POSITIONS

Sustainable use of

GLOBAL LAND AND BIOMASS RESOURCES

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For our Environment

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1.

Introduction

1.1 BACKGROUND AND PURPOSE OF THIS PAPER

Before humankind discovered oil, coal, natural gas and uranium and learnt how to put them to use, biomass covered all of the respective needs. Since time immemorial, it has provided food, feed and fodder, fuel, construction materials, and the raw materials for textiles as well as medicinal drugs. Until the mechanisation and motorisation of farming subsequent to the Industrial Revolution, agricultural biomass production was based on regional, largely closed, food and energy cycles. The energy needed for this production (fodder for working animals and food for the human workforce) came from within the agricultural sector itself. As technology progressed in the 20th century, it significantly changed the way in which biomass is produced and used (cue: specialisation, increasing global division of labour and trade). Fossil fuels made the motorisation of agriculture and the energy-intensive production of fertilisers and pesticides possible. The globalisation of food and energy flows resulted in a more intensive, specialised form of biomass production and ushered in an era of wealth and abundance in some parts of the world. However, neither the globalisation of the biomass trade flow nor a global food production that has by now increased to 2,800 kcal per capita and day (FAOSTAT) has managed to permanently reduce the proportion of the global population that is suffering permanent hunger.

Before humankind discovered oil, coal, natural gas and uranium and learnt how to put them to use, biomass covered all of the respective needs.

Globally, the pressure on land and other resources is increasing. It is caused by the resource-intensive consumption habits of the industrialised and newly industrialising countries as well as the increasing demand for agricultural produce and forest products fuelled by the global demographic development. A growing world population needs more food, more renewable raw materials and more energy. As incomes rise in the newly industrialising countries, their per capita resource-intensity of the consumption habits is also gradually reaching the levels seen in the industrialised countries. All this is happening against the background of climate change, whose effects are increasingly affecting global biomass production.

The environmental cost of the intensification of agriculture, i.e. the extensive destruction of environments, was an issue that was not addressed until the second half of the 20th century. The way how and to what extent crops are cultivated, livestock is kept and biomass is extracted from natural reserves (e.g. forests and natural grassland etc.) has a considerable impact on the integrity of the global ecosystems and their ability to fulfil functions such as climate control, the conservation of soil fertility and biodiversity and the regeneration of regional water bodies.

Due to the worldwide network of agricultural produce and forest product trade flows, the causal chains for the problems associated with the production are also linked across the globe. Therefore, the major environmental problems and the deplorable fact that a billion people go hungry also call for global problem analyses and solution approaches for a more sustainable production, use and distribution of biomass.

This report gives an overview of the current status of biomass-based land use and highlights existing and likely global development trends. It outlines what an ecologically more compatible and socially fairer resource use could look like and what the priorities are that must be set in the production and use of biomass in order to reach this goal. It identifies respective initiatives and puts forward policy recommendations for the development of a globally sustainable, resource-saving land use.

1.2 GUIDING PRINCIPLE: SUSTAINABILITY AND CONSERVATION OF NATURAL RESOURCES

As a consequence of the growing world population and the accompanying rising demand for resources, we are progressively reaching the stage of an advanced overuse of the natural resources. Considering the effects of climate change, the impending shortage of resources, the growing world population and the fact that today, a billion people already go hungry, we are faced by the existential questions of how land use can be resource-saving, how biomass use can be sustainable and how we can and must contribute to solving these problems.

Our guiding principle is the vision of sustainable development first defined by the Brundtland Commission[1], which understood this to be ‚development which meets the needs of the present without compromising the ability of future generations to meet their own needs'. The central theme of this guiding principle is equality on an ecological, economic and social level, both for those currently living as well as future generations (see also UBA 2002).

We consider the maintenance of ecosystem services, i.e. the preservation and extensive reconstruction of multi-functionality and diversity in land use accompanied by the optimum integration of the various land and soil functions as well as the need satisfaction of all people and also future generations to be central elements in this vision of sustainable biomass and land use. The latter is an essential component of this guiding principle: If land and biomass are used with resource conservation in mind, but this use does not satisfy the elementary needs of a large part of the global population, it cannot be considered sustainable.

Vulnerable people are put at risk by the clearly rising demand for land and other natural resources; any reconsideration of resource use must therefore take equity issues into account, particularly the phenomenon of ‚land grabbing', the upcoming need of importing biomass to maintain the industrialised countries' energy-intensive lifestyle, but above all the persistent malnutrition people in many parts of the world continue to suffer from whilst food is shamefully and unnecessarily wasted in others are developments which we view as pressingly in need of reexamination

and critical from an ethical point of view.

Food security[2] is generally considered to be one of the core targets of sustainable biomass production and resource-saving land use, and we concur. The Right to Food is a human right (Article 25 of the 1948 United Nations Universal Declaration of Human Rights). This right is also laid down in the International Covenant on Economic, Social and Cultural Rights (social contract), which came into force in 1976. According to international law, all states which undersigned this social contract are obliged to realise the right to food in their country. All people must either have access to the means of food production such as land, seed and water, or they must have an income that allows them to buy sufficient food. Amongst other things, this also indicates that a state clearly bears some responsibility for the protection of the natural resources that are the basis for food production.

It is absolutely vital that consideration is given to the intergenerational component, i.e. securing the food supply of those currently living or creating the preconditions for enabling them to feed themselves must be a long-term venture. It must take the situation of future generations into account, and must not make it worse for them – and this must be achieved despite the challenges of a growing world population and dwindling resources. Essentially, we will have to find ways of producing More with Less in future. Each individual, every nation and the global community are now tasked with the permanent conservation of our natural resources, including fertile soil, clean water and biological diversity. They are not only vital for the production of biomass but are also needed for the satisfaction of other, quite diverse and in part also fundamental needs and desires.

A rapid trend reversal in many areas is necessary in order to get closer to meeting the requirements set out in these guiding principles. In this respect, suitable and feasible measures must be developed and implemented as soon as possible. The answers to the question of how this may be achieved are complex. They require a wide range of approaches at different levels. At an international level, the drivers of environmental destruction must be identified and stopped, and the distribution of commodities must be fundamentally redesigned with intra- and intergenerational equality in mind. In the course of formulating a sustainable economic strategy, it is vital that the overriding importance of local social and economic conditions and natural habitats is globally recognised. Competent actors must also regain increased decision-making scope in terms of the available choice of existential production and consumption options.

1.3 DEFINITION OF THE TERM BIOMASS

The scientific definition of the term ‚biomass' includes all organic substances of non-fossil origin (Kaltschmitt, et al., 2009). Biomass therefore encompasses all phytomass and natural living organisms (flora and fauna), the resultant residues (e.g. animal excrements), dead (but not yet fossilised) phytomass and organic matter (e.g. straw) as well as, in a further sense, all substances generated through, for example, transformation by means of the application of a technology and/or a use of the material or substances that are the result of such a transformation (e.g. abattoir waste, organic household waste) (Raschka, et al., 2012).

