands, and these need to be factored into analysis. Evidence suggests that these lands do not lead to very profitable production of oil from seed crops such as *jatropha curcas*, which several East African countries are

31. Marcos Fava Neves, ‘Industry speaks: strategies for solving the food inflation problem’, *International Food and Agribusiness Management Review* 11, 3 (2008), pp. 179–86; Philip Abbott, Christopher Hurt, and Wallace Tyner, ‘What’s driving food prices?’ (Report, Farm Foundation, Oak Brook, IL, 2009); Royal Society, ‘Sustainable biofuels: prospects and challenges’ (Report, The Royal Society, London, 2008).

32. Andrew Martin, ‘Food report criticises biofuel policies’, <<http://www.nytimes.com>> (5 August 2009).

33. Donald Mitchell, ‘A note on rising food prices [leaked draft report prepared for the World Bank, 8 April 2008]’ <<http://image.guardian.co.uk/sys-files/Environment/documents/2008/07/10/Biofuels.PDF>> (5 August 2009).

34. World Bank, ‘Rising food prices: policy options and the World Bank response’ (Washington, DC, World Bank, 2008); FAO, ‘The state of food insecurity in the world 2009’ (Report, FAO, Rome, 2009).

35. ‘Biofuels: food from the poor’s mouth into the tank of my car!’, *Daily Monitor*, 29 December 2009, p. 11; Government of Kenya, ‘Proposed National Biofuel Policy [16 December 2009 draft]’ (Ministry of Energy, Nairobi, 2009).



planting or have been exploring opportunities for, and which hold potentially large export markets.<sup>36</sup> *Jatropha* may grow on land that will not support arable agriculture, for example, but it will grow better (and potentially more profitably) on better-quality land. The food-versus-fuel problematic may not go away.

Other striking statistics also inform the debate. Oxfam estimates that the livelihoods of at least 290 million people are immediately threatened by the food crisis, and as previously noted the World Bank estimates that 100 million people have already fallen into poverty as a result.<sup>37</sup> According to the FAO, 30 percent of Africans are undernourished and Millennium Development Goal 1, the eradication of extreme poverty and hunger, seems more elusive than ever.<sup>38</sup> Another commonly used example is the consumption of biofuels by large cars. The WorldWatch Institute offers the comparison that the amount of grain required to fill the 90-litre petrol tank of a 4x4 vehicle once with bioethanol could feed one person for a year, while (not) filling it every two weeks over the same period would feed several families.<sup>39</sup>

These headline-grabbing figures are regularly quoted in the food-versus-fuel debate, but there are very few available studies into the impact of biofuels production on the availability of food domestically. Several initiatives are investigating these issues, including the FAO's Bioenergy and Food Security (BEFS) project to determine the potential effects of biofuels production on food security and land use in Peru, Tanzania, and Thailand.<sup>40</sup> There is an urgent demand to conduct more 'life cycle' assessment studies of the energy 'surpluses' or 'deficits' in various biofuels production scenarios and to produce more analyses of farmer behaviour and investment in biofuels production before we can look beyond rhetoric and begin to understand the relative benefits or disadvantages of widespread biofuels investment in developing countries. These complexities are acknowledged in UNEP's recent assessment of biofuels, which considers supply as well as demand over the life cycle of a number of individual crops.<sup>41</sup>

The focus also tends to be on the cultivation of biofuels in developing countries, ignoring an increase in biofuels production in developed countries. This is quite possible, given that the EU is already paying farmers an extra 45 euros a hectare to grow crops for biofuels.<sup>42</sup> It may well be that food insecurity as a result of biofuels is driven by Northern agricultural prac-

36. Oxfam, 'Another inconvenient truth'.

37. *Ibid.*

38. FAO, 'State of food insecurity'.

39. Carol Thompson, 'Agrofuels from Africa, not for Africa', *Review of African Political Economy* 35, 3 (2008), pp. 516–9.

40. <<http://www.fao.org/bioenergy/foodsecurity/befs/en/>> (13 March 2010).

41. UNEP, 'Towards sustainable production and use of resources: assessing biofuels' (Report, UNEP, Nairobi, 2009).

42. Clements, Kariuki, and Hayanga, 'Scoping study'.

tices, as appears to be the case according to the suppressed World Bank analysis of food price rises, or will at least be driven by Northern demands for certain types of energy in the future.

One effect of a focus on biofuels production is that it may reduce wealthy nations' food and feed production, benefiting all producers, including those in developing countries, as world prices rise. Developing country farmers could then expand their production of food and feed, thereby increasing the availability of crop residues available for energy feedstock. On the negative side, however, it has been borne out thus far that higher world prices would lead to higher food prices for the poor. This impact might be offset in the longer term by the higher employment and incomes generated by agricultural-led growth, although this is very hard to predict.<sup>43</sup>

The impact of biofuels on food availability and price increases is difficult to disaggregate from a wide range of other temporary and longer-term factors that have combined to create what has been described by Oxfam as 'a perfect storm'.<sup>44</sup> Navigating the storm from these combined influences – among them increased oil prices, weather-related shortfalls, poor harvests, global population growth, and economic growth in emerging economies – will require a revolution in the social and natural sciences concerned with food production.<sup>45</sup> Biofuels more than likely deserve some of the blame for the food crisis, and have been identified as a major culprit by the UN, World Bank, and International Monetary Fund (IMF). The use of corn to produce bioethanol in the United States, for example, has increased from 6 percent of total corn production to 23 percent over the last three years, and this has undoubtedly contributed to tightening food supplies and rising food prices.<sup>46</sup> What can be said for certain is that biofuels production is a 'new' factor impacting on world food prices.<sup>47</sup> What is equally certain is that increasing world food prices globally will have the largest negative impact in Africa.<sup>48</sup>

43. Daniel de la Torre Ugarte, 'Developing bioenergy: economic and social issues' (IFPRI report, Washington, DC, 2006).

44. Oxfam, 'Another inconvenient truth'.

45. H. Charles Godfray, John Beddington, Ian Crute, *et al.*, 'Food security: the challenge of feeding 9 billion people', *Science* 10, 1126 (2010), pp. 1–11.

46. Lian Pin Koh and Jaboury Ghazoul, 'Biofuels, biodiversity, and people: understanding the conflicts and finding opportunities', *Biological Conservation* 141, 10 (2008), pp. 2450–60.

47. Clements, Kariuki, and Hayanga, 'Scoping study'.

48. FAO, 'State of food insecurity'.