Rothamsted Research

NUFFIELD COUNCIL ON BIOETHICS: CONSULTATION DOCUMENT ON NEW APPROACHES TO BIOFUELS

RESPONSE TO CONSULTATION BY ROTHAMSTED RESEARCH

Rothamsted Research – background and general position on biofuels

Rothamsted Research (RRes) is a BBSRC institute. It is the largest institute in the UK conducting world-class scientific research of relevance to crop-based agriculture and the environment. Much of its research is relevant to food security, bioenergy and environmental change, encompassing adaption of crops and land-based solutions for mitigation related to climate change. The research at Rres is organised in five Centres, (see: www.rothamsted.bbsrc.ac.uk/Research/Centres) and is located at three sites: Rothamsted, Brooms barn and North Wyke.

- The **Centre for Bioenergy and Climate Change** aims to understand and predict the likely impacts of climate change on agro-ecosystems and to provide land-based solutions for mitigation and adaptation through development of bioenergy crops and sustainable management strategies that retain ecosystem functions and reduce greenhouse gas emissions.
- The **Centre for Soils and Ecosystem Function** seeks to predict and manipulate processes affecting soil and ecosystem functions, productivity and resilience by understanding biotic and abiotic interactions that occur within soil and between above and below ground ecosystem components, from the molecular to the community level.
- The **Centre for Crop Genetic Improvement** aims to elucidate underlying mechanisms determining resource use, and to develop novel strategies for crop improvement with an emphasis on traits that impact on sustainability.
- The **Centre for Mathematical and Computational Biology** has capacity in biomathematics and modelling which it is using to develop and apply predictive models of biological systems and their interactions with the environment at multiple biological scales.
- The **Centre for Sustainable Pest and Disease Management** has relevant research within its portfolio on impeding the emergence of new variants of pests and diseases.
- Rothamsted's long-term "classical" experiments, Insect Survey databases and participation in the UK Environmental Change Network provide unique resources.
- The **North Wyke Research Station** Devon joined Rothamsted Research in April, 2009 and focuses on hydrology and ecology at a systems scale, enabling us to study the impacts of environmental change on a wide range of managed land-based systems; arable and pastoral. **Broom's Barn** is the **Applied Crop Sciences** department of RRes, based in the east of England, which acts as a link between the arable industry; focussing particularly on sugar beet production and the national and international biological sciences community.
- Rothamsted participates in two **Cross-Institute Programmes (CIPs)**; the CIP for Sustainable Soil Function (SoilCIP) and MONOGRAM. These coordinate research in soils and cereals, and grasses, across BBSRC institutes and have links beyond, including the Scottish Main Research Providers, NERC's Centre for Ecology and Hydrology and key universities.

In the Centre for Bioenergy and Climate Change, Rothamsted Research underpins development of sustainable bioenergy and biofuels by optimising the yield and composition of perennial biomass crops and through improved understanding of the impacts of land-use conversion to biomass cropping. Growing crops, particularly for liquid biofuels, has raised concerns over land displacement, competition with food production and failure to achieve energy savings and significant GHG reductions. Perennial biomass crops, such as willow and Miscanthus, have potential for sustainable bioenergy and biofuels because they require lower inputs than conventional crops, can be grown on lower grade land and life cycle analyses indicate high energy gains and GHG reductions. However, breeding of perennial

biomass crops is in its infancy and although feedstock from such crops is widely used for heat and power, technologies for conversion of total lignocellulosic biomass to biofuels require considerable further development. Rothamsted aims to fill these research gaps and deliver improved willow varieties for the energy industry. Rothamsted focuses on the perennial biomass crops – willow (grown as short rotation coppice) and the rhizomatous grasses- switchgrass, and Miscanthus. Research on willow began in the 1920s and Rothamsted has unique germplasm and genetic resources in this crop. Research on perennial grasses started in the 1980s. Rothamsted has some of the longest running perennial biomass crops experiments in the UK (and indeed Europe).

Rothamsted has a leading or key role in many bioenergy crop projects including DEFRA-funded willow breeding, Tsec-Biosys (http//:www.TSEC-Biosys.ac.uk/); Supergen (http://www.supergen-bioenergy.net/); RELU-Biomass (http://www.relu-biomass.org.uk/ (which was on the social, environmental and economic implications of increasing land use under energy crops). More recently, Rothamsted leads the Perennial Bioenergy Crops Programme (BSBEC-BioMASS), one of six hubs of BSBEC - the BBSRC Sustainable Bioenergy Centre (http://www.bsbec.bbsrc.ac.uk/).

Many staff at Rothamsted have responded to the questions below. Although some collation has been done to avoid too much duplication, the responses are presented in their full range for the Bioethics panel to conside. In most cases the general Rothamsted answer is given first and then colated responses are bulleted.

Response to the questions

Question 1

What is your view on society moving towards greater use of biofuels?

Rothamsted supports the view that society should move to greater use of biofuels but adds the important caveat that these must be sustainably produced and lead to real energy savings and greenhouse gas reductions (See Background).

Individuals at Rothamsted are very positive towards greater use of biofuels, provided biofuels are produced sustainably.

The main comments in support from collated individual responses were:

- With the twin challenges posed by climate change and the potential for global stocks of fossil fuels to diminish in the medium-term, research into biofuels is important alongside other forms of renewable energy.
- It should have been encouraged/ initiated earlier.
- Society energy demand could be satisfied in part with the sustainable production of biofuels. At the same time decentralized production of biofuels could provide new jobs in regions of special interest, as depressed rural areas.
- For thousands of years humans have used biofuel/biomass to cook their food, increase their mobility and improve their livelihoods. Fossil carbon resources have accelerated and enlarged these drivers of human growth and we are exceedingly abusing our planet. The move towards biofuels will impact on all human activities and therefore increase our alertness about resource limitation and will bring society to a more responsible lifestyle (eat less [meat], drink less [alcohol], and use less energy...)

Qualifying comments and caveats from collated individual responses were:

- LCA and other appropriate techniques are needed to assess the energy balance of a biofuel and make a comprehensive assessment of its benefits and impacts on food production, the environment, etc. Rothamsted has contributed significantly to research in this area.
- It is also important to use different strategies in different countries in relation to their natural resources and what is more suitable for the particular (local) environment.

Question 2

What are the most important ethical challenges raised by the prospect of future generation biofuels?

