Earth on fire

climate change from a philosophical and ethical perspective

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Biofuels – Crops for food and energy

CLAUS FELBY

The Earth is covered by plants. Plants act as natural solar collectors, and by means of photosynthesis they are capable of converting CO_2 and water into biomass. Wherever there is water, there are plants. They are the very foundation of our entire ecosystem and a source of nutrition for animals, bacteria and fungi. But we also use plants for purposes other than just food. Plant biomass is used for materials and energy, e.g. paper and timber from wood, electricity and heating from wood and straw, and now also liquid fuels for cars and aircraft from oil and grain crops.

Sustainability – challenges and opportunities

The total annual biomass production from land plants is five times the world's total energy consumption. Plants first and foremost produce sugars, which make up more than 75 per cent of the entire biosphere. By far the largest quantity of biomass (80 per cent) consists of wood. Globally, biomass meets 10 per cent of the world's total energy consumption, primarily for cooking, heating and electricity. Biomass is also a major contributor to renewable energy, i.e. types of energy that do not increase the level of CO_2 in the atmosphere and which, in principle, are inexhaustible as long as there is a sun. In Denmark, for example, biomass accounts for 65 per cent of the renewable energy generated. According to the *International Energy Agency* (IEA), biomass for energy, including biofuels, is one of the required key technologies if we are to meet the UN climate targets. In an expansive, but conservative, sustainability perspective, we can probably triple our use of biomass for energy production to cover 30 per cent of the world's total energy supply (Berndes et al. 2003). But how should we utilise biomass for energy, and how do we at the same time ensure that it does not have a negative impact on food production? That is the challenge we are facing if bioenergy is to contribute to a more sustainable world.

Bioenergy is unique. It is the only type of energy which can be used both for transport, heating and electricity. Biofuels can reduce CO_2 emissions from transport by 30-50 per cent compared to fossil fuels. According to the IEA, biofuels will initially replace petrol and diesel for cars, but will in the longer term mainly be used as fuel for aircraft and ships.

But can we replace petrol with biofuels extracted from plants without negatively impacting our food production, resulting in less food and higher prices? The answer is yes, but we must take into account the required technological development, and we must take the concept of sustainability seriously – a feel-good purchase of three litres of organic milk is simply not enough. It takes a different lifestyle, and it takes technology.

We are facing a technical and economic transformation of unparalleled dimensions. To prevent the climate change from getting out of control, the entire world must reduce its CO_2 emissions by 50 per cent. According to the Intergovernmental Panel on Climate Change (IPCC), the West must cut its CO_2 emissions by 80 per cent. At the same time, by 2050 the planet must feed 35 per cent more people than today. This requires new technology as well as an entirely new way of including agriculture and forestry in a sustainable cycle which produces both food and energy.

Sustainability and bioenergy are a challenge which must be incorporated from the very beginning. The objective is to strike a balance between food, energy and the environment. Sustainability means utilising the Earth's resources in the best way possible for humans and the environment without compromising the ability of future generations to meet their own needs. This means that we can certainly manipulate the natural world and our surroundings as long as we maintain a balance. Bioenergy in the form of biofuels can be used both to manufacture animal feed and highly efficient energy carriers, and both must

When annual and perennial plants are grown in the same field system, higher biomass yields can be obtained and, at the same time, higher biodiversity and very limited leaching of nutrients are achieved. CFE culturing systems can be used both in tropical and temperate areas. (Photo: Claus Feldby)

be incorporated in a holistic approach. The objective is, in particular, to pull global agriculture in a far more sustainable and balanced direction.

How much biomass can land plants produce for energy?

Generally speaking, what limits the use of biomass for energy production is the land area available. Forests contribute most to the biomass which we use for energy, but wood is less easily converted into liquid biofuels than grasses and herbs. Some 10 per cent of Earth's land area is today used for agricultural crops, and just over 30 per cent is used for livestock grassing. In the West and some parts of South-East Asia and South America, the agricultural sector is highly efficient, whereas many regions in Africa still rely on Iron Age agricultural technology. We could, of course, just choose to increase the farmed area to meet the need for biomass, but this may, in many cases, have a number of negative environmental impacts, and it is thus often not a sustainable solution.

