

Does Biofuel Production Threaten Food Security

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Abstract

The world's population is growing despite hunger and diseases which spread around the globe, it is anticipated that in 2050 more than 9 billion people have to share the limited resources which are necessary to meet all needs of humanity. According to the many forecasts it will be especially difficult to provide sufficient food, water and energy for a sustainable livelihood. In order to provide sufficient food to 9 billion people the food production has to be raised by 50% compared to the present level according to FAO data. The increased food production and the energy provision should rely to a great deal on environmental friendly sustainable resources also with regard to the climate change mitigation. These two requirements are very often considered as competing with each other because a major share of sustainable energy should be based on biofuels, i.e. on substances originating to a large part from agricultural resources, resources which have also to be available for securing the food supply for the world's huge population. The problem becomes especially evident by considering that at the present time "first generation" biofuels are produced from soy-, palm-, and rape seed oils or starch and sugar crops like maize, wheat, or sugar cane which are all valuable food resources.

Growing food crops and to some extent, also where feasible fuel crops, both as cash crops could create a highly desirable cash-flow especially for Developing Country farmers which would help to intensify crop production, provide affordable energy sources for mechanizing agricultural production, and after all improve resource efficiency.

Crops which are especially suited as fuel crops are drought-resistance crops and crops which might also have the potential to improve the properties of soil on degraded land.

Projections of the development of the global population demonstrate that it will be extremely difficult to comply with environmental goals and to feed the world's growing population. Those goals will only be compatible by dramatic changes in the present time patterns to generate and utilize energy and to use agricultural produce.

Introduction

The sun is the source of all terrestrial energy. The incoming energy flux amounts to 174 PW, 89 PW are absorbed by the land mass and oceans; an almost similar amount of 85 PW is reflected back into the space

Solar Energy Balance

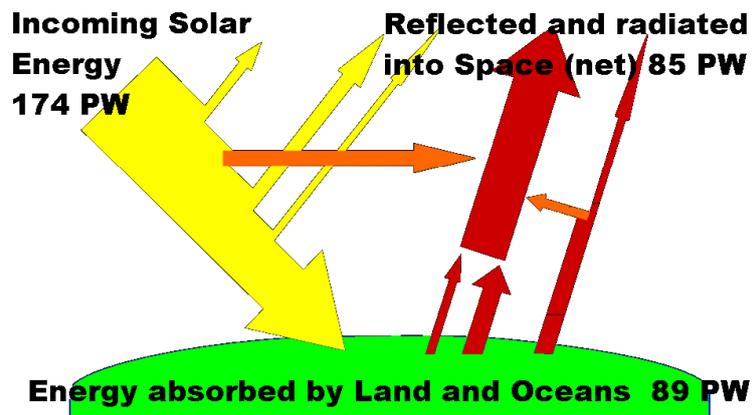


Fig.1 Solar Energy Balance [en.]

From the available energy flux of 89 PW or in other terms 89 000 TW (TW = terawatt; 1 terawatt are 10×10^{12} watts) air movements i.e. the wind on our globe consume 870 TW, the movement of water 7,2 TW. The global human energy consumption amounts to 15 TW. These considerations demonstrate that by far not all terrestrial energy sources are utilized.

Available Energy Sources and Consumption

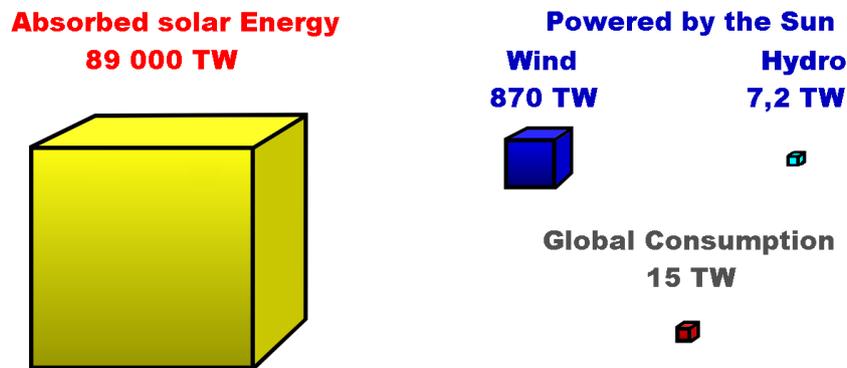


Fig. 2 Available Energy Sources and Consumption [en]

The major share of the energy consumption for maintaining our life in its various characteristics and activities is based on fossil energy sources. At the present time the largest source of energy consumed is oil with almost one third of the total consumption, followed by coal and gas. Renewable energy sources are presently playing only a minor role.