There are two three issues:

The first is getting the land use balance towards food, energy and other ecosystems services correct otherwise it will seem to the general public and concerned stakeholders (even when this is not correct or as simple as perceived) that we could be taking food from mouths to put fuel in our cars. It is important that the developments of biofuels are demonstrably sustainable and to provide evidence that land use issues have been taken into account (see answer to Question 13).

The second issue has to do with potential exploitation of land and resources for the benefit of only few nations. Measures to ensure more equitable share of energy, income generation and environmental benefits are required (see answer to Question 14)

The third issue has to do with whether or not GM should be deployed for improvement of biofuel crops that are not in the food chain (see answer to Question 3).

Collated individual responses fell into three broad categories: the impacts on developing countries; land-use conflicts and environmental issues:

The impacts on developing countries

- The developed world should not to ask third world countries to supply cheap energy and cause displacement of their own food production – ie "dislocation" of our responsibility towards sustainable solutions for the whole planet
- Land –grabbing and monopolisation by big energy industries could be encouraged without any local benefit – which needs to be addressed
- Negative impacts associated with land use change need to be addressed.
- Sub optimal use of the agricultural lands could result
- It should not be allowed that important goals reached in this field become the profit for only few people instead of increasing the common welfare.
- There should be fair job distribution between regions.
- It should promote the advance of the society, particularly in those regions where the biomass is being produced.

Land-use conflicts

- The food vs fuel debate. In particular, the economic power of developed countries in driving developing countries to produce biofuels could impact on their food production. At the moment we import nutrients and water and thus deplete these resources in developing countries. Importing biofuels could exacerbate their problems of sustainable food supplies.
- Primarily the potential for biofuel crops to threaten food security should be tackled.
- Other conflicts such as the with palm oil and rainforest conflict need to be avoided.
- There is a need to ensure that biofuels meet the aims of GHG reduction and energy savings.
- Issues regarding where they should be grown and how much should be considered -home grown vs imported need addressing.

Environmental issues

- Negative impacts of change of land use, destruction of rainforests.
- Competition for soil surface between energy crops and food crops.
- Energy and efficiency balance of biofuels compared to other alternatives, i.e., other renewable energies, carbon storage, etc. The production of biofuels should produce more energy than what is actually required to produce them.
- The production of biomass needs to be sustainable, and follow some criteria such as:
    a. Local production of biomass that will be locally transformed into biofuels, to avoid energy wasted in transport and consequent CO_2 emissions due to transport;

b. Environmentally friendly, and thus the emissions of biomass production should be minimized, perhaps by integrating different processes.
c. The production of biomass should be technically efficient and cost effective.

Question 3

Do you regard yourself as well informed about biofuels? Where do you get your information from?

Not all staff at Rothamsted work in the area of biofuels but our answer is **yes**. Rothamsted leads the BBSRC Sustainable BioEnergy Centre (BSBEC) sub-programme on biomass crops)BSBEC- BioMASS) and Defra's Bioenergy Genetic Improvement Network (BEGIN), and has a national and international role in research, as well as being involved in many other key projects, developing policy and informing the public (see Background section).

Question 4

Which factors are going to be the most important in driving the development of biofuels in the future? To what policy concerns should priority be given? What advantages not mentioned here could and should future biofuel production aim to deliver?

There are technological barriers which need to be overcome because of the recalcitrance of lignocellulose- particularly in the pretreatment steps and the enzymology. There will not be sustained investment from industry if these technologies are not progressed within reasonable time-frames. There are also supply and demand logistics which need to be determined. Industries require a secure supply, however, uncertain and unstable policies plus incompetitive prices against alternative fuels have meant the farmers are reluctant to commit to planting biofuel crops in the UK, resulting in reliance on imports by the industry.

Policy must be favourable to biofuel crops over alternative energy supply and economic returns need to make it worthwhile for growers (price of feedstock needs to be higher). Stability and confidence need to be restored as policy changes have made it difficult for farmers to commit long-term. Policy relating to carbon or GHG benefits is needed.

Collated individual responses to this question were:

Factors

- In developing methods to generate/process biofuel, new technologies will no doubt be invented. Our basic understanding of organisms used to produce biofuels will be furthered and lead to future uses.
- Overall cost of the fuel, derived from transport and processing costs. Also compatibility with existing land use (e.g. arable crop rotations), value to the grower and flexibility (annual crops are preferred by growers compared to long-term crops like arable coppice).
- Decentralized production to prevent monopoly, speculation and transport costs.
- Increase of biomass yields in energy crops and identification of alternative sources of biomass as forest, agricultural or urban waste.
- Synergy with other ecosystem services, like clean air, water and soil improvement, reclamation (in addition to carbon sequestration, reduction of GHG...)"

Policy

- Reduction of gas emissions should be given a priority, the effects of climate change are already visible and measures need to be taken quickly to try and mitigate future changes that are unavoidable. Additionally biofuels will reduce dependence on fossil fuels and hopefully encourage more research and use of renewable energy resources.

- Political pressure to move towards a greener economy could & should drive biofuel development. In the drive to reduce GHG emissions we should not lose sight of other environmental concerns however (i.e. loss of biodiversity).
- The state needs showing responsibility driving the well-informed process by giving initiation and vision and a reliable planning framework as in any large-scale planning or demand and has shown in other domains (atomic energy, infrastructure, ...)
- Environmental and economical factors...The main advantage should be the possibility to get rid of fossil fuels and reduce GHG.
- Farmers need planning security, risk minimisation, - and as the main producer (next to forestry) information needs to be organised, levy-based support groups, state funded advisory services,
- The cost of carbon and any Government subsidies available to develop biofuels.
- Some bioenergy crops could deliver biodiversity benefits and, possible carbon sequestration.
- Environmental regulations.
- Energy efficiency should be a priority in policy concerns.
- Energy security is very important in driving the development of biofuels in the future.

Climate change

Question 5

Which of the new approaches to biofuels will be most successful in generating GHG emission savings? How should these be encouraged? Are there any reasons why these new approaches should NOT be encouraged?

Rothamsted supports sustainable biofuels – in our view this means that we must move away from “first generation” in which food crops are used (crops which store or sugar/starch in their grain) and concentrate on the non-food parts of crops (wastes such as straw) as well as dedicated non-food crops (perennial biomass crops). It is our view that it will be possible to improve the pre-treatment and breakdown of lignocellulose which are the steps needed to improve in efficiency for this route (of second generation) to be successful. We also need to improve yields per hectare and optimise composition of the feedstock to improve the economics for the grower.