The solution to this apparent paradox is a more balanced and intelligent use of our biomass resources. We can utilise existing crops better, grow new crops and change agricultural and forestry practices. Over the past 10,000 years, agriculture has been optimised to produce food for humans and livestock. Energy from biomass has not been a part of this equation, and there is a huge potential for processing which does not necessarily compete with food production. We have, for example, bred short-straw grain varieties because it was more efficient, and we had little use for the straw. However, a Stone Age rye variety such as *svedjerug* has straws of up to two metres. By employing a combination of technology and agricultural development, it is possible to meet the existing targets that biofuels should be developed to cover 5-10 per cent of the total need for transport fuels based on the existing agricultural area. But it requires clear political control of the market and the technology.

By far the highest biomass potential is found in the tropics, and biofuels are an opportunity for farmers in developing countries to create more agricultural value. But a well-developed infrastructure must first be established. In areas which are hardly self-sufficient in food, it would be risky to start producing crops for biofuels. Here, the first step would be massive investments in establishing the area's own food production.

Different types of biofuels

Biofuels are not just biofuels (Tolleson, 2008 and The Royal Society, 2008). Their effect on CO_2 emissions and the potential synergies with food production depend to a large extent on whether the biofuel is first or second-generation bioethanol to replace petrol or biodiesel from oil crops. First-generation biofuels utilise, with the exception of sugar cane and sugar beets, food and fodder crops such as wheat, corn or rape, while second-generation biofuels are based on the parts of the crops which neither humans nor animals eat.

The process of manufacturing bioethanol from corn or wheat grains involves the simple fermentation of starch and has been known for thousands of years. Almost 90 per cent of the original energy in the starch is retained in ethanol. The residual product from the process corresponds, in terms of quantity, to ethanol, and it contains high-quality protein which is used for animal feed. One hectare of farmland with wheat used for bioethanol yields almost as much protein as one hectare with soya beans. This does not mean that first-generation bioethanol does not have any impact on the food supply, but there is a level at which the agricultural area used for first-generation bioethanol is offset by the freeing-up of an area elsewhere which should otherwise have been used for growing protein crops (Bentsen et al. 2009).

Oil crops such as soya, rape, oil palm and Jatropha may be used for biodiesel. The process is simple: The oil is pressed from seeds and is then purified and filtered. Plants produce less oil than glucose, and a larger area is required to produce the same amount of liquid fuel than for bioethanol production. Increased production of both soya and oil palms also poses a large risk of deforestation in the tropics. A crop like Jatropha may be relevant in dry tropical areas, but, from a sustainability perspective, it presupposes that the area in question already has its own agricultural production supplying the local community with food. The existing biodiesel production based on soya, rape and oil palms must be considered a dead end both from an environmental sustainability perspective and from a wider perspective which also includes the supply of food.

Second-generation biofuels are made from the part of the biomass that does not form part of the human and animal food chains. Examples of this include straw, grass, deciduous trees, household waste etc. Using biotechnology, the structural carbohydrates in the plants are converted into bioethanol. An advantage of the process is that the plants bring extra energy in the form of lignin which can supply the electricity and vapour required to convert the biomass. The challenge for second-generation bioethanol is to establish a supply of biomass based on existing agriculture and forestry, so that it does not end up competing with food production. This is possible, and, at the same time, new crops can be developed which produce feed and energy, e.g. perennial grasses, which make it possible to create high-yielding and very robust agricultural systems with very limited nutrient leaching.

If we look further ahead in terms of technological development, we will see algae and new energy carriers such as butanol. As the technological development of biofuels progresses, not only will the technology become more efficient, it will to a larger extent also become more and more disconnected from food production. It is a development where the technologies build on each other and depend on whether there is an industry and a market to drive the development (Tolleson, 2008).

Food crisis and biofuels

From autumn 2007 to summer 2008, the price of rice and wheat in particular saw a sharp increase which was followed by a corresponding drop, so that in autumn 2008 the prices had fallen back to more or less the same level as before they skyrocketed (Institute of Food and Resource Economics, 2008). The debate on the reason for the increases singled out biofuels, and especially the use of corn for bioethanol, as the cause of the shortages and higher food prices.