Total Primary World Energy Supply (2008) Total 142 6652 PWh			
Source	Share %	Source	Share %
Oil	33,2	Renewable/Waste	10
Coal/peat	27	Nuclear	5,8
Gas	21,1	Hydro and Others	2,2 / 0,7

Tab. 1 Total Primary World Energy Supply [IEA]

Round about 70 percent of the consumed energy is used for residential, industrial and transport purposes a minor part of the fossil energy sources is used for the production of chemicals etc. It is quite interesting that 27 percent of the quoted energy consumption is used for transport purposes .

World Energy Use by Sector (2008) Total 98 022 PWh			
Sector	Share %	Sector	Share %
Industry	28	Residential and Services	36
Transport	27	Non Energy Use	9

Tab.2 World Energy Use by Sector [IEA]

At the beginning of the railway age black coal was the dominating source of energy for transportation. Steam powered engines however were inflexible and required huge backup systems. The invention of the Otto and Diesel engines allowed for a high flexibility and the use of those engines in almost any type of transportation system. The function of Otto and Diesel engines is based on the availability of combustible fuels, this fact explains that almost 80 percent of the worldwide petroleum production is used for transportation purposes. Gasoline has with 46 percent the major share of the consumption.

Use of Petroleum World wide			
Use	Share%	USE	Share%
Gasoline var. purposes	46	Heavy Fuel Oil	4

Diesel and related Fuels	26	Asphalt	3
Various Products/Chemicals.	11	Lubricants	1
Aviation Fuel	9		

Tab. 3 Use of Petroleum World wide [IEA]

In 2008 the total transport energy consumption amounted to 2 299.37 Million Tones of Oil Equivalent (Mtoe). The share of combustible biofuels was with 23.22 Mtoe around 1 percent; IEA and OECD are expecting that the share can be increased to 5 to 6% in 2030. [IEA; OFID]

Biofuels, relevance and nature

Biofuels are certainly the energy source which was first used by mankind. Wood and dried dung were however in the past gradually replaced by fossil fuels, coal, petroleum and more recently natural gas because these energy sources were more convenient to handle and of higher energy density; their definite disadvantage is however that during conversion into mechanical energy generation considerable amounts of CO₂ are released.

By definition biofuels are energy sources which are derived from renewable biomaterials such as plant materials preferably with a high carbohydrate and fat content and which lent themselves to a fast crop rotation. Biofuels can also be produced from all types of organic wastes e.g. agricultural and food processing wastes and manure from various sources.

Various types of biofuels		
Solid	Wood, Charcoal, Dung, Bagasse	
Liquid	Ethanol, Fatty-Acid-Methyl-Ester =FAME-Biodiesel	
Gaseous	Biogas (Main compounds %)	
	Methane 50-70 Carbon dioxide 25-50 Nitrogen 0-10	Hydrogen 0- 1 Hydrogen sulfide 0- 3

Tab. 4 Various types of biofuels

Biofuels can be classified as solid, liquid and gaseous. Solid biofuels are wood, charcoal, dung, and bagasse; liquid biofuels are mainly ethanol and Fatty-Acid-Methyl-Ester (FAME-Biodiesel); the most important gaseous biofuel is methane.

In case the huge amounts of wood and dung --which are still used in the developed but also in the developing countries-- are not considered the dominating biofuel is Ethanol and Bio-Diesel.

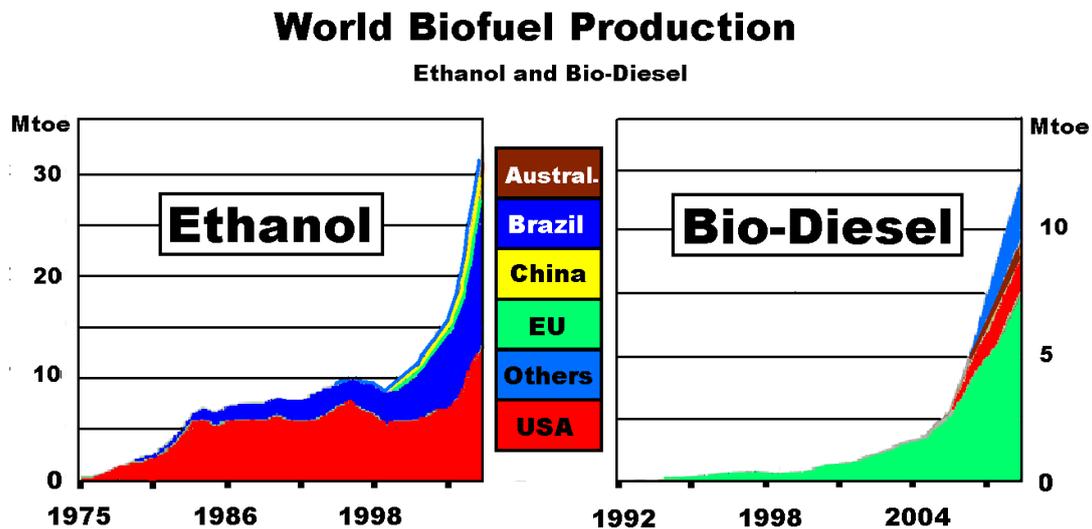


Fig.3 World Bio-Fuel Production [OFID]