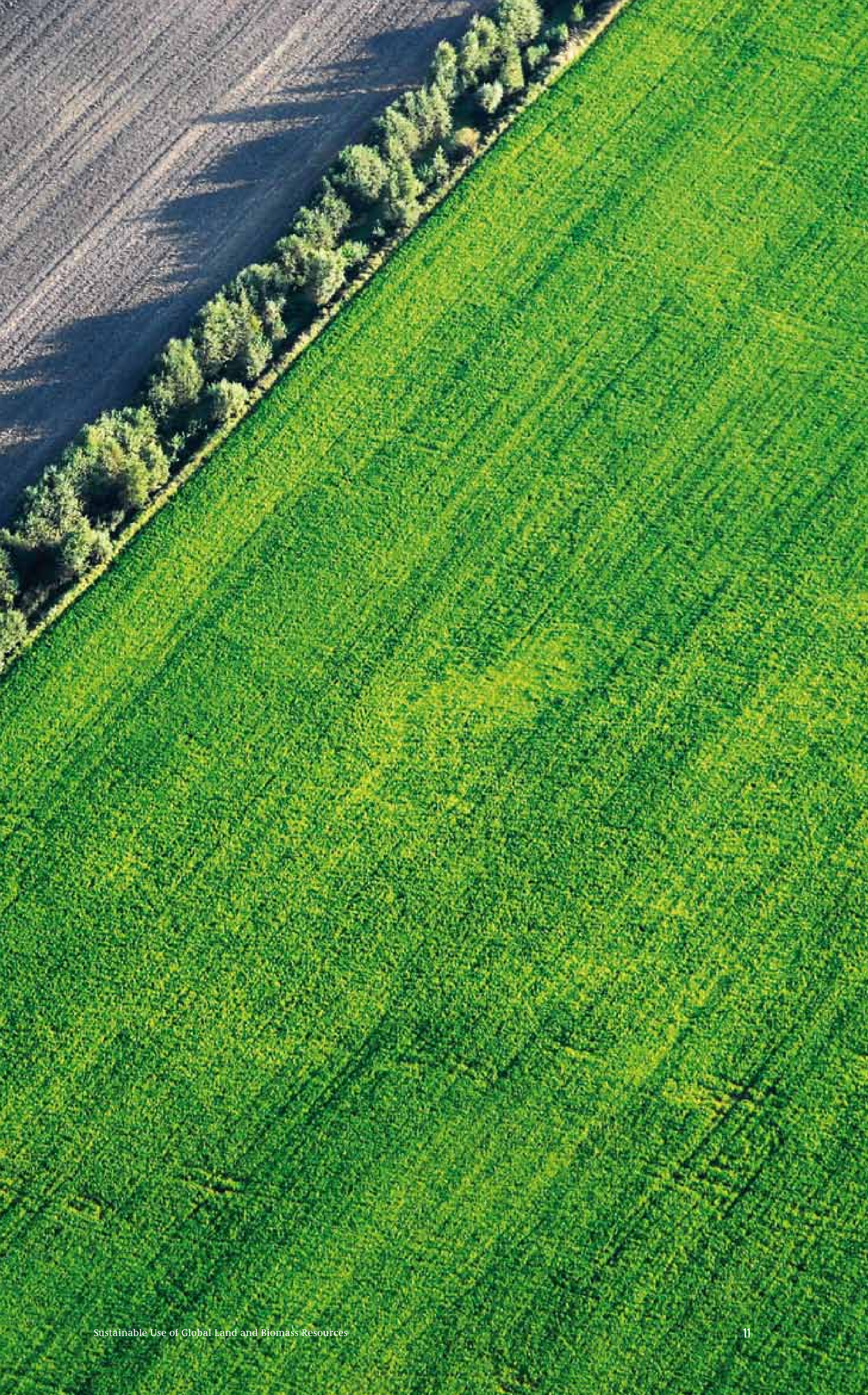
This paper only examines the proportion of biomass that people use either directly, for example as food or fodder, or convert, for example in order to produce energy or raw materials for industrial use (biogenic raw materials). This report applies the term biomass to all biogenic raw materials, although aquatic biomasses are explicitly excepted. However, Ch. 2 contains a brief discourse on the importance of aquafarming.

[1] The United Nations World Commission on Environment and Development defined the concept of sustainability in its 1987 report ‚Our Common Future' (Brundtland Report, 1987).

[2] **Food security** refers to the availability of food and access to food. The 1996 World Food Summit defined food security as existing when: ‚All people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.' Although the availability of food is a precondition for meeting a population's dietary needs, this food must also be used and distributed properly in order to provide food security. This also includes being prepared for emergencies (secure food supply during times of crises and natural disasters) (FAO, 2010a).
The term **food sovereignty** was initially defined by members of the Via Campesina movement on the occasion of the 1996 World Food Summit as ‚the right of each nation to maintain and develop its own capacity to produce its basic foods respecting cultural and productive diversity. We have the right to produce our own food in our own territory. Food sovereignty is a precondition to genuine food security.'
The term **food safety** merely refers to the qualitative aspects of food (no harmful substances, nutritious etc.).

2.