During the past ten years, US farmers have increased their corn production corresponding to the demand from ethanol production, and, at the same time, US exports of corn and wheat for food have seen an upward trend. All other things being equal, the absence of bioethanol would have resulted in lower corn production and probably did not have much of an impact on food production in 2007-2008. The US bioethanol also produces protein animal feed, which reduces the actual load on the land. If the production of protein feed is included, the total net global area used for biofuels in 2008 was estimated to be below 10 million hectares or approx. 0.5 per cent of the total agricultural area (Taheripour et al. 2008). As is the case with all other types of goods in demand, biofuels from agricultural crops will increase prices, but 0.5 per cent of the agricultural area will only have a limited effect on pricing.

There is obviously a limit to how much corn can be used for bioethanol, and the Americans have probably reached the ceiling in relation to a balanced agricultural production. However, there is every reason to believe that the high food prices in 2007-2008 were mainly attributable to poor harvests in Australia and Europe as well as heavy speculation in agricultural products, and as such not related to the production of corn. The big problem in relation to the food supply is, however, not biofuels but the absence of strategic stocks which can make up for poor harvest years. The question is: How come we have central banks spending huge amounts on stabilising the financial market, when at the same time we have abolished the intervention grain stocks that stabilised food prices?

Another factor influencing price development is the increasing amount of meat consumed in the West. More than 70 per cent of global agricultural production is used for animal feed. Approx. 300 million hectares, for example, are used for growing protein feed for livestock, while the gross area used for biofuels amounts to approx. 15 million hectares (FAO, 2008). The largest climate impact from agricultural production today is attributable to cattle breeding as the production involves deforestation to establish grazing areas and large emissions of methane, a greenhouse gas that is 25 times stronger than CO_2 (put differently, ruminants fart). The more meat we eat, the higher the prices of basic foods and the larger the climate impact from our food production.

In 2008, the FAO published a report recommending that international consensus be reached on the development of sustainable biofuels, taking into account both food supply and greenhouse gas emissions. The objectives of the current research activities tie in nicely with the targets and guidelines issued by the FAO. It is thus a political decision to ensure the right development of sustainable biofuels and at the same time develop a balanced food supply. The technologies are available, but focusing on technology only does not solve the fundamental problems we are facing. First and foremost, we must change the way we behave. It does not mean an end to eating meat, but we must eat less and better-quality meat. We need to reduce our energy consumption considerably, travelling to Thailand on holiday by plane is a luxury we can no longer permit ourselves, and then we will have to develop an economy where growth not only equals bigger and more but also includes stability and sustainability. Quite simply we must learn to value the future highly.

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Biofuels: Hunger, subsidies and lack of effect on CO_2 emissions

CHRISTIAN FRIIS BACH

"Something bad is happening to our corn." This is how strongly an elderly woman states it in a documentary on food and biofuels from Guatemala. Corn tortillas are the most important ingredient of all meals. In just a couple of months in 2008, the price of corn increased dramatically, creating a very serious situation for poor families and people living on a few dollars a day. Many organisations in Central America are already reporting that some families only light their stove every other day because they cannot afford to buy food. There are also reports of desperation and riots provoked by the high prices.

Central America is one of the places where the footprint of biofuel can be seen most clearly. It is particularly North America which has seen an explosion in the use of corn for the production of bioethanol, and it has been an important factor in the price increases. Globally, opinions are divided as to the impact of biofuels on the exploding food prices – the US Administration has argued that the impact only amounts to a few per cent, but most researchers believe that the impact is far greater. *The International Monetary Fund* estimates that up to 60 per cent of the price increases are attributable to biofuels (IMF, 2007). In an internal analysis, the World Bank's leading agricultural economist, Don Mitchell, states that biofuels, together with the derived effect on food stocks, export restrictions and speculation, may be responsible for up to 75 per cent of the price increases (The Guardian, 2008). Even though less than 0.5 per cent of total grain production is used for biofuels, the production of biofuels accounts for 50-75 per cent of the total increase in the demand for grain in recent years. This has had an impact on the food market which is under pressure from increasing grain and meat consumption, not least in Asia, and clear signs of climate change.