Collated individual responses to this question were:

Most successful

- Lignocellulosic biofuels e.g. biomass grasses and short rotation coppice of willow. They could be encouraged by the numbers that show they would substantially cut GHG emissions. Furthermore they hold considerable advantages over first generation biofuels which are thought to give little or no saving in green house gas emissions and cause considerable issues with food security.
- Cellulosic biofuel once optimised should save the most GHG,.More dedicated scientists/ engineers are required which needs monetary input.
- Low nitrogen input biofuel crops and/or crops that improve soil fertility if part of an arable rotation (this would reduce GHG emissions from the following food crops).
- Fermentation/biogas systems could be integrated with various other fuel sources (domestic/garden and animal-production waste), which otherwise release GHG during composting (I’m not sure how the scale of this compares to potential biofuel crop production).
- Complete life cycle analysis of the biomass production, storage and transformation is required that will focus on: Mass balance; Energy balance; Cost balance
- Alternative use of biofuels should be considered, e. g., biofuels could power fuel cells that are more energy efficient than internal combustion engines.
- GM crops could increase biomass production although there are environmental concerns."
- Bioenergy crops will generate emission savings in that they will offset the use of fossil fuels. However, any use of nitrogen fertilisers to stimulate the growth of bioenergy crops will reduce these benefits if fossil fuels are used as the energy and hydrogen source to produce the fertiliser, and if any of the applied fertiliser is lost as nitrous oxide. Nutrients needed for optimal bioenergy crop growth

could be provided from biosolids such as sewage sludge, but issues of contamination from toxic metals in the sludge and excessive amounts of mineral nutrients (especially potassium) must be monitored. The application of biosolids could also generate nitrous oxide if not used efficiently by the crop, reducing the emission savings.
- Low input systems are eneded, as they not only capture carbon but also reduce GHG emissions at the industrial level, e.g. fertilizer production, crop management and harvest

Any reasons why they should not be encouraged?

- Lack of evidence and lack of exploration/monitoring is the biggest enemy of any ill-defined encouragement
- I cannot see any reason why the new approaches should not be encouraged. I think that new approaches have to be improved in order to cut the costs and reduce the GHG that nowadays are still too high.
- The main issues are land use change, competition with food resources for water supply (may become more of an issue if climate change worsens- (see answers to Question 2).
- Legislation needs to be put in place to protect land.

Energy security

Question 6

Which of the new approaches to biofuels will be most successful in improving energy security? How should these be encouraged? Are there any reasons why these new approaches should NOT be encouraged?

A mix of approaches will be required. As many of these are not fully advanced it is difficult to say which will be the most successful but Rothamsted doubts that there will be only one solution.

Collated individual responses to this question were:

Most successful

- In the short term, lignocellulosic ethanol could improve energy security. This should be encouraged by investment in research in the biomass production, biomass transformation and biofuel use.
- Plants which are native to Britain and can be home grown/ cultured will be best for energy security, again more minds and more money for encouragement along with government targets and land use as a problem.
- Energy (e.g. for power and electricity) could come from other renewable sources (wind, solar, hydro, tide, wave, geothermal, etc) but crops may be the only source of chemical feedstocks (oils, plastics) in the absence of fossil fuels. None of the other renewable energy sources could provide these chemicals.
- Energy security should comes from a mix of resources, especially, because at this point we don't have enough evidence how successful fuel production from various ligno-cellulose resources is in comparison to biogas and other non-fuel based transport infrastructures (electric, solar etc),

Any reasons why they should not be encouraged?

- The biofuel production should provide and economic benefit, if some processes do not have this perspective they should not be encouraged

Economic development

Question 7

Which of the new approaches to biofuels will be most successful in supporting economic development? How should these be encouraged?

It is not possible at this time to state which will be most economical as the technologies are not yet fully developed and the answer will depend on the efficiencies of the whole process, costs of feedstock and the competitive price of alternatives, e.g. coal.

With respect to encouragement, collated individual responses to this question were:

- It needs commitment without the security that a certain avenue will be successful. The whole crux of the current situation is that there is too much hesitance. Any type of biomass based energy production will have its difficulties, but any kind of decision will need a certain critical mass to encourage the development of new technologies of rearing, harvesting, processing etc. – in other words establish an industry. The biggest enemy is the fact that the (UK and European) policy does not set enough incentives to reach this critical mass.
- Most of the energy we use is in heating buildings and transport. So any biofuel that can support either energy requirement will be more advantageous.
- If the emissions are detrimental, or for example they are not cost effective, they should not be encouraged.
- Local production of biofuels will have a big impact to the local economies especially in the less industrialized regions.
- This can be encouraged with the local biomass production and transformation. The differentiation between biofuels produced locally and imported should be addressed.
- If locally produced biofuels are high energy intensive, technically unsustainable or with a high carbon footprint, they should not be encouraged.

Science, technology and research

Feedstock development and processing

Question 8

Of all the new approaches to biofuel feedstock development, pretreatment and processing (including any additional to those mentioned here), which is looking most promising for eventual commercial and sustainable use? Over what timescales might such developments be commercialised? Are there any risks associated with these developments?

This is also a difficult question to answer at the present time as the technologies are not yet fully developed. However, we feel confident that both pretreatment and processing will be improved with the next 5 years. However to make commercial plants fully optimal may take 10 years.

Collated individual responses to this question were:

- Time scales are probably 5 to10 years to have anything commercial, of course dependent on number of people working on it and financial restraints.
- I think lots of small local production sites will be better than transporting high volume raw materials long distances. So anything that can be done efficiently on relatively small scales should be better.
- High efficient and cheap celluloses.
- These products should be developed in the coming years and not decades.
- We have been talking about biomass since the early 1990s. The problem is that most of this has been developed on very limited funding. Even £25M (e.g. BSBEC) is insufficient. We need to increase locally produced biomass. We are still importing tropical wood to cofire because there is not enough biomass produced on home grounds.
- Gasification and pyrolysis for bio-electricity and bio-oil production..... I think there are some risks for such development and that the crucial point is always the same: we need to produce bio-fuel

by reducing and not increasing the GHG and we need to obtain this in a cheaper way that is competitive with coal or other energy.

Advanced plant breeding strategies, genetic modification and synthetic biology

Question 9

Is the use of the following technologies to develop new approaches to biofuel production appropriate? Why?

Advanced plant breeding strategies

Genetic engineering

Synthetic biology

Yes. Rothamsted believes that we should deploy all advanced technologies to make the advancements necessary.