Significant amounts of liquid biofuels entered the market in the early 1970ties; the biofuel market grew from this point on steadily. The ethanol production amounts presently (2010) to round about 70 billion liters per annum; 80% of this quantity are used as fuel for transport; 61% of the ethanol production is sugarcane based, 39% maize based; major producers are Brazil (sugarcane) and the US (maize). The biodiesel production is around 15 billion liters per annum. Major producer world wide is Germany with a share of more than 50% [Bio; Ener] It has to be expected that biofuels will play gradually a vital role in at least partially replacing petroleum as energy source for transport; it is however also clear that in the foreseeable future fossil fuels will maintain their dominant role in the world wide energy supply.

The search for new sustainable energy sources i.e. energy sources with a low or even no Green House Gas (GHG) emission sparked worldwide the interest in biofuels despite the understanding that presently only in special cases the production of biofuels have a positive impact on the reduction of Green-House Gases. Especially countries with a high agricultural surplus production e.g. the US and Brazil stimulated the production of combustible biofuels by favorable taxation and direct and indirect financial subsidies or other supportive measures like mandatory blending with fossil fuels. The worldwide efforts, sanctioned by national and international legal bodies and agreements, have paved the way for the rise of biofuels also in countries with deficient agricultural production.

The production of biofuels and the possible expansion of the production as requested amongst others by OECD countries and non-OECD [REV] countries have already now an impact on agricultural production at large and also on the availability of agricultural produce for human consumption. It has to be stated that the price for major raw materials suited for biofuel and for food production, especially of

cereals/roots and fruits/seeds containing high amounts of fats in increased sharply in the last years after a decline until the early 1990ties. This situation has without doubt increased the number of those who are not able to pay for their daily food demand and who are suffering under malnutrition and hunger. [IUFoST]

As mentioned above the main feedstock for the production of biofuels like Ethanol and Bio-Diesel are agricultural produces originally cultivated for human consumption like Maize and Wheat but also Root-Vegetables and Soya or Rapeseed as well as the fruits of the oil-palm. It is hoped that in the next decade those raw materials can be replaced by materials not suited for human consumption like wood, grass and tree-nuts like Jatropha. The utilizations of those materials require however new and more efficient conversion processes. Those processes are characterized as Second Generation Conversion Processes/Technologies they are based on pyrolysis, gasification or unconventional fermentation processes. Especially in case effective cellulase and ligninase and related enzymes (LMEs) are available to convert cellulose and lignin containing materials (wood and fibrous plant materials) into fuel the pressure on food related biofuel feedstock will be relieved. Second generation conversion of feed stock like forest and or agricultural residues, wood waste and energy crops etc. are so far however not ready for a larger industrial application. Pilot plants are operating in most industrialized countries.

Major Types of Feedstock presently used for biofuel Production	
Cereals	Maize, Wheat, (Sorghum)
Root-Vegetable	Potato, Cassava, Sugar-Beet
Leguminous plants and Brassicaceae	Soya, Rape-seed
Grass	Sugar-Cane, Switchgrass
Tree- and Shrub-Fruits, Wood	Palm-trees, Jatropha, Willow, Poplar

Tab.5 Major Types of Feedstock for biofuel Production

Biofuel production from food feedstock, consequences for producers and world food supply

The impact of the biofuel production on the world wide food supply and availability is difficult to predict, it is without any doubt closely related to the development of three major parameters: Climate (with consequences amongst others for agricultural production), Population Development (with consequences amongst others for food demand) and Energy Demand and Satisfaction (with consequences amongst others for CO2 emission and by this with a feedback on Climate).

A detailed discussion of the interrelation between biofuel production and availability of food in the future has to rely mainly on scenarios developed for those three major parameters. Various international working groups amongst others the International Institute for Applied Systems Analysis (IIASA), the Food and Agricultural Organization of the United Nations (FAO), the International Energy Agency (IEA) have devoted major efforts to the development of such scenarios; simplified elements of these scenarios are together with other publications the basis of the following considerations. The scenarios take into account the General Circulation Models (GCMs), the AEZ (Agro-ecological Zones) methodology, the World Food System Model and similar modeling approaches [Implic; STATE].