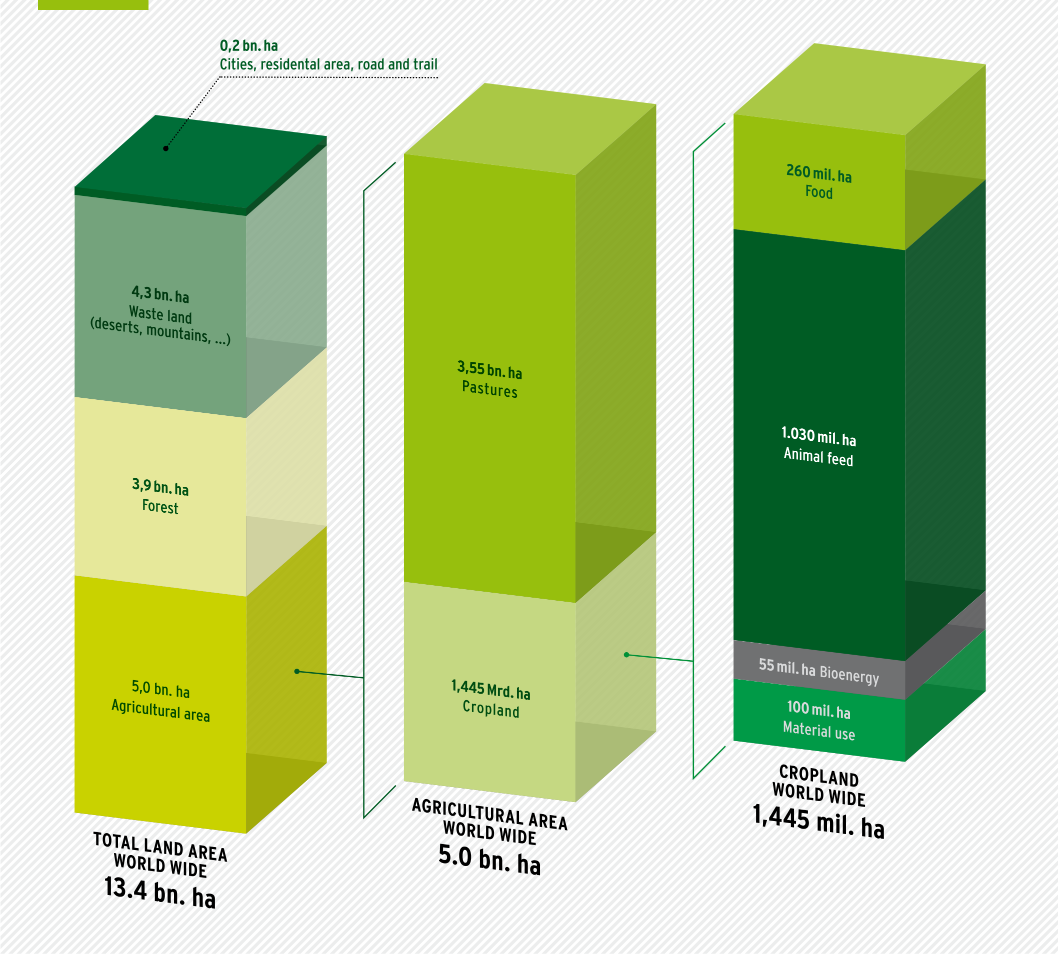
Global Land Availability and Land Use



2.1 BASIC DATA ON GLOBAL LAND USE AND BIOMASS VOLUMES

The total global land surface amounts to 13.4 billion hectares (ha). Due to extreme physiogeographic conditions, a not inconsiderable part of this land surface is not usable or usable only to a very limited extent (deserts, barren lands, ice sheets etc.). 37 % of the global land surface, approx. 5 billion hectares, is farmland. The largest proportion of the available land surface is therefore utilised for agriculture. The world‘s forests cover around 3.9 billion hectares. 36 % of these forests are primary forests .

FIG. 1: Global land use for food and renewable raw material production 2008



Source: Raschka et al. (2012 S. 21)

Around 70 % of the farmland is pastureland, i.e. with around 3.55 billion hectares by far the largest proportion. Only slightly less than 30 % of farmland is cropland (approx. 1.45 billion ha, plus around 0.152 billion ha of land dedicated to permanent crops). Most of the cropland serves fodder and food production. A mere 11 % of this land is used for the production of raw materials for biofuels and industrial biomass use (Raschka, et al., 2012).

Of Europe‘s total area of 440 million hectares, 43 % is used as farmland. Around 40 % of this area is covered by forests. Germany occupies an area of 35.7 million hectares; as approx. 17 million hectares of these are used for agricultural purposes, the respective proportion even equals almost 50 % of the available area; forests cover around 30 % of the total area.

Worldwide, around 30 % of the land surface is covered by forests. In Latin America and

Europe including the Russian Federation, the volume of forest cover is above average with 49 % and 45 %, respectively. Asia (19 %), Oceania (23 %) as well as Africa (19 %) are below the average in terms of forest cover (FAO, 2010c). Whilst the timber extracted from forests in Africa, Asia and Oceania is used mainly as firewood, it is clearly used predominantly for industrial purposes in Europe and North America (FAO, 2011). Between 1970 and 2009, the rate of timber extraction in Africa and Latin America also increased significantly, whereas volumes have remained more or less constant or have declined slightly in the other global regions (ibidem).The growing awareness of the importance of the ecoservices provided by forests (biodiversity protection, protection of soil and drinking water, protection against floods etc.) is also reflected by the fact that forests are increasingly being designated as areas that primarily fulfil a protective function. In 1990, for example, around 12.3 % of global forests were designated as being of major importance for the protection of biodiversity, soils or water. In 2010, 16.5 % of global forests were designated as such with the primary aim of conserving ecoservices. The proportion of the total area with a designated production function remained constant at 28.3 % (1990) and 28 % (2010), respectively (FAO, 2011).

Globally, the volume of crop- and pastureland increased by 154 million ha (approx. 3 %) between 1985 and 2005. These increases occurred mainly in the tropics, whilst the respective areas decreased in the temperate zones (Foley, et al., 2011).

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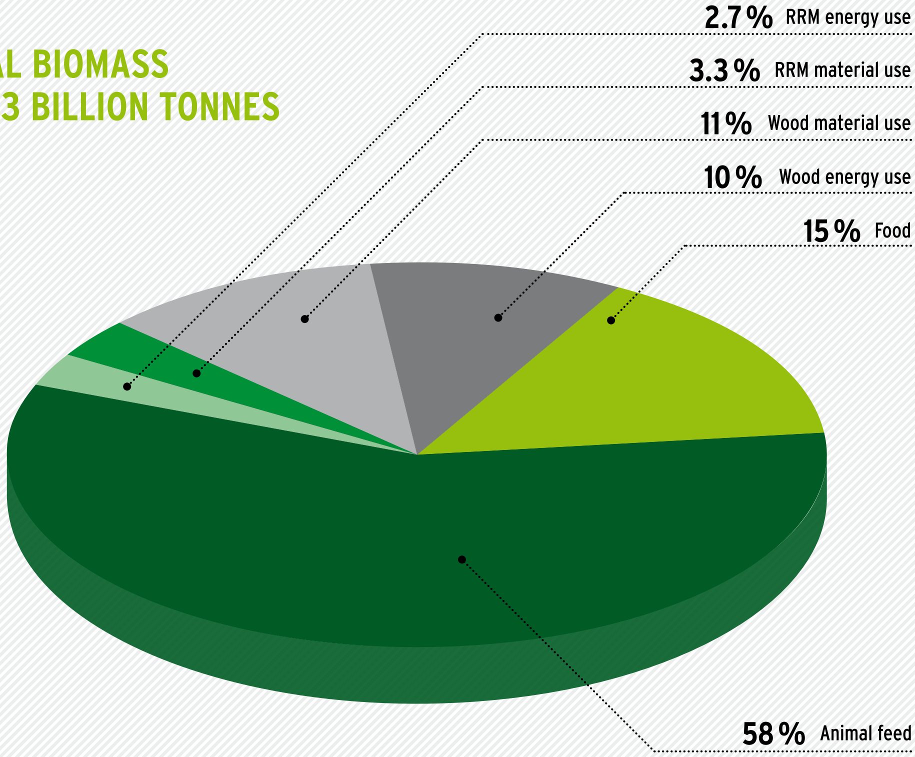
The opposite tends to be the case where global forests are concerned. The conversion of forests to farmland in tropical regions, mainly Latin America and the Caribbean, is contrasted by the reforestation and natural afforestation of farmland in Europe, North America and China (FAO, 2010c). This has nevertheless led to a global forest loss of around 135.2 million ha between 1990 and 2010 (FAO, 2011), or 3.2 % of 1990‘s global forest cover. However, the annual global forest cover loss of around 8.3 million ha (1990 – 2000) was successfully reduced to an annual 5.2 million ha (2000 – 2010) (ibidem).