We are using molecular breeding to improve perennial biomass crops. We use GM approaches to validate gene functions and help identify the causal genes determining important traits.GM is an extremely important tool especially in perennial crops where breeding is an even longer process than occurs with standard arable crops. In future we believe that GM also offers important opportunities for achieving crop improvements where the trait is determined by a single gene with a major effect. This includes pest and disease resistance (biotic stresses can cause up to 50% yield losses) as well as modifications in cell wall composition to improve the efficiency with which conversion of the lignocellulose to sugars can be achieved. At present, Rothamsted is using natural variation in conventional breeding assisted by molecular marker technologies. We have no immediate plans to release GM perennial crop. However, Rothamsted believe the GM debate should be re-opened –in order to improve the speed and efficiency with which we can achieve improvements for both food security and energy security. Both GM and Synthetic biology will be important for improving the enzymology associated with the conversion steps.

Collated individual responses to this question were:

- Definitely, due to the considerable improvement these techniques may offer in improving biofuel yield and processing. This technology gives the potential to develop biofuels that are suitable for the area they are grown in e.g. developing more drought resistant varieties for more arid regions of the world. If the process becomes quicker and more efficient it becomes more of a reliable fuel source and will therefore be used more widely.
- Given the possible urgency of the situation we find ourselves in, we should look to develop as many of these technologies as financially possible, only ceasing research and development in an area if and when it becomes clear that it is not a productive avenue. We should also look into the potential of a more collaborative approach, rather than spending money and man-power on duplicating research across countries.
- All avenues should be explored and if possible / deemed appropriate after further research, used to collectively produce biofuel.
- Yes – to enable growth on poor land and improved availability/extraction of the energy.
- Genetic engineering - Yes – as above:Synthetic biology - Yes – this is more applied to processing/fermenting of the raw energy-crop material.
- Advanced plant breeding strategies yes -It could increase biomass production in for example marginal land or under drought stress.Genetic engineering- yes- It can help to achieve the above strategy and could improve the biomass transformation into biofuels. Synthetic biology- yes- It can help to produce new biofuels from biomass and improve the biomass composition."
- Advanced plant breeding strategies, yes-because they make use of genomic knowledge for the selection and also perform serious testing in the field; GM yes -but will take more time but can be important for pest or disease control.

- Yes they are all important. They represent the step towards a scientifically intelligent biofuel production.

Question 10

What are the most important intellectual property and access issues raised in new approaches to biofuels? What is the best way of governing these?

Research and development (R&D)

It is important that commercial companies feel able to achieve a return on their investment, otherwise industry will not invest in biofuels. Where IP resides in government departments, such as Defra (for willow and Miscanthus breeding) the government departments needs to transfer the IP to organisations that did the work so as not to impede the ability of these organisations to attract investment (this I happening in these cases). The main issues revolve around who owns the IP and licensing agreements which are agreed. We believe exclusive agreements should be avoided as these can results in too many closed doors. Instead commercial companies should think realistically and honestly about where their marketing efforts are like to be concentrated.

As much as possible IP and licensing agreements should be simple rather than complex and include clauses which allow exploitation by other parties if the original commercial partner is not interested in doing so. There should be no block to using results for R&D.

Special provisions need to be made for developing countries. Effective R&D is expensive and the commercialization of the new approaches should pay for the necessary research infrastructure and human capital. There is, therefore, a need to protect the commercial interests of a patent holders. However, any investment in the technology should also be balanced against the needs for developing countries to access the technology. Much IP can and should be generated in the developing countries themselves where both biofuel feedstocks and final products will be generated, often for export to developed and developing countries.

One way out of this problem could be the collaborative generation of IP between developed (UK) and developing countries with shared IP and value generated. To govern these, agreements need to be drawn up that ensure equity in the sharing of IP and that the technology(s) is not too expensive for developing countries to access and develop.

Collated individual responses to this question were:

- The need protect the commercial interest of a patent holder and any investment in the technology balanced against the need for developed countries to access the technology. To govern these, agreements need to be drawn up that ensure the technology is not too expensive for developed countries to access.
- As stated above, collaboration may be the best way forward. In that case IP disputes should be the least of our concerns, even if that means taking a pay-what-is-necessary stance. Hopefully a way can be found where some form of payment in kind (e.g. knowledge transfer, reduced seed costs etc.) can replace monetary transactions in many cases.
- R&D is expensive and the commercialization of the new approaches should pay for it. The issues will be originated with the commercialization of the products.
- A competitive and efficient commercialization of the new approaches to biofuels is the best way of governing these.

Question 11

What are currently the main constraints to R&D in new approaches to biofuels?

There needs to be a commitment by government to provide long-term strategic research. It is extremely important and helpful that Research Councils have identified Bioenergy/Biofeuls as a priority. Five-year

projects and LOLAs in this area are to be encouraged. However, in addition the UK needs a clear research strategy that is connected and signed up to across all the different research sponsors. This programme should go up to 20 years with 5 year checks. The role of both Universities (for more short-term underpinning research) and Institutes (for longer-term strategic research) is very important.

Whilst the immediate constraint to UK R&D in developing a world-leading biofuels industry is financial, to a certain extent the restricted amounts of R&D funding are a result of the uncertainty surrounding the UK, EU and US positions on the future of biofuels. The reduction in the short-term (2014/15) targets for biofuel inclusion in the UK transport sector under the Renewable Transport Fuels Obligation (RTFO) as a result of the Gallagher Review (2008) recommendations has also resulted in a significant delay in investment in the UK biofuel industry. In turn, this uncertainty, which centres on doubts about the sustainability of a substantive biofuel industry, has made it difficult to focus existing funding on longer-term research targets.

Whilst the US, and a number of developing countries, not least Brazil, have continued to make very substantial financial commitments to R&D for biofuel development the UK has not, notwithstanding the investment in BSBEC. As a result, historically, the UK was well positioned to take advantage of its existing world-leading research capacity, it is currently loosing that advantage. This is evidenced by the investments multi-nationals are currently making in the biofuels industries outside the UK e.g. Shell's US$12 billion joint venture investment in COSAN (Brazil) and the US$1 billion investment in the five US national bioenergy centres.

Developing the R&D capacity to make a meaningful contribution to the future of biofuels requires compiling a consortium spanning several different disciplines within an integrative framework that is needed to ensure an effective system from field to useable end-product. The UK's BSBEC centre is demonstrating how this can be achieved but balancing the need for, and scale of, public and private investment remains extremely challenging, particularly whilst longer term Governmental policy is uncertain about the future for biofuels.