The discussion of the development of the energy demand follows in broad terms and with some simplifications the IEA World Energy Outlook Scenario (WEO). This projection takes especially into account that major OECD and Non-OECD countries have passed legislation or have committed themselves to expand biofuel production above the present level e.g. the EU has passed legislation for a minimum target of 10% for biofuels within the transport energy consumption in 2020 ; other major countries have passed similar legislation [REV].

Country	Important Mandatory Targets (MaTa) regarding Fuels from Renewable Energy Sources
Brazil	MaTa of 2% biodiesel in 2010; 5% from 2013 on.
Canada	MaTa at least 5% biofuels of gasoline sold
China	Big cities/9 prov. MaTa E10 blending by 2012.
EU-25	MaTa of 10% for biofuels sales in 2020.
India	MaTa 15% ethanol and 2% for biodiesel by 2015
Japan	MaTa 50 million liters of biofuels by 2011
Malaysia	MaTa of 5% for bio-diesel in all diesel sales
New Zealand	MaTa of 3.4% of total transport fuel sales by 2012
South Africa	MaTa of 4.5% biofuels of liquid transport fuels
USA	Up to 28.35 bill. liters biofuels blended by 2012

Tab. 6 Important Mandatory Targets regarding Bio-Fuel utilization by OECD and Non-OECD Countries [OECD]

Underlying Scenarios

It is assumed that transport energy demand develops as projected by IEA in its WEO 2008 Scenario assuming that mandatory and voluntary or indicative targets for biofuels-use (as announced by major OECD and None-OECD countries) will be implemented by 2020. This will result in about twice the biofuels consumption compared to 2008. [IEA; Fuel Standard; OFID]

World Biofuel Production by Country (ITP (IEA - WEO 2008) Reference Scenario)

Total: ~ 5% of Total World Fuel Production

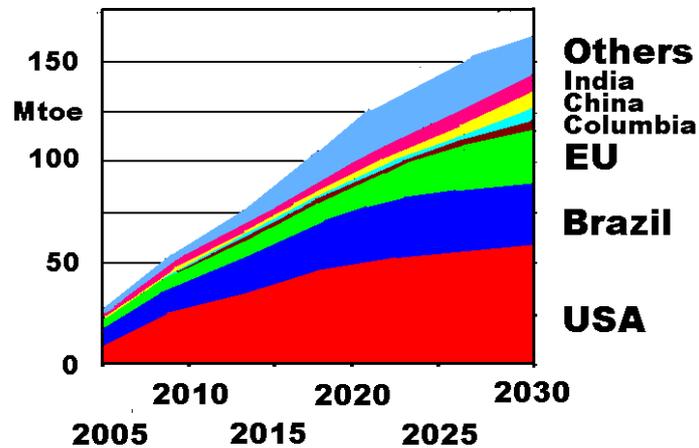


Fig. 4 World Biofuel Production by Country [World]

During the next decade Ethanol produced from grains and Sugar-Cane and Bio-Diesel produced from oil seeds will dominate the market. It is however expected that in about 20 years Second Generation Fuels from cellulosic materials and other non-food feedstock will gain more and more importance.

At this point Palm-Oil and Jatropha should be mentioned as of special relevance. Up till now Europe is the main producer of Bio-Diesel with a production mainly based on Rapeseed. With the US, China, India, Brazil, Indonesia and Malaysia entering the scene the production will be based on different feedstock, mainly on Palm-Oil, Soybean, Jatropha, and most probably in a more distant future on Algae.

Malaysia has already recognized the large potential of a Palm-Oil based Bio-Diesel production and passed legislation that all Diesel sold in Malaysia must contain 5 percent Palm-Oil.

According to the WEO Scenario USA and Brazil will continue to be the major biofuel producers closely followed by Europe. Interestingly Developing Countries like Colombia, China and India will also contribute significantly to the total world production.