High food prices have dramatic consequences for the more than 800 million people already affected by hunger and malnutrition. The amount of grain required to fill the fuel tank of a large four-wheel drive car (240 kg of corn for a 100-litre ethanol tank) could feed one person for an entire year (The World Bank, 2008). The financial crisis and good harvest conditions resulted in falling food prices in autumn 2008, but practically all forecasts indicate higher

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food prices in the coming years. There is thus reason to be sceptical about producing biofuels for the transport sector.

However, producing biofuels from the agricultural sector can certainly also have positive effects in poor countries, because agriculture is crucial for employment, growth and for combating poverty. Around two-thirds of the world's poor live and work in rural areas. If the income in the agricultural sector in a poor country goes up by one dollar, the income in society as a whole typically increases by 2 to 2.5 dollars. This is because the farmer will buy a new hoe from the local smith, invest in a new tin roof for his or her house or buy new clothes for the children. This kick-starts the economy and creates new jobs. Industrialisation and agricultural development are closely related. Here, biofuels may play a positive role, both directly and through higher food prices. There are also positive examples of poor farmers who have generated both energy and an income from, e.g., Jatropha for biodiesel.

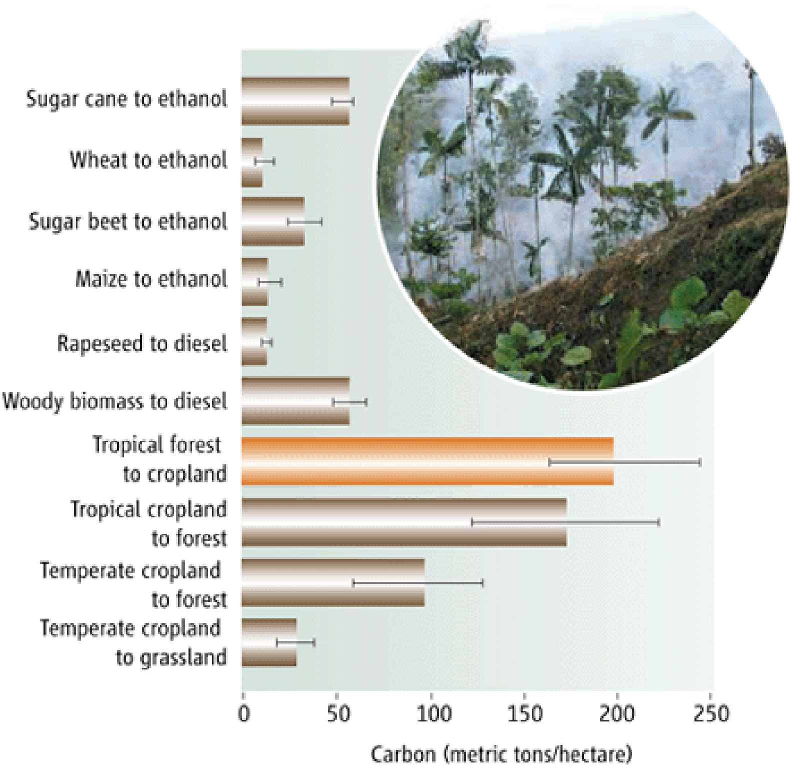
Such examples are, however, rare. Firstly, biofuels are often produced in large plantations without strong links to poor farmers, because the production process requires economies of scale and mechanisation. This excludes small farmers. At the same time, there are more and more reports – from Uganda, Malawi, Burma – about enterprising businesspeople who, using more or less unsavoury methods, try to gain access to large areas for growing crops for biofuel production without thinking about the poor who otherwise use and live from the land. Like oil and other valuable energy sources, biofuels typically contribute to reinforcing the political power struggles, rarely for the benefit of the poorest parts of the population. And in many poor countries, not least in Latin America, the distribution of land is extremely inequitable. The poorest farmers do not have enough land to produce sufficient food for the entire year and are thus affected by the higher food prices, while a small wealthy elite, which owns most of the land, profits from the higher food prices and the production of biofuels. You certainly cannot blame biofuels for the world's unequal distribution of land, but the type of production and market which characterises biofuels can maintain and further add to the unequal distribution of land because the production of biofuels leads to high politics and economies of scale. This applies both to sugar production in Brazil, oil palms in Indonesia and the attempts at starting up large-scale production of Jatropha in, among other places, Africa.