Collated individual responses to this question were:

- Financial. Public image to a much lesser extent.
- Number or dedicated researchers/engineers and funding.
- Compiling a consortium spanning several different disciplines needed to devise a workable system from field to useable end-product.
- The main constraint is the adaptation of the biofuel production to the future transport industry that will not be based on internal combustion engines.
- Inadequate and short-term funding. Is the UK really serious about biofuels?
- Lack of funding and low risk attitude and the obsession with commercialisation

Question 12

Where should R&D for new approaches to biofuel be targeted, and who should decide about future biofuel R&D strategies?

As outlined above, there is an urgent and uniquely strong need for an integrated approach to biofuels R&D that targets the whole supply chain from feedstock production, through process optimisation for processing and converting the feedstock to biofuel, distribution and end use (e.g. transport engine technology). Ideally, a consultation group of scientists, engineers, civil servants, commercial producers should be established who gather information/ consult members from their areas of expertise. At the national level, it would make sense for such a body to be closely associated to the UK's Renewable Fuels Agency in order to maximise the learning-by-doing opportunity that the data gathering activities under the RTFO provides. There is also a need to make the work of the UK Cross-departmental group on bioenergy more transparent and to effectively integrate BBSRC, EPSRC, NERC and Defra into this process.

At the international to global levels there may well be a need for a new institution for energy and in fact there is already an inter-agency UN group called 'UN Energy'. However, much of the current debate over the sustainability of biofuels centres on land use issues including how much land can be allocated for biofuel production. Resolving land use conflicts and synergies will require a strong producer-focus, is required to establish the large range of potential planting material (NIAB analogy to cereals etc) required and which needs to be integrated with the dedicated research institutes and advisory services.

Collated individual responses to this question were:

- If a collaborative approach is taken then an intergovernmental panel of some description. A UN energy security council perhaps…
- The whole process from optimising stock, converting to biofuel, distribution should be addressed. A consultation group of scientists, engineers, civil servants, commercial producers should be put together who gather information/ consult members from their areas of expertise.
- BBSRC?Defra,with other funding sposnors
- Biofuels should be targeted in the commercialization of the product at competitive prices. The market should decide about the future of biofuels R&D strategies.
- I think the success comes with two conditions: first, producer-focus, to establish a large range of potential planting material (NIAB analogy to cereals etc) and its implementation through dedicated institutes and advisory services and, second, integration with the consumer / processor who tackles all the downstream problems with infrastructure, processing technology (e.g. COREN, Power Stations, boiler producers) and product distribution (Fuel companies)
- Politics and research should work together with energy companies to decide about the future strategies.

Question 13

Are new approaches to biofuels likely to raise problems related to land use? If yes, how? If not, how do new approaches avoid these issues?

Yes. There could be a conflict between land used for growing food and land used for energy crops. Negative impacts are not certain and much can be done to avoid any potential problems with careful planning and implementation. Large and rapid increases in demand for biofuel feedstocks could reverse the trend of decreasing land area under the 'arable and horticulture broad habitat' as highlighted in the Countryside Survey (2007). In turn, this could lead to the loss of protected land (particularly former set aside land) and biodiverse areas which could impact on our natural flora and fauna. This could also impact on ecosystem services e.g. clean air and water and recreational areas. The reversal of this trend would also imply greater economic activity from the UK land base and an associated increase in income to the rural areas of the UK.

A number of reports have now estimated future land availability in Europe highlighting the long term decline in arable land areas across Europe and the large areas of 'potentially available' land that is likely to arise or could be generated by improved land management and technological implementation, particularly in Eastern Europe.

Where the expansion of demand for feedstocks for biofuels occurs at a faster rate than the balance of increased yields vs increased demand, then the quantity of food provision will be negatively affected and the balance of indigenous supply versus imported supplies of food will be altered. Should the supply of imported foodstuffs then become constrained, food security problems could arise. However, the food security and self-sufficiency impacts of biofuel feedstock provision are complicated by the need to account for the co-products of the likely conventional biofuel supply chains, in particular animal feed-based co-products such as 'distillers dried grains with solubles' (DDGS) from cereal-based ethanol, and rape meal from rape seed biodiesel routes. A significant amount of the UK's cereal production is exported as animal feed and large volumes of animal feed (soy meal in particular from Brazil and Argentina) are imported. Projecting the net impact on land use in the UK, Europe and internationally is

highly uncertain but some projections show a decrease in deforestation pressure in Brazil as a result of increased biofuel (wheat-based ethanol) in the UK and Europe.

In order to avoid the possible negative impacts of increased biofuel production in the UK a number of options need to be considered concurrently including: develop a better understanding of integrated crop production and incentivise optimisation strategies for efficient land use; concentrating biofuel feedstock production in regions currently under less-productive agriculture; investigate the potential for growing biofuel crops in 'new' land previously inaccessible to agriculture e.g. degraded or abandoned land, where biodiversity concerns may be less problematic. Marine-based fuels need to account for potential depletion of fish stocks/fisheries, but may – through excluding fishing from fuel production sites - encourage stock recovery.

Farmers prefer annual crops and ones with low set-up costs so they can use existing machinery. However, biofuels based on perennial lignocellulosic crops offer a number of opportunities to enhance land management because they can exploit different types of land / soils than annual crops and can also have other secondary benefits (flood control, soil improvement increased biodiversity; Karp, 2010; www.relu-biomass.org.uk).
Studies on European land availability for bioenergy:

- Fischer et al (2010) calculate that by 2030 some 44–53 million hectares of cultivated land could be used for bioenergy feedstock production in Europe (EU-27) and the Ukraine. *Biomass and Bioenergy;* 3 4 : 1 7 3 – 1 8 7.
- Fischer et al (2009) suggest that 22 million ha of land would be available in EU-27 by 2030 to grow bioenergy crops in their "*Land use – Environment scenario*". This is land which is currently fallow or would become idle in the absence of increased demand for agricultural commodities (supported by E4Tech ILUC analysis, 2010). Fischer et al. Biofuel production potentials in Europe: Sustainable use of cultivated land and pastures, Part II Land use scenarios, *Biomass and Bioenergy* (2009).
- European Environment Agency (2006). How much bioenergy can Europe produce without harming the environment? 'Overall, the available *environmentally compatible* arable land area will rise by 50 % over the time period to reach 19 million ha in 2030.' (for EU-25).
- J. van Dam (2009). Biomass production potentials in Central and Eastern Europe. PhD Thesis. Utrecht University, The Netherlands. 'More favourable scenarios show a highest potential of 11.7 EJ (85% from energy crops, 12% from residues and 3% from surplus forest wood) when 44 million ha of agricultural land become available for energy crop production. This potential, however, is only realizable under high input production systems and most advanced production technology, best allocation of crop production over all CEEC and by choosing willow as energy crop.'