FIG. 2: **Use of agricultural and forest biomass harvested worldwide**

TOTAL BIOMASS CA. 13 BILLION TONNES



Allocation of biomass to production target (main product). Respective amounts include raw materials and by products, even if their use fall into a different category.

RRM = Renewable Raw Materials

Source: Raschka et al. (2012)

Raschka et al. (2012) estimate that the worldwide biomass volume produced by means of agriculture and forestry amounted to 13 billion tonnes in 2008. Whilst 58 % of this was used as fodder, a mere 15 % was actually used for food, a proportion of 21 % can be allocated in equal shares to the use of timber for the production of energy or for industrial purposes, and 3 % each to the use of renewable raw materials for the generation of energy and other industrial uses.

Due to progressively more resource-intensive consumption patterns in the industrialised and newly industrialising countries, global demographic developments[4] and the impact of climate change and a growing shortage of productive land, the arable land will increasingly feel the pressure of being expected to meet a growing demand (UNEP, 2012).

2.2 LAND USE FOR FOOD PRODUCTION

Per capita, 0.72 ha of farmland are available today worldwide. Whilst global grain yields have more than doubled over the past five decades, the volume of farmland available per capita has gone down considerably over the same period. This development is particularly pronounced in Africa. In many developing countries, this reduction is caused mainly by the rapid population growth – which far surpasses any moderate land expansion. Although most of the arable farmland is located in the developing countries, the farmland available to each inhabitant was just under 0.2 ha per capita in 2010, or 50 % less per capita than the farmland available to each inhabitant of the developed countries (Bruinsma, 2009). Prognoses up to 2050 show a continued worldwide reduction of the per capita availability of farmland (Foresight, 2011).

The grain yield growth rates of only 0.5 – 1 % per annum will at best be around half of those seen over the past decades (Bruinsma, 2009). In addition to the volume of available farmland, the volume of specific surface area per capita required for the production of food crops also plays a role. The cropland necessary to produce various plant-based foodstuffs varies across the world and depends very much on the respective local conditions and cultivation intensity with regard to soil quality, climate, use of fertilisers and crop treatments (von Körber, et al., 2009).

According to FAO projections, today's food production volumes will have to be increased by 70 % in order to cover the expected demand of a world population of 9 billion in 2050. Assuming the median of the various population growth projections, the industrialised and the newly industrialising countries will need to increase their production by a mere 23 %, and the developing countries by a staggering 97 % (Bruinsma, 2009). The key respective challenge will be to achieve this productivity increase in an ecologically and socially sustainable way (see Ch. 5 on the use of additional potentially usable land).

In 2009, according to data published by the Food and Agriculture Organization of the United Nations (FAO), a total of 1.023 billion people across the globe suffered from malnourishment. (FAO, 2010a). Theoretically, i.e. in terms of figures, the amount of agricultural produce would be enough to feed all people everywhere in the world. The amount of calories available to each person in the world every day has gone up from 2,200 kilocalories (kcal) in the early 1960s to 2,790 kcal between 2006 and 2008. In the developing countries, it has even increased from 1,850 kcal to 2,640 kcal over the same period (FAO

TABLE 1: Meat consumption in selected countries per capita and annum in 1980 and 2005

	1980	2005	Change in %
Industrialised countries	76.3	82.1	7.6
Developing countries	14.1	30.9	119.1
China	13.7	59.5	334.0
Latin America and Caribbean	41.1	61.9	50.6
India	3.7	5.1	38.0
Africa (sub-Saharan)	14.4	13.3	-7.6
WORLD	30.0	41.2	37.3

Source: based on FAO (2009a)

2012a). This shows that there is evidently a distribution problem; hunger is primarily a poverty issue, i.e. the problem is having access to food. In 2011, global grain production hit a new high of 2,325 million tonnes, a 3.7 % increase compared to the previous year. Only 46 % of this grain was used for food; 34 % was used as fodder and the rest was processed to provide fuel or other industrial products (FAO, 2011).

Global meat production and consumption has increased dramatically over the past decades. Between 1970 and 2009, meat production tripled from just over 100 million tonnes to around 300 million tonnes. A trend reversal is not in sight. Over 1.4 billion head of cattle, 1 billion sheep, 1 billion pigs and 19 billion chickens are kept worldwide (FAO, 2012). Around 1/3 of the global land surface is already dedicated to livestock farming today due to the need for pasture- and cropland (Steinfeld, et al., 2006).

> Between 1970 and 2009, meat production tripled from just over 100 million tonnes to around 300 million tonnes.

On the one hand, livestock farming offers a way of using land resources which cannot be used or exploited in any other way. Most pastureland, particularly in arid regions, does not lend itself to any agricultural use other than extensive pasture farming. Where animals feed on grass and parts of plants that are not actually fit for human consumption, they increase the food supply, provide manure, can be used as draught and pack animals and are a way of utilising waste or agricultural by- or co-products. On the other hand, the overuse of pastureland in some regions of the world through traditional livestock farming is a serious problem. In many regions, natural ecosystems have been extensively destroyed in order create pastureland to provide the basic fodder. Livestock farming is the main driver of deforestation.

In contrast, intensive livestock farming does not require pastureland as the animals are kept in stables. The downside of the modern intensive livestock farming processes is their pronounced dependency on economic crops such as maize, soy, wheat and other types of grain that are also fit for human consumption. This not only applies to pig and poultry farming in the industrialised countries, where the animals are usually fattened up on grain-based fodder, but also to dairy and cattle farming. Alone the proportion of land dedicated to growing grain for animal fodder is estimated to amount to around 470 million ha worldwide, which equals around 33 % of global farmland (Steinfeld, et al., 2006). Raschka et al. (2012) calculate that 58 % of the biomass grown globally on fields and pastureland is needed for livestock farming. With regard to the use of plant-derived biomass, livestock farming is the main competitor when it comes to providing food for people and ensuring global food security.

Excursus on the importance of aquafarming and fishery for food security

Aquafarming is the fastest growing animal-derived food sector and contributes a good third of the global fish supply. Aquafarming and fishery supply 140 million tonnes of fish (2008), this volume has risen fivefold over the past 50 years. Global per capita supply is 17.2 kg/annum (2009). Today, over 200 species of fish, mussels, shellfish, reptiles, amphibians and various kinds of algae are bred worldwide outside their natural habitat to supply the international markets. Most of these species are finfish, the rest mainly molluscs and shellfish (FAO, 2010d).

Aquafarming is particularly prevalent in China, followed by India, Japan, the Phillippines, Indonesia, Thailand, Korea, Bangladesh, Vietnam and Norway. 90 % of the volumes produced globally originate in Asia, a marginal 4 % in Europe and 2 % in Latin America.