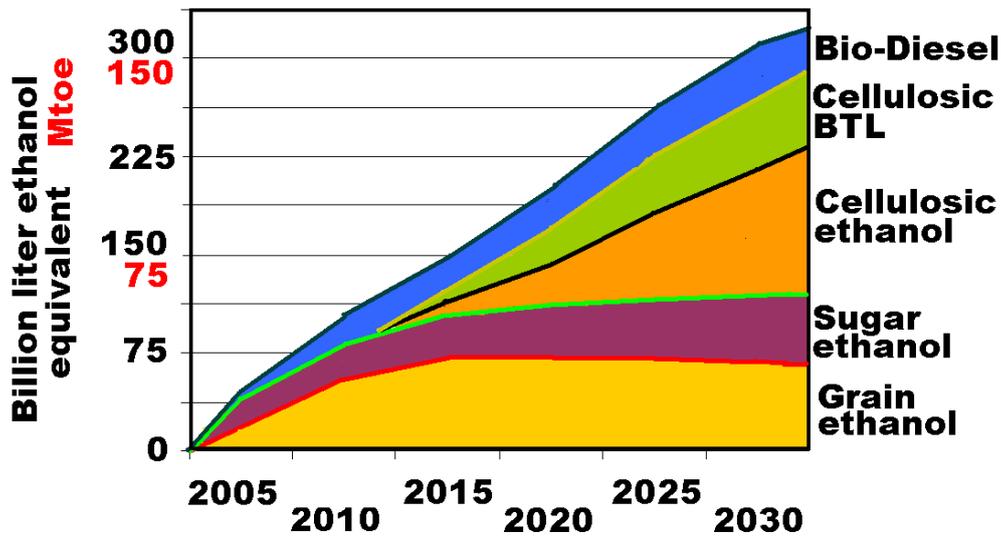


Fig. 5 World Biofuel Production by Type [World]

Feedstock production for Biofuels versus Food Production

Biofuel Feedstock Demand

The yield obtained from various oil containing plants or fruits respectively depends very much on the variety, growing conditions and after all harvesting and post harvest processing. The presented figures represent average data, in individual cases the figures may vary considerably.

Average Oil Yield (L/ha/year)			
Produce	Yield	Produce	Yield
Soybean	740	Palm-Oil	4752
Sunflower	767	Algae	3000
Rapeseed	954	Jatropha	3000

Tab. 7 Average Oil Yield of important Oilseeds and Algae [Biodi; auto]

The largest raw material demand is required for Ethanol production from Sugar-Cane, for 1000 liter of fuel 13 000 T of raw material is needed. The production of Ethanol from Sugar-Beet is equally demanding, 10 000 T of raw material are required for 1000 liter. In case cereals are used for the production of Ethanol the mass of the required raw materials is roughly one third, this statement is also correct in case biomass or cellulosic materials are used for the production of Ethanol in a "Second Generation" process. In case the anticipated biofuel production in 2030 is considered, raw material equivalents between 690 Million Metric Tones (MMT) (Sugar-Cane) and 100 MMT in case of Rapeseed will be necessary.

Feedstock requirements for 1000 liter alcohol (ethanol) (average sugar / starch content, wet basis)/Bio-Diesel			
Produce (Product)	Amount T/1000/ fuel	Biofuel production 2030 -Billion liter-	Raw material equivalent - MMT-
Maize (Ethanol)	2,300	68	156
Wheat (Ethanol)	2,800	68	190
Sugar-Beet (Ethanol)	10,000	53	530
Sugar-Cane (Ethanol)	13,000	53	689
Rapeseed (Bio-Diesel)	2,700	38	102
Biomass (To Liquid) (Bio-Diesel)	2,000	57	114
Cellulosic Materials (e.g. straw)(Ethanol)	3,000	98	294

Tab. 8 Feedstock requirements for 1000 liter alcohol [Vogel]

Food Demand

According to international statistical data the population growth rates will decline in the years to come quite dramatically whereas the cereal production growth rates will stabilize at a level of 1,2 percent. In other words the present world cereal production of 2238 million tons will rise close to 3000 million tons in 2030.

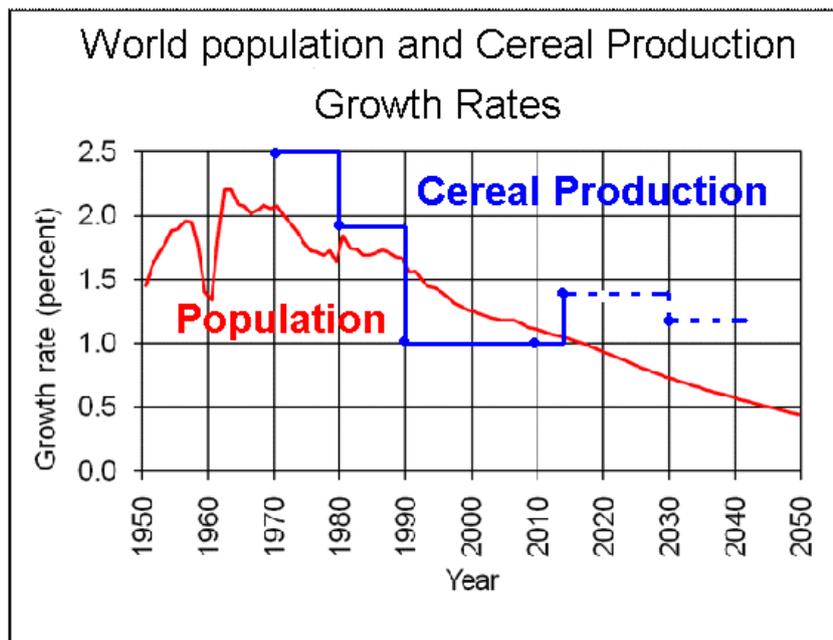


Fig.6 Population and Cereal production Growth Rates [World-Agri; WORLDPOP;Unit]