Collated individual responses to this question were:

- Yes, in this country it could lead to the loss of protected land and biodiverse areas which could impact on our natural flora and fauna. This could also impact what we as humans gain from the ecosystem e.g clean air and water and recreational areas.
- Quite probably. Particularly biodiversity & food security concerns. To avoid these issues we should be looking at concentrating our biofuel plants in regions currently under less-productive agriculture. Possibly instituting food-for-biofuel deals in countries where food security is an issue. We can also look at the potential for growing biofuel crops in 'new' land previously inaccessible to agriculture – thawed tundra for example – where biodiversity concerns may be less problematic. Marine-based fuels need to account for potential depletion of fish stocks/fisheries, but may – through excluding fishing from fuel production sites - encourage stock recovery.
- Yes, domestically if more financially viable than other crops farmers may be tempted to replace other crops, if less so, they may not get planted. Countries with unique habitats may be tempted to destroy them for biofuel production.
- Farmers prefer annual crops and ones with low set-up costs so they can use existing machinery.

- Yes. The competition between energy crops and food crops for land there will be always there. With the present level of energy consumption more land will be needed. In addition, other types of renewable energy production as solar will require higher levels of land use.
- Yes. There could be a conflict between land used for growing food and land used for energy crops.
- Yes, if biofuels are grown on land that could/should be producing food. See Pimentel D et al. Food versus biofuels: environmental and economic costs. Human Ecology, DOI: 10.1007/s10745-009-9215-8 and Science Dailey: http://www.sciencedaily.com/releases/2009/01/090128074830.htm
- Biofuel from high input systems, like wheat, oil seed rape will impact on the land available for food production. It is therefore necessary, to further second generation fuels because they need different land and also can have other secondary benefits (flood control, soil improvement). However, any biofuel must go hand in hand with saving measures.
- The new approaches can bring problems relate to the land use. Indeed the choice of where it is more convenient to plant energy crops has to be carefully analysed. One of the main fears is that also the land usually dedicated to food crops can be savagely turned into bio-energy cropland.

Question 14

What differences are there between the developed world and developing countries with regards to the potentially problematic effects of future generation biofuel production on land use?

Priorities for the use and development of land are often very different in developing versus developed countries. This has become clear during the stakeholder-based sustainability evaluation carried out within the EU's Competence Platform for Energy Crops Africa (COMPETE; http://www.compete-bioafrica.net/) project. Bioenergy stakeholders, including governmental representatives, industry and NGOs, were asked to develop a set of principles under which the sustainability of bioenergy projects in Africa could be assessed. This was compared with the principles, criteria and indicators developed in the UK for the Renewable Transport Fuel's Obligation (RFA, 2008) and also those for the EU's Renewable Energy Directive (EU-RED, 2009).

Major differences from the African perspective included: a wish to transition away from subsistence agriculture, a focus on gender issues, a much lower priority for climate change mitigation, a view that large areas of land are available and indeed in need of development; a much lower priority for the food vs fuel argument, indeed, in some cases the belief that biofuels (and bioenergy) will be needed to support food production; much less concern about health and safety issues; greater concern about land tenure conflicts; greater emphasis on community and small scale / small holder development; caution about the water and biodiversity impacts.

Collated individual responses to this question were:

- In the developing world it is probably more likely that populations could be displaced to make way for biofuel production. Biofuels crops could also be grown at the expense of food crops which I think would create food shortages in developing countries.
- In the developed world I think that problems will be more related to the loss of protected areas.
- Food security may be more of an issue in developing countries if agricultural land is turned over to more profitable biofuel production, particularly countries with less-developed property rights legislation.
- Differences in mechanisation and field-size
- Most of the developing countries have problems to feed their population. However biofuels production from wasted or energy crops in marginal land could be of great interest for the developing economies. A good and delicate management should be used in countries that sometimes do not have enough ethical warranties. Biofuels could be a great solution or a big problem…
- Food production is even more critical in most developing countries. The use of land to grow biofuels could lead to even greater shortages of food and starvation.

- There is much more a problem of “land grab” by rich and ruthless countries like Saudi Arabia and China in Africa for producing food for export from those countries in exchange for weapons for corrupt regimes.
- Any country should see the changes that lie in biofuel production rather than biofuel collection; for developing countries just look at the deforestation rate in Africa due to the fuel hunger. Controlled biofuel production from afforested areas or other resources could reverse this.

Question 15

Should iLUC be considered when evaluating the GHG emissions savings of new approaches to biofuels, and if so, how?

The answer is yes but the question “how” is a serious issue – since if it done badly it could have the opposite result to what is required. Also it should not just be applied to biofuels. Another question is what are the comparators?

Collated individual responses to this question were:

- Yes because this could lead to the release of more carbon if forest are destroyed. Clearing of forest land needs to be carefully monitored and capped at a certain level that will not lead to increased carbon release.
- Yes – if food production is increased elsewhere and or transportation of food is increased due to a land-use change to fuel crops, the GHG emissions associated with that change can be calculated and deducted from savings due to the fuel crop.
- Yes. The carbon stored in the soil should be calculated
- This must be surely considered in a two way view, it is a complex accounting necessary that other people are more competent to answer.

Question 16

What advantages and disadvantages for environmental security could new approaches to biofuels have? How could harms for environmental security be dealt with?

Using wastes from food crops should not change the current situation for environmental security associated with these crops – as they are already widely grown – although the land area may be increased to serve both food and fuel which could have effects on biodiversity and natural habitat conservation. The introduction of new crops raises concerns such as invasion and it is clear that invasive species must be avoided (see new EU Directive). However, there is no evidence that the commercially grown biomass crops in the UK are invasive. Also although Miscanthus is not native, willows are and have been grown for a long time in the UK. There have also been many studies on enivironmenat impacts of these biomass crops, including Relu- biomass (http://www.relu-biomass.org.uk/). Gm is a special case in point but Miscnthus is a sterile triple hybrid and Willows are dioecious (female and male are separate trees). Many varieties are female and this could be set as a standard (thus zero risk of of pollen transfer).