The advantages aquafarming has over traditional fishery are steady and predictable volumes as well as lower prices (the price for farmed salmon has gone down by around 80 % since the early 1980s). Aquafarming can counteract the over-fishing of the oceans and represent a new food source. However, this only applies to some forms of aquafarming. Conventional aquafarming also has potentially harmful ecological consequences such as over-fertilisation through animal effluents and the use of drugs and chemicals. The demand for feed causes considerable ecological problems. Fish meal and fish oil are irreplaceable as feed for some aquafarmed species. Sustainable fishery and ecological aquafarming concepts therefore limit the use of fish meal and oil as feed to a minimum; the products used must also be made only from processed bycatch or seafood processing waste.

2.3 LAND USE FOR RENEWABLE RAW MATERIAL PRODUCTION

International and German Area and Volume Structures

It is currently estimated that in 2008, the global land area dedicated to the cultivation of renewable raw materials (RRM) for conversion into energy or for other industrial uses amounted to 155.3 million ha of farmland and 3.95 billion ha of forest (Raschka, et al., 2012). In total, plants or plant parts from 4.1 billion ha are used; this is predominantly due to the use of wood. The volume of biomass used for industrial purposes still slightly outweighs the volume of biomass used to provide energy.

Besides wood or timber, the largest proportion of areas dedicated to the production of renewable natural resources for industrial use, 2.15 billion ha, is used primarily to cultivate starch-rich maize and wheat, oil palms and coconut for the extraction of oil, sugar cane and cotton used exclusively for industrial purposes, and natural rubber.

As the following table shows, almost 2 billion ha are currently dedicated to the supply of biomass for energy use. In terms of area volumes, it is primarily wood that plays a role in the production of bioethanol, followed by maize and sugar cane. Next comes bamboo, used as a fuel, and the oil palm fruit for biodiesel production. Natural fibres and rubber, which account for more than 20 % of industrially used biomass, are not important in terms of energy use (see Table 1 in Appendix 1).

The area comparison shows that the proportion of farmland dedicated to cultivating biomass for industrial use is considerably higher than the proportion dedicated to energy use. This is not least explained by the high proportion of cotton, over 30 %, for industrial use.

TABLE 2: Global cropland dedicated to the cultivation of renewable raw materials in 2008, in hectare (ha)

Cropland	for industrial use (in 1.000 ha)	for energy use (in 1.000 ha)	Sum of industrial + energy (in 1.000 ha)
Cropland	100,498	54,822	155,320
Forests	2,055,040	1,896,960	3,952,000
TOTAL	2,155,538	1,951,782	4,107,320

Source: simplified version of total table by Raschka et al. (2012) (see Table 1 in Appendix 1).

Firewood is the predominant biogenic energy carrier as it provides 71 % of the bioenergy used. It is followed by charcoal with 7 %, recovered wood with 6 % and timber industry residues with 5 %. Currently, bioenergy is therefore primarily energy provided by the burning of wood. Its agricultural production on around 55 million ha of cropland contributes approximately 10 % of the bioenergy; 7 % of this is generated by recycling co-products and residues and around 3 % of the global bioenergy is yielded by energy crops (IPPC, 2011).

A volume comparison[5] between the proportion of biomass for industrial use and the proportion dedicated to energy production reveals a similar picture. According to Raschka et al. (2012), around 52 % of the overall volume including wood can be allocated to industrial and 48 % to energy use. Excluding wood, there is only a marginal shift to around 54 % for industrial and 46 % for energy use (see Fig. 1). Compared to the use of agricultural raw materials in the food and fodder sector, however, only a very marginal proportion of the total area used for biomass cultivation is dedicated to the sector that comprises industrial and energy use, i.e. 7.4 % for industrial and only 6.3 % for energy use (excluding wood).

A comparison of the volumes or quantities of selected raw materials shows that the renewable raw materials, particularly wood, represent a very large proportion compared to the other raw materials used worldwide. In terms of mass, they are comparable to other raw materials such as concrete or steel (see Fig. 3).

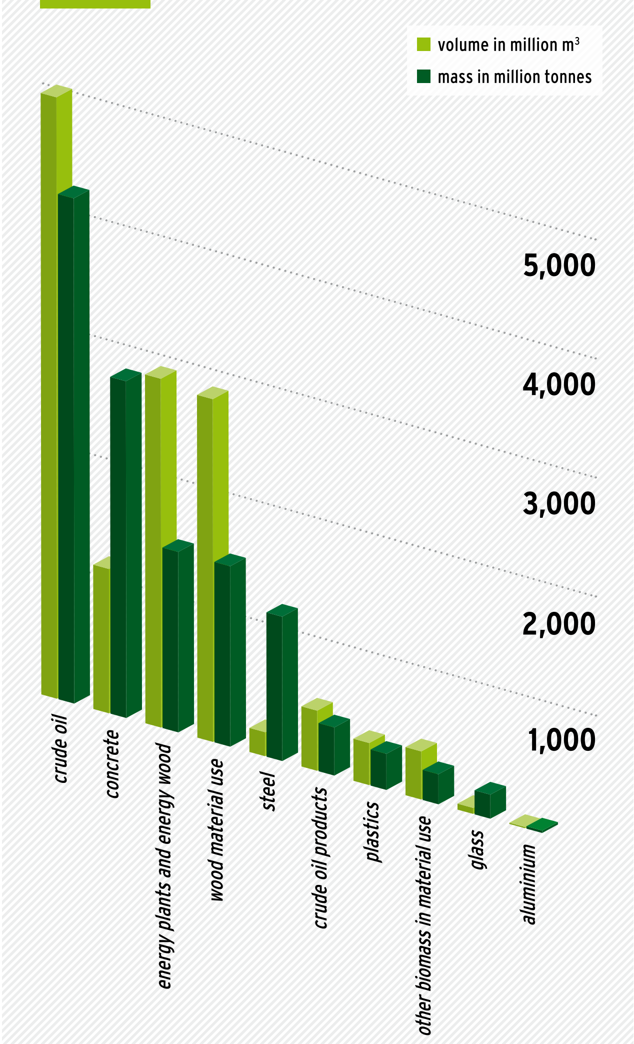
In 2010, renewable raw materials were cultivated on over 2.1 million hectares, or a good 18 %, of Germany's total cropland. In addition, the 11.1 million ha of forests – still a respectable third of the territory of the Federal German Republic – supply wood for industrial and energy use.

The following illustration of the cultivation of renewable raw materials in Germany (FNR, 2012) in 2010 shows the extent of the areas dedicated to growing plants for industrial and energy use. Energy crops grown on fields dominate here with over 1.8 million ha (approx. 16 % of the total cropland), whilst the industrially used plants occupy only 317,000 ha. In terms of area, the dominant energy crops are oil-producing plants (oilseed rape) and biogas plants (maize). Political framework conditions have a major influence on whether renewable raw materials are used for energy or fodder production.

In Germany, the cultivation of renewable raw materials has been subsidised since the late 1980s, initially with the aim of establishing new sales markets for agricultural produce. Towards the end of the 1990s, climate protection and energy supply security became additional political issues. The transport sector's dependence on mineral oil made simple technologies such as first generation biofuels seem an attractive alternative. Since the turn of the millennium, a comprehensive array of tools has been introduced to encourage the use of biomass for energy generation with the help of various instruments (see Ch. 4).