The increased production of cereals will be absorbed by the growing world population of 8.3 billion people with a higher average daily caloric intake in 2030 compared with today [Unit]. It is estimated that in 2030 the average daily caloric intake will be 3050 kcal/capita*day compared with today 2800 kcal/capita*day. In Developing countries the average will be somehow lower around 3000 kcal/capita*day.

By 2030 the Developing Countries will produce only 86% of the cereal needed to provide the daily requirements. That means that the, net imports have to rise from currently 103 MMT to 265 MMT by 2030. The imbalances in production and consumption will also have a negative impact on the general price level, a fact which will mainly effect underprivileged segments of the population in Developing Countries [Cere; Agri; FAO2] .

Land use for Food, Feed and Biofuel Feedstock

The World Land area is about 130 000 000 sqkm, approximately one third can be used for agricultural purposes, a little bit more than 10 percent as cropland. For major crops less than 10 percent are used, alone 5 percent for the production of cereals.

Land type		km2	
World land area		130 134 754	
Agricultural area		49 675 795	
Cropland		15 616 817	
Produce type	km2	Produce type	km2
Roots and Tubers	33 801	Vegetabl./ Melons	529 462
Cereals	6 877 512	Tree-nuts	82 154
Pulses	699 733	Oilcrops	2 520 130
Fibre Crops	382 577	Fruit	523 412

Tab. 9 Cropland areas in 2005 relative to world land area [FAOstat]

It is obvious that the impact of biofuel production on Food Security depends upon the crop grown and the land on which it is grown. So for example the presently land area used for agricultural production is not expanded it means that e.g. 156 MMT of Maize are not available as a source of food. In case of an average demand of 160 kg/capita*yr approx. 1 billion people in addition to the already hungry people would be Food insecure. This is certainly an alarming situation!

In order to get a more detailed understanding of the impact of biofuel production on the food/feed supply 3 Scenarios will be discussed: a) Use of existing arable land; b) Expansion of the agricultural land and c) Use of marginal land and forests not otherwise suitable for crop production

Scenario 1: Use of existing arable Land

In the near future the land area used for agricultural production will not really grow in a significant way. That means that Sugar-Cane will be the major feedstock for biofuel production in the Southern Hemisphere, where as cereals will dominate in the Northern Hemisphere as feedstock. It is expected that from 2015 on other, also non

conventional feed stock like jatropha and algae will appear on the market produced mainly on newly cultivated areas releasing the pressure of biofuel production on the availability of food/feed. The level of cereal prices will be quite high with negative impact on the general supply situation. [World Fuel]

Scenario 2 and 3: Expansion of the agricultural land and use of marginal land and forest

The additional land requirements for the production of biofuels, Ethanol and Bio-Diesel seem quite demanding so for example the additional area required for the production of wheat for the Biofuel production is about 10% larger than France, compared with the amount of land not used for agricultural purposes the perspective changes however.

Scenario 2 and 3 Expansion of the agricultural land and use of marginal land and forest			
Land requirements for alcohol (ethanol) (average sugar / starch content, wet basis)/Bio-Diesel production			
Produce (Product)	Spec. Requirements litres/ha	Biofuel production 2030 -Billion liter-	Required Land resources - km2 -
Maize (Ethanol)	1 960	68	346 938
Wheat (Ethanol)	952	68	714 2879
Sugar-Beet (Ethanol)	5 060	53	104 743
Sugar-Cane (Ethanol)	4 550	53	116 483
Rapeseed (Bio-Diesel)	954	57	595 611

Tab. 10 Expansion of the agricultural land and use of marginal land and forest [STATE; E-Welt]

In case of Brazil as a major Ethanol producer it becomes obvious that in certain

Land Utilisation in Brazil Total land area 8 500 000 km ²			
Land Use (Agricultural Product)	Area MKm ²	% of arable Land	% of cultivated Land
Forests	4,10		Not utilised
Arable Land	3,40	100	Resources: 0,77 Mkm ²
Pasture	2,00	59	
Cultivated land	0,63	19	100
Soybean	0.22	7	35
Maize	0,13	4	21
Sugar-Cane (Total)	0,07	2	11
Sugar-Cane (Ethanol)	0,04	1	6
Sugar-Cane (Ethanol Production 2030)	0,05	1,4	8

Tab 11 Land Utilisation in Brazil [Work]

areas especially in the Southern Hemisphere huge reserves of not utilized land resources are available. Besides the reserves in Brazil and other South American countries, huge reserves are also located in South Africa e.g. in Mozambique. In Asia the reserves are limited, only China has the potential to expand its agricultural land in case those areas can be sufficiently irrigated. In North America also the lack of water is the limiting factor; in Europe the land reserves are close to zero. [FAO3]

Those reserves can be utilized without touching the virgin forest reserves. It is obvious that the land required for biofuel production is available and almost below 10 percent of the land reserves.