Collated individual responses to this question were:

- The newer second generation biofuels can be put on poorer marginal land therefore taking pressure off planting and protect land of conservation value. There is possibility that the lignocellulosic biofuels could be planted on protected land of high value as this was never used for food crops. Therefore to prevent this happening I think that strict legislation needs to be imposed that defines precisely where and where not the biofuels can be planted
- Turning areas of high biodiversity over to biofuel crops will likely have a hugely negative public reaction and should be unnecessary if more creative approaches to siting of biofuel crops are considered. For example the thawed tundra suggested above or turning over areas of amenity parkland or unproductive farmland (e.g. ‘horseyculture’) or even combining polytunnel cultivation with biofuel crops.

- Tree or vigorous grass- biofuel crops may spread and oust native vegetation – this can be prevented if the crops do not set viable seed.
- The advantages are the use of perennial energy crops that need fewer inputs and produce lower contamination than traditional crops. The disadvantages are the improper use of GMO energy crops and the use of environmental valuable land for growing energy crops.
- I think one has to distinguish arable and perennial crops. Ligno-cellulose from arable crops (straw usage) has to account for the impact on soil carbon and a minimum has to be returned, left on the field. Perennial crops as currently discuss (miscanthus and willow, poplar), if managed properly, should have little impact, although the issue of water consumption need further evidence. Others tested abroad, like Eucalyptus, may impact greatly (negatively) on the water balance and biodiversity

Question 17

Are new approaches to biofuels likely to raise problems related to food security? If yes, how? If not, how do new approaches avoid these issues?

We have answered this question in answering question 13. Just one point to add – we need energy to do agriculture!

Collated individual responses to this question were:

- There is still the possibility because that the new biofuels could cause conflict with food security as farmers may plant less food crops than they previously did (how profitable could biofuels become for farmers?) Additonally they could direct resources such as water away from food crops.
- If carried out in a purely profit-oriented fashion then yes. Better planning & legislation should help avoid these issues.
- Yes, domestically if more financially viable than other crops farmers may be tempted to replace other crops, if less so, they may not get planted.
- If the world population increases then eventually there would need to be a decision between producing enough food or enough energy from the available land. So energy production would impact on food security but hopefully not if new technologies can improve renewable energy provision and food production before that point is reached.
- Yes, they are. These new approaches will be implemented when energy prices will rise. High energy prices will affect the price of agricultural inputs making less likely to use them and thus the agricultural yields will plummet. In a feedback system, high energy prices could make more pressure in food orientated land.
- See Q13. However, research at Rothamsted has identified land that could be used for biofuels without compromising food production. Pricing is critical to this.
- It is unlikely that new biofuel crops exacerbate food-biofuel conflict but it is not excluded that they cause the same problem because after all it will be an economic decision and a question of optimizing farm-specific management. Potentially, new crops are targeting low fertility sites or sites of lower grading with respect to infrastructure, less intensive management allows using more remote sites. Also, sites that are in danger of erosion or flooding could be allocated to perennial biofuel crops and thereby create a win-win situation.
- I do not think so. Bio-energy woody crops (or algae) do not directly compete with food (but for the land use). Therefore, they should not have any kind of “negative” effect on price and accessibility of food.

Question 18

What differences are there between the developed world and developing countries with regards to the potentially problematic effects of future generation biofuel production on food security?

We have covered this in answering question 14.

Collated individual responses to this question were:

- Probably more of an issue in the developing world especially if these new generation biofuels still increase food prices.
- Food security may be more of an issue in developing countries if agricultural land is turned over to more profitable biofuel production, particularly countries with less-developed property rights legislation.
- There will be less food produced that could be produced in the absence of biofuel crops.
- In the developing countries the population soars and problems appear to feed people. In developed countries if biomass is used for biofuels production, it could reduce the amount of food available. At the same time in developed countries the meat consumption is increasing the problem on food security. If the population keeps growing at the present rates, developed and developing countries may need to reduce meat consumption and biofuels production to be able to feed the planet.
- Can the developed countries stop driving a car to go and eat a hamburger? and can the developing countries achieve a population control? In other words, can we change our habits in a very short period of time? At the moment the earth can not sustain the current world populations and energy demands."
- The most striking differences is that in developing countries a lot of small holders are subsistence farmers who depend on the production of food from their land and external demand may displace them. But this is also true for displacement due to food production for external producers. If 20% of the biofuel energy is supposed to come from agricultural production – which in the UK is possibly 1 million hectares which is about 15% of the agr land then still 85% is devoted to food production, in developing world this ratio is probably even more towards food. That would mean that any increase in population would stand for a much higher demand on food than fuel as mobility and the economy is not fuel driven. Careful consideration of the population issue has to be given in this matter. After all, food needs to be transported and processed (cooked) but more resources may come from its primary production which cannot be decoupled from the increasing demand (population).

Rights of farmers and workers

Question 19

Are new approaches to biofuels likely to raise problems related to rights of farmers and workers? If yes, how? If not, how do new approaches avoid or benefit these issues?

We have covered this in answering question 14.

Collated individual responses to this question were:

- Only in as much as agriculture in general raise these problems.
- They are not because the new approaches will generate jobs in areas with low employment rates and in recession.
- "Distinguish developed from developing countries and separate the investment issue in which size (=profit/greed) matters most (see below).
- New mass products always impact on the small scale farmer and worker negatively unless they are protected in participatory schemes (shares, minimum price regulations, etc.)."
- I do not think so.

Question 20

We have covered this in answering question 14.

What differences are there between the developed world and developing countries with regard to the effects of the production of future generation biofuels on the rights of farmers and workers?

Collated individual responses to this question were:

- Human-rights & employment legislation is generally better for the workers in developed nations.
- Developing countries may need more labour in the biofuel production, and this may require training (including health and safety).
- "Developed countries: An analogy would be the production of industrial starch from potatoes and sugar from beet/cane. This has been (non-)regulated down to the individual farmer who has his individual contract: the more he produces the better is his position to negotiate a good price. Grower associations help to secure rights. The milk market is an example of failure to secure decent prices for the producer.
- Developing countries: here the position of the farmer is desperate against land grabbing and corrupt elites. Of course, the hunger for food and energy is trampling the rights of individual indiscriminately (whether fuel, food or flowers) and we are responsible to aggravate the situation of small farmers."
- The same there can be for any kind of job. It depends on the local work policy and not on the biofuels.