Global comparison of selected raw materials used for industrial and energy-generating purposes in 2008

FIG. 3:



Source: from Raschka et al. (2012 S. 24)

TABLE 3: Cropland used to cultivate renewable raw materials in Germany, 2010/2011 in hectare (ha)

	Raw material	2010 (in ha)	2011* (in ha)
INDUSTRIAL CROPS	Maize for industrial use	160,000	165,000
	Sugar for industrial use	10,000	10,000
	Oilseed rape for industrial use	125,000	120,000
	Sunflower oil for industrial use	8,500	8,500
	Linseed oil for industrial use	2,500	2,500
	Plant fibres	1,000	1,000
	Medicinal drugs and dyes	10,000	10,000
	TOTAL INDUSTRIAL CROP	317,000	316,500
ENERGY CROPS	Oilseed rape for biodiesel/vegetable oil	940,000	910,000
	Bioethanol crops	240,000	250,000
	Biogas crops	650,000	800,000
	Solid fuel crops	4,000	6,000
	TOTAL ENERGY CROPS	1,834,000	1,966,000
TOTAL AREA DEDICATED TO THE CULTIVATION OF RENEWABLE RAW MATERIALS IN ha		2,151,000	2,282,500

Source: adapted from FNR (Agency for Renewable Resources) data (2012) (*estimated 2011 values)

These financial incentives have made the use of agricultural produce and forestry raw materials for energy generation attractive; in consequence, the areas dedicated to the cultivation of energy crops have increased significantly over the past decade. Over the same period, the size of the areas dedicated to industrial use, around 300,000 ha, remained constant as there was no equivalent subsidy programme in place to encourage this use.

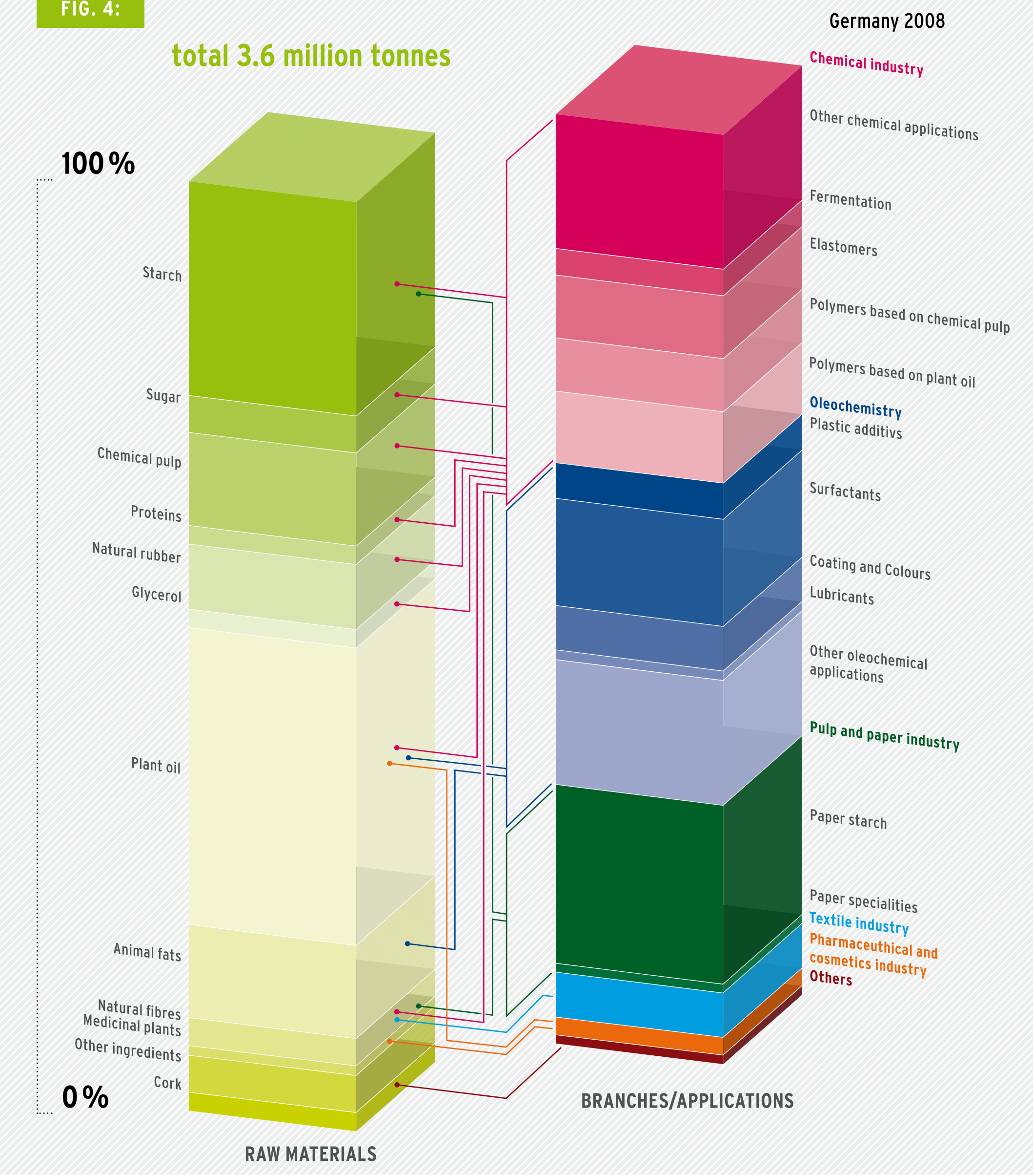
Essentially, biomass cultivated as a renewable raw material can be used exclusively for energy generation, exclusively for industrial purposes, or for both of these purposes in random proportions. The political framework conditions impact these proportions considerably.

Industrial Biomass Use According to Industry Sector

In terms of volume, the largest proportion of biomass used for industrial purposes in Germany can be allocated to the sawmill and timber industry (36 million t wood), the paper and cellulose industry (approx. 7 million t of which 6,5 milion t are wood), the chemical industry (1.7 million t) and the oleochemical industry (0.98 million t). These are followed by the considerably lower volumes used in the textile industry (0.158 million t), in the pharmaceuticals and cosmetics sector (0.074 million t) and assorted other sectors (Carus, et al., 2010).

In total Germany thus uses 43.2 million t of wood and 3.6 million t of other biomass as a raw material; for how the 3.6 million tons break up into the different branches and applications see Fig. 4. According to German chemical industry federation (Verband der chemischen Industrie, VCI) data, over 12 % of the raw materials used in organic chemistry are already based on renewable raw materials. So far, renewable raw materials have always been used where starting substance compounds are close to the required material components, as is the case, for example, with surfactants for cleaning purposes.