Cultivated land areas and gross reserves Million km ²				
Continent	Total arable land	Land use 1990	Land use 2010	Land Reserve
Latin America & Caribbean	10,59	1,90	2,17	8,42
Sub Saharan Africa	10,09	2,13	2,55	7,54
South Asia	2,28	1,91	1,95	0,33
East Asia (excl. China)	1,84	0,88	1,03	0,81
North Africa and Near East	0,92	0,77	0,81	0,11
Total	25,72	7,59	8,51	17,21
Est. demand of arable land for biofuel production				0,7 – 1,4

Tab. 12 Cultivated land areas and gross reserves [FAO3]

Besides expanding the land area used for crop production, the crop production can be increased by higher cropping frequencies using higher yield species and improving yields through improved agricultural methods. [FAO4]

In detail it is expected that agricultural production will be expanded through land expansion in South America and SS Africa by 20% (1,20 Mkm²), through higher yields by 70% (better soil management, genetically modified crop, organic agriculture), and through multiple cropping and shorter fallow periods by 10%.

The expected overall effect of climate change on global food production by 2030 is likely to be small.[FAO4].

The availability of water

The availability of water is the crucial element in all efforts to expand agricultural production, without a minimal water supply any efforts to expand the agricultural production is in vain. The possibilities of extending the present irrigation practices seem to be limited since water resources of sufficient quality become scarce or too expensive to use especially in Developing Countries and major agricultural countries despite the fact that at global level there is enough water available The problem will even increase in the future because of the already ongoing climate change. More efficient use of rain in rain fed agriculture requires more scientific attention amongst others more stress tolerant varieties of crop plants have to be bred mainly by genetic engineering. Factors with an impact on soil, water, climate and crop have to be put

into focus in more detail because they play an important role in optimizing the use of rainwater.

Presently approximately 20% of agricultural land is operated under irrigation production systems, providing for 40% of the world food production. In the year 2000 in Developing Countries 2 million km² were irrigated this area will be expanded to 2,42 million km² by 2030. Most of this expansion will occur in land-scarce areas where irrigation is already crucial requiring considerable improvements of irrigation technologies [FAO4].

Economy, CO₂ Reduction Goals and Food Security

According to the World Food System Model a considerable increase in staple food prices has to be expected. As predicted in the World Food System Model for 2020 a 30% rise is assumed against a situation without biofuel production. Especially alarming and of concern is the assumed dramatic increase of prices for coarse grains, maize and sorghum. These cereals are of major importance for developing countries especially in Africa where they are the most important staple foods; high prices of coarse grain are therefore a definite threat to food security in developing countries. Because of the large quantities of the protein rich byproducts in the first generation biofuel production especially in the case of biodiesel production the price of protein rich feed materials may fall significantly below the reference level (no biofuel production) [Chal].

The number of malnourished people worldwide is still increasing; the majority of the food insecure is living in Asia and the Pacific Region followed by Sub-Saharan Africa. In case the CO₂ reduction goals and in more practical terms the goals set for the production of biofuel will be maintained the number of malnourished people will rise instead of being reduced despite the fact that the land resources are available for both biofuel feedstock and food/feed production. Higher prices of staple food will deny access to a nutritional balanced diet to millions of people in developing countries. The only way to reduce the number of malnourished people in a significant way would be to cut biofuel production to zero. In case biofuel production is maintained in its present pace or expanded according to recommendations of OECD countries and non- OECD countries the number of malnourished will dramatically grow, it is understood that even the market introduction of second generation biofuel will not reduce the number of malnourished below the present baseline [FAO 2011]. It is obvious that reduction of traffic borne CO₂ emissions by replacing considerable parts of fossil fuel by biofuels may result in a "transport fuel security approach" for combustion energized transport, it is however also obvious that this development enlarges the number of hungry people considerably. It has to be understood that for the time being biofuel production to achieve transport fuel security and food security cannot be dealt with as independent parameters, they are closely related. In case biofuel production is increased as proposed there will be a need for significant savings on the food but also at the feed side [Tren].