Secondly, biofuels are rarely processed in the world's poor countries, which reduces the beneficial effect on the economy. Finally, felling forests to make way for biofuel production and then employing intensive cultivation methods without regard for the land's productive capacity can have a negative impact on the environment.

Growing biofuels in rich countries is typically not a good idea either, in particular for economic reasons. Practically all rich countries still maintain high agricultural subsidies, and combined with the direct and indirect subsidies available to the transport sector, the growing of biofuels will lead to subsidies on top of subsidies. It is simply not good for the economy. The subsidies paid to biofuel production in OECD countries total USD 13-15 billion, and around USD 1 billion in Brazil. The subsidies can amount to up to 50 per cent of the total production costs (OECD, 2007). New calculations show that only ethanol production based on sugar cane in Brazil can compete with petrol and diesel. All other biofuels are considerably more expensive to produce than the oil-based alternative (FAO/OECD, 2008).In light of the major challenges we face due to climate change, biofuels could still be a useful strategy if it really did translate into significant CO_2 reductions, but that is not even the case. This is, among other things, because of the conversion of organic material in the ground resulting from the intensive growing of crops for biomass production. Cultivating new land can result in CO_2 emissions which are 200-900 per cent more than can be saved over 30 years by substituting fossil fuels with energy crops (Righelato and Spracklen, 2007).

Even if we do change to the much-talked-about, and reportedly promising, second-generation biofuels, this can result in less organic material being applied to the farmland, and this will reduce the positive effect on CO_2 emissions.

Figure 1. The effect of a number of interventions on CO_2 emissions (Righelato and Spracklen, 2007- Photo Credit: World Land Trust)



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In addition, there are better alternatives to energy production, for example wind power, solar collectors and solar cells, which require less space and resources.

Last, but not least, the energy efficiency obtained by converting biomass into bioethanol and then using it in a car engine is low, as low as 10 to 20 per cent. If we want to use biomass for energy purposes, it would be more efficient to burn it directly for power and heat production (Nielsen and Wenzel, 2005) where efficiency rates of 50-80 per cent can be obtained, and instead focus on electric cars which also results in increased energy efficiency (Wenzel, 2007). In addition, the demand for biomass for chemicals and plastics production will increase, and here biomass will be a more direct replacement for the increasingly scarcer oil and natural gas. This will, at the same time, lead to higher CO_2 reductions than producing bioethanol and biodiesel for the transport sector.

Overall, there are very few arguments for producing biofuels such as bioethanol and biodiesel. Food prices will increase to the detriment of the world's poor. The effects on poverty and growth are often limited, and we risk unfortunate social and environmental consequences in the world's poor countries. We accumulate subsidies that damage the economy. And the effect on CO_2 emissions is very low, and we could achieve far greater effects from alternative applications of biomass or other alternative energy sources.

Compared to focusing on energy savings, the use of biomass for heat production and biogas and other types of renewable energy, producing bioethanol and biodiesel for the transport sector is thus a bad idea.

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Case 1 ■ Biofuels

Study questions

1. In the opinion of the two authors, what consequences does the current (2008) production of biofuels have on, e.g., food prices, CO_2 emissions, social justice etc.?
2. In the opinion of the two authors, what does the concept of *sustainability* cover in connection with biofuels?
3. What are the two authors' main arguments for and against biofuels, and on what assumptions are they based?
4. Is the disagreement between the two authors about biofuels as a tool for controlling climate change primarily the result of different views of the scientific knowledge in the area or is it value-based?
5. Are you able to find out whether new knowledge has surfaced since the two articles were written (autumn 2008) which could alter the conclusions made in the articles?
6. Discuss how disagreements of this kind form part of the overall social and political discussion on climate change.