FIG. 4: Renewable raw materials used per raw material, industry and product (without wood)



Source: Raschka et al. (2012)

Biomass is almost the only source of carbon for the chemical industry that is ‚renewable‘ within a reasonable timeframe. In organic chemistry, the use of fossil raw materials continues to be the more economical option, in most cases. Reasons for this are the processes and value chains built up and optimised over decades on the basis of petrochemical raw materials, as well as the synthetic pathways of the compounds. An increased use of renewable raw materials in the chemical industry is desirable, also from the industry‘s perspective, although to which degree and in what kind of timeframe this increased use of renewable raw materials could be achieved remain unresolved issues (DECHEMA, 2008).

> Europe is the continent that depends most on global hectares: the EU needs an area of around 1.3 ha per capita, whilst countries such as China or India need less than 0.4 ha per capita.

The importance of industrial biomass use is described by Carus et al (2010) as follows: ‚Securing the German industry‘s raw material basis will require extensive resource management and diversification with regard to raw materials. This diversification must include agricultural raw materials. In fact, they are as important for the industry as they are for the provision of food or fodder. The industrial use of organic renewable raw materials is a key technology for securing the industry‘s supply with raw materials, and the importance of organic renewable raw materials will steadily increase‘ (Carus, et al., 2010 S. 18).

Traditional and Modern Use of Bioenergy

Worldwide, biomass currently supplies approx. $50.3*10^{18}$ J, which is a good 10 % of the primary energy used globally. The largest proportion of bioenergy, approx. $31*10^{18}$ J/a of the overall total of $50.3*10^{18}$ J/a, is produced as a result of traditional use, i.e. the use of wood, charcoal, agricultural residues and dung for cooking and heating purposes in the southern countries, the so-called developing countries. Around 80 % of the primary energy used in the poorest countries is generated from biogenic resources (IPCC, 2011). Around 2.7 billion people (approx. 40 % of the world population), primarily in rural areas, depend exclusively on biomass for cooking and heating (BMU, 2011 S. 89). Since the 1980s, it has become apparent that the pressures of an increasing population and the growing hunger for land and fuel lead, in many cases, to the irreversible loss of tropical forests and to soil degradation, frequently through overuse but also through, for example, the loss of nutrients from cultivated crops when animal excrements are used for fuel rather than as a fertiliser.

In terms of energy yield, the traditional usage forms (e.g. ‚three-stone-fires‘, for example) are often extremely inefficient and accompanied by a high level of harmful emissions. The consequences include a domestic environment that causes serious health problems, which mainly affect women and girls, as well as a considerable adverse impact on the climate through particulates (so-called ‚black carbon‘).

In the early industrialised countries (the G8 nations), modern bioenergy makes a relatively small but steadily growing contribution to the primary energy supply. In some of the largest of the newly industrialising countries (Brazil, India, Mexico, China, South Africa), this proportion is considerably higher. Modern bioenergy processes are estimated to contribute $6.6*10^{18}$ J/a to the global final energy supply, requiring approx. $11.3*10^{18}$ J/a primary energy to do so (IPCC, 2011). Many newly industrialising and industrialised countries, including the EU, have heavily subsidised the use of bioenergy over the past few years. Ch. 4 addresses modern bioenergy in more detail.

2.4 EUROPE'S GLOBAL ECOLOGICAL FOOTPRINT

The global hectares Europe uses to produce all of the biomass it needs for the provision of food, fodder, raw materials for the chemical industry, construction and other materials and the fuel it consumes exceed by far the hectares Europe is domestically devoting to such purposes. They can be quantified as Europe's Ecological or Consumption Footprint.

An area's Ecological Footprint is an indicator that reflects the land and resources needed to produce agricultural and forestry products. It is calculated by adding the size of a country's domestic territory dedicated to the production of agricultural produce and forestry products to the size of areas in other countries required to produce all imported commodities (e.g. food, clothing, cellulose etc.) less the size of the area dedicated to the production of goods for export.

Europe is the continent that depends most on global hectares, i.e. ‚land imports'. Over 50 % of the agricultural and forest commodities consumed in Europe have to be produced on land located somewhere other than the European continent. On average, the EU needs an area of around 1.3 ha per capita, whilst countries such as China and India need less than 0.4 ha per capita (Lugschitz, et al., 2011).

As a result of the high consumption of meat and dairy products, timber and other forest products whose production requires extensive land areas, the EU has the second largest Ecological Footprint in the world with 640 million global ha. Only the US have a larger Ecological Footprint, with 900 million global ha. The EU is followed by China (500 million global ha) and the nations in the former CIS (330 million global ha).

Six of the ten countries that need the highest amount of global hectares are located in Europe, these include Germany, the UK[6], Italy, France, the Netherlands and Spain. Germany is Europe's second-largest importer of agricultural commodities, and third-largest nation in terms of exports. Germany and the UK each import 80 million global ha per annum. Each of these two countries imports 10 million ha from other EU countries whilst the largest share of their ‚imported land', the remaining 70 million global ha, come from non-European countries.

These figures clearly show that the high consumption level in Europe depends on the extensive indirect use of land located in regions beyond the borders of Europe. The EU needs 15 million global ha just to cover its soy imports, for example; of these, 13 million ha are located in South America. The EU demand for soy contributes considerably to the pressures these countries' natural environments are exposed to due to the respective land use changes.

For reasons of inter- and intra-generational fairness, Europe's Ecological Footprint must be reduced. Political goals must be set in order to achieve this, and measures must be implemented.

[3] The FAO defines primary forests as forest of native species in which there are no clearly visible indications of human activity and ecological processes are not significantly disturbed (FAO, 2010b).

[3] As this only takes statistically recorded timber extraction into account, the use for firewood may be even more predominant.

[4] According to the latest UN prognoses based on a global population of 7 billion people today, the global population will grow to a record high of approximately 9 billion by 2050. Population growth has serious effects on urbanisation and rural development. Currently, urban and rural populations are roughly equal, viewed globally; however, urban populations will rapidly increase whilst rural populations will decline. Amongst other things, this affects food production, urban infrastructures and the energy supply.

[5] from the original table, see Appendix

[6] UK – Great Britain including Northern Ireland.

3.

Global Trends and Environmental Impact of Land Use

3.1 CLIMATE CHANGE THROUGH THE CONVERSION OF NATURAL ECOSYSTEMS

Importance of forests as carbon sinks and a source of raw materials

Forests provide many services, both at a national and at a global level. They are habitats for an estimated 80 % of land flora and fauna and therefore decisive for the conservation of global biodiversity (UNEP, FAO, UNFF, 2009). Around 1.6 billion people, including above all indigenous peoples, depend on forest ecosystems to provide their natural life-support systems, primarily food and shelter (UN, 2011). Progressive global deforestation, forest degradation and the increasing fragmentation of forests are destroying these natural habitats and environments, often irreversibly (FAO, 2011). Forests also function as buffer zones and provide protection. At a national level, forest ecosystems help to control the climate. They filter and store precipitation, thereby making an important contribution to the water supply, and they offer protection against floods, erosion and avalanches /rock fall (UNEP, FAO, UNFF, 2009). Forests are also a decisive chain link in the global carbon cycle. An estimated 283 gigatonnes (Gt) of carbon are stored in the living biomass alone, plus 38 Gt globally in forest deadwood (FAO, 2011). Including the carbon contained in the uppermost 30 cm of the topsoil and the coarse woody debris (around 317 Gt), the carbon contained in global forest ecosystems is estimated to amount to around 638 Gt in total. This is more than all of the carbon contained in the atmosphere (FAO, 2011).