Dramatic are however the reductions in food uses in developing countries, the quoted numbers underpin the statement that the biofuel production reduces the nutritional basis in especially in poor developing countries The chances to expand profitable agricultural production in so far non-profitable areas are utilized for the production of second generation biofuel feedstock may offer some steps out of the crisis it may help in reversing migration into urban centers especially in developing

countries. The expectations of an expanded feedstock production for biofuels should be however not too high. The projections show that first of all again the farmers in developed countries are the main profiteers, the farmers in developing countries draw only marginal profit from the development.

Possible are improvements in the case of small hold farmers in developing countries e.g. Africa. The concept could be that small hold farmers would grow biofuel crops like Jatropha (*Jatropha curcas*) or Pongam (*Pongamia pinnata*) alongside food crops, which would help them to increase their cash income. Both trees are quite interesting. The collateral benefits from an expanded biofuel production could be that the farmers earn additional cash for an labor extensive production.

Are there any real benefits through the biofuel production?

The underlying idea for biofuel production was and still is that the transportation related part of the fossil fuel use could be considerably reduced by replacing fossil fuels through biofuels, their use should be emission neutral or even positive. The practice of biofuel production has however shown that considerable quantities of energy have to be invested for the biofuel production only biofuels manufactured from biomass grown on degraded and abandoned agricultural lands incur little or no carbon debt. Starting with the agricultural production including soil management, harvesting, transportation, processing, there are a multitude of steps in the chain to the final product which burn energy. Projections developed on various scenarios do not reveal a clear picture, depending on the fertilizer's part of the balance the indications are that in the near future (2020 to 2030) the global carbon emission balance through the production of biofuel is negative to neutral or slightly positive; only in the distant future (2030 to 2050) a really positive carbon balance can be expected. The production of biofuel may also be connected with negative impacts on the environment through deforestation, loss of biodiversity and unfavorable interventions into the water-resources [Impli].

Concluding remarks

As stated the impact of biofuel production on the availability of food will depend on various factors, mainly how fast second generation biofuels will appear on the market. IEA is assuming that the contribution of second generation biofuels to the biofuel share will grow steadily from (2015)/2020 on it may then take 5 to 10 more years before it will have a significant influence on the biofuel production. It is anticipated that only from 2050 on the carbon debt of biofuel production through Second Generation biofuel production will be entirely negative

It is however evident that for the time being biofuel production is competing with food and feed production, with the effect that both food and biofuel prices will be interdependent. The level of both prices will depend on various factors, on market mechanisms, but at the very end on the political willingness of the Developed Countries to allow people in Developing Countries to develop a sustainable (agricultural) industry.

An important question is also if the export oriented industrial production in Developing Countries will grow in the near future; with growing exports most

Developing Countries will/should be able to afford, at least to a higher extent than presently, the imports of cereals required to provide food to their growing populations. Prices and availability of food are also linked to patterns of food consumption which are becoming more similar throughout the world, shifting towards higher-quality and more expensive foods such as meat and dairy products. Cereals will stay the most important staple food.

The change from plant based proteins to more meat and milk/dairy products with all its implications is more environmentally damaging than biofuel production.

Meat and Milk/Dairy Products Consumption in DC		
Year	Meat Consumption kg	Milk/Dairy Products Consumption kg
1966	10	28
1999	26	45
2030	37	66

Tab.13 Meat and Milk/Dairy Products Consumption in DC [De]

The central question of this report if biofuel production threatens Food Security is difficult to answer. At the moment there is certainly an impact because of a rise in coarse grain prices, in the very near future this situation will continue. Beyond 2050 or even before biofuel production will certainly be based on non-food plant feedstock and will not interfere anymore with food and feed production [IEA2].

The analysis of the presented data shows that the production of various types of first generation biofuels will not be restricted by the availability of land resources and will not impede the production of sufficient food and feed to avoid Food Insecurity. There is certainly enough land available to produce sufficient food, feed and biofuels to meet the anticipated targets amongst others Millennium Development Goals 1 [UnMDG]. The existing Food Insecurity and the problems of the near and far future can only be remediated by a new way of political thinking. The political classes in the Developed but also in the Developing Countries have to assume their responsibility in a truly global way of thinking. It has to be kept in mind that “Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life” [FAO1].

In case it is targeted, under the present political situation, that around 10% of the fuels used for transportation are derived from renewable biological sources it has to be expected that around 10% of the global population will be food insecure this means that out of 9 billion people 900 million people will be food insecure..

The authors of the study BIOFUELS and FOOD SECURITY arrive at the conclusion: “The mandates and targets together with substantial funding and subsidies to develop biofuels in the presumed interest of transport energy security should raise ethical and moral concerns regarding the failure of the international community to make decisive progress towards achieving world food security” [Impli] .

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