Investment, policy and governance

Question 21

Where do you think investment in new approaches to biofuels should be directed and where should it come from (public sector, private sector or public-private partnerships)?

We have partly answered this in Q in our answer to question 12 (… there is an urgent and uniquely strong need for an integrated approach to biofuels R&D that targets the whole supply chain from feedstock production, through process optimisation for processing and converting the feedstock to biofuel, distribution and end use (e.g. transport engine technology). Ideally, a consultation group of scientists, engineers, civil servants, commercial producers should be established who gather information/ consult members from their areas of expertise. At the national level, it would make sense for such a body to be closely associated to the UK's Renewable Fuels Agency in order to maximise the learning-by-doing opportunity that the data gathering activities under the RTFO provides. There is also a need to make the work of the UK Cross-departmental group on bioenergy more transparent and to effectively integrate BBSRC, EPSRC, NERC and Defra into this process.)

We need all three- government needs to fund long term strategic science (breeding of energy crop to increase yields) and underpinning research. Partnerships are important for realising the innovation into products and getting the products into market. Some research may be so specialised to a certain industry's process that it is better done in-house as it could not be shared with others who do not have other parts of a process.

It is important to remember that this is a growing industry. A rule of 50% industrial investment e.g. still in place for the Renewables LINK is too high for many UK players in the chain (such as the growers). Partnerships mechanisms should be encouraged by being open to all manner of investments with more emphasis on what will be delivered or changed as a result rather than a financial costing rule!

Collated individual responses to this question were:

- Money should be directed towards research both at the small scale and larger industrial level
- Redirect the subsidies currently directed towards GHG fuel production to biofuel R&D and production. This must be strictly controlled to avoid the pitfalls illustrated by the bioethanol subsidy scheme in the States.
- Public sector, private sector and public-private partnerships
- Investment should come from diverse sources and should be directed towards all the processes of the biofuel production as plant breeding, agronomy, engineering, biomass transformation and fuel use and distribution.

- Public for some research; public-private partnerships for development and commercialisation.
- New approaches should be directed in a Public-private partnership to avoid unregulated failure. Perennial crops need a long-term perspective and the development of new technologies.
- Agricultural research in Universities and Institutes are a prime example for the success.
- Subsidies and ill-calculated demand contributed to the collapse of the system and market forces left a lot of collapsed over-dimensioned farm units. This danger is there in bioenergy from biomass etc as well.
- Public sector and public-private partnerships. For me it is important that this kind of research and development does not become completely private.

Question 22

Which policy issues in relation to new approaches to biofuels would you like to bring to our attention?

We need an integrated policy across the whole supply chain which examines and removes and current policy conflicts. We need a secure policy which doesn't keep changing. Biomass crop plantings of both SRC and Miscanthus rose steeply over the period when the Energy Crops Scheme (ECS) paid on a per hectare basis. They stopped increasing at this rate a soon as the ECS moved to the basis of % of planting costs and many planting requests were withdrawn in the year that this happened. Approval for energy crops planting should also be examined – why are so many turned down? Is this really fair or over-caution. And real contributions made to our taget. For example, there should not be an option to "buy out" – only a significant penalty if not demonstrating true savings. It is imperative that emphasis is placed on maximising carbon benefits and GHG savings.

Collated individual responses to this question were:

- To pay enough to farmers to produce a biofuel crop instead of wheat or OSR, the price needs to be right and reasonably certain. This might need a tax on less clean fuels to create funds to pay farmers to grow biofuel crops(?)
- The policies should aim at real and feasible objectives and state of the art technology and science.
- Reliability for long-term planning
- Fair pricing
- Critical mass

Question 23

What would be the most effective policies a) to promote and incentivise; and b) to regulate the development of new approaches to biofuels?

Agriculture and forestry are vulnerable to short term price fluctuations

The great majority of the UK's agricultural and forestry production occurs under globally recognised and respected assurance and certification schemes e.g. the Assured Combinable Crops Scheme (ACCS). This gives the UK industries an advantage when developing competitive low greenhouse gas industries based on products arising from agriculture and forestry e.g. biofuels, foods, materials. However, until the accounting methodologies currently applied to biofuels are equally applied across all biological products, applying such assurance and certification acts as a penalty rather than an incentive to low greenhouse gas biofuels. Applying a so-called 'level playing field' for all biological products would encourage innovation across all areas of crop production and result in efficiency improvements, potentially providing a major tool towards the UK's target of an 80% GHG reductions by 2050. The need for assurance and certification arises because local climatic, soil and management factors can dominate the greenhouse gas emissions of biological products. This is also true for the other key social and environmental impacts that are used to assess the sustainability of biological products.

Innovative technologies will need direct support as is occurring in other countries, most notably the United States.

When biofuels are directly competitive with fossil fuels i.e. no governmental incentives are required, a different set of policy tools will be required to control their development. These tools are likely to be inherently regulatory in nature because incentives are no longer need and so cannot be used to control the development of the market, as is currently the case. Again, regulatory approaches will need to be evenly applied across all biological production systems in order to avoid distorting markets and creating perverse incentives.

Collated individual responses to this question were:

- Direct financial penalties/incentives seem to be the only way to get the majority of people to change
- To promote and incentivise.
- "To a)
    - A ten-year programme for a successful start
    - End the in-out hesitance and the hope for the market, biofuel is up against giants
    - Put in real money
- To b)
    - Guarantee a realistic price which is based on sustainability criteria (environmental costs/benefits, ecosystem services)
    - Encourage on-site use, small-medium size networks (co-generate heat/fuel, electrifying transport
    - Decentralisation to minimise transport and storage losses"
- I think that, also if not directly related to the development, it is important to have the support of the people and, therefore, avoid negative manipulations and publicity.

Other issues

Question 24

Are there any other issues not mentioned in this consultation that we should consider in the ethical evaluation of new approaches to biofuels?

Rothamsted felt the main ones are covered. One of our respondents made the following comment which we have included for you to consider:

- I seriously think that this consultation is over the top with regard to the special case of biofuel within the land-based production. There are multiple other pressures of society on land, e.g. the average 100 ha/day loss of productive land due to housing and industrial development, infrastructure. A bit similar is the biodiversity issue: why is an “ecological desert” of a 100 ha wheat field more acceptable than 100 ha willow plantation which has so many demonstrated biodiversity benefits?