> Progressive global deforestation and forest degradation is also one of the major sources of CO_2 emissions, accounting for approx. 18 % of global emissions.

The rising demand for wood due to the increasing replacement of fossil raw materials intensifies the productivity pressure forests are subjected to, unless the demand for wood for other uses declines at the same time. This increased pressure harbours risks, from overuse to the deforestation of already depleted areas or the first time use of primary forests. Overuse leads to a significant reduction of forest efficiency, particularly with regard to nutrient cycles and biodiversity conservation (cf. e.g. EEA, 2008; Meiwes, et al., 2008; SRU, 2012). Deforestation or forest clearance also lead to erosion, causing the loss of fertile soil, which in turn leads to water being contaminated with nutrients, from inland waterways all the way to the oceans.

The carbon stored in the forest biomass through photosynthesis, which is transferred to the soil and can remain sequestrated there in the humus or, under anaerobic conditions in the form of peat, over a period of several hundred to one thousand years (carbon sink). Respiration, fermentation, harvest, fire and other activities cause the carbon that is stored in the biomass to be released again (source). If the sequestered CO_2 exceeds the volumes released, the respective area is considered a net CO_2 sink, and vice versa. A store is therefore always also a potential source.

Progressive global deforestation and forest degradation is therefore also one of the major sources of CO_2 emissions, accounting for approx. 18 % of global emissions (IPCC, 2007b). As the deforestation occurs mainly in tropical regions with a high proportion of global biodiversity, the need for action is twofold. For example, in 2005, Brazil‘s greenhouse gas emissions due to land use changes and forest exploitation in the Amazonas region alone amounted to around 845 million tonnes of CO_2 (Brazilian Ministry of Science and Technology, 2010). In terms of volume, this comes close to Germany‘s total greenhouse gas emissions, which in 2009 amounted to 912 million tonnes (only around 70 million tonnes more) (UBA, 2011).

The protection of boreal forests is extremly important from the perspective of CO_2 emission avoidance, as their soil is particularly carbon-rich and therefore contains the highest global carbon stores (IPCC, 2000).

Germany's forests, too, are currently at risk of developing from a carbon sink into a carbon source. In 1990, the annual carbon sink capacity of German forests still amounted to around 80 million tonnes. Since then, however, this amount has constantly decreased and is now down to an estimated 25 million tonnes of carbon dioxide (UBA, 2011). One decisive reason for this dramatic reduction in carbon sink capacity lies in the forests' changed sequestration structure. For example, particularly in the wake of Germany's Second National Forest Inventory, the amount of timber harvested every year was gradually brought in line with annual volumes of timber growth. Due to this increase in the timber stock, the existing forests' annual rate of carbon sequestration has clearly decelerated. It is estimated that today, 90 % of the annual timber growth is already being harvested (SRU, 2012).

According to the latest findings by the Thünen Institute (vTI) (Rüter, et al., 2011), the carbon sink capacity of German forests will have declined to 2.1 million tonnes of CO_2 by 2020, assuming the vTI's projection modelling of forest development and timber harvesting potential (WEHAM) BAU scenario. This projects that by 2020, the annual timber harvest should equal the annual timber growth, which will amount to around 100 million solid cubic metres of stock. These figures are also stated in the Federal German government's Forest Strategy 2020 as the targets for 2020 (Bundesregierung, 2011). If the assumptions the scenario is based on turn out to be incorrect or the timber stock is decreased through accelerated use, an approach already demanded by some in order to fill the emerging gap in the supply with raw timber, Germany's forests are at risk of becoming carbon sources, as other scenario calculations (Rüter et al., 2011) show that accelerated use, shorter rotation times and a reduction of timber stocks down to the level of the First National Forest Inventory (1987) would lead to annual CO_2 emissions of 22.7 million tonnes between 2013 and 2020. This reveals a potential conflict between the aims of the forestry industry on the one hand and climate protection goals on the other. The current German Advisory Council on the Environment (SRU) report also addresses this issue quite explicitly and calls for respective measures such as capping forest exploitation or increasing the age of Germany's forest stands (SRU, 2012).

The IPCC also shows that refraining from exploitation or protecting forests contributes more to the avoidance of greenhouse gas emissions than their use (IPCC, 2000). However, the emissions of forests that are already being used commercially still harbour a mitigation potential if they are managed strictly according to sustainability principles and ecological standards (ibidem).

Contribution of farming to climate change
Agricultural land use contributes around 15 % of the total gas emissions responsible for climate change; it is therefore responsible for climate change more or less to the same degree as deforestation. As most of this deforestation is undertaken to gain new agriculturally usable land, farming (including land use changes) is in fact responsible for an estimated 30 % of the global greenhouse effect. It is therefore clear that an 80 % mitigation of GHG emissions will not be possible without a substantial reduction of agriculture‘s contribution. Climate change has a considerable influence on global biomass production as the rising temperatures impact on all of the requisite decisive factors: precipitation, water supply, extreme weather and rising sea levels. Climate change will in all probability lead to diminished yields in Australia, India and parts of Africa. It is not yet clear to what extent this can be offset by the achievement of higher yields in northern Europe, northern Asia and North America (IPCC, 2007).

In a biomass debate context, soil is a decisive climate factor. With a capacity of 2,300 Gt, the soil can store around three to four times as much carbon as the entire global vegetation cover. In Europe alone, 70 billion tonnes of CO_2 are sequestered in the soil. Between 1989 and 1998, around a third of the increase in atmospheric CO_2 due to human activities was caused by land use changes (IPCC, 2007). On the other hand, though, the storage and sequestration of carbon in the soil could even mitigate climate change – and, at the same time, also increase soil fertility.

Climate change will disproportionally affect mostly the developing countries, and the poor in all countries. Existing inequalities will be amplified, particularly with regard to state of health, access to food, clean water and other resources. Especially at risk in terms of being able to secure their livelihood are the smallholders and subsistence farmers living in the lower latitude countries, due to the effects of changing weather conditions, rising sea levels and more frequent and intensive extreme weather events (WBGU, 2007).

3.2 INCREASING PRESSURE ON THE NATURAL RESOURCES

Soil degradation
Fertile and healthy soil is one of the most valuable natural resources available to us. It is not only a prerequisite for food, fodder and renewable raw material production but also provides essential ecosystem services. Soil filters pollutants, thereby protecting the ground water, stores nutrients and plays a major role in biodiversity conservation as the habitat of animals, plants and microorganisms. Worldwide, soils store around three times as much carbon as all trees, shrubs and grasses taken together. As they are the Earth‘s second-largest active carbon reservoir after the oceans, they are of vital importance for the climate. It is important that we use the resource soil diligently, as the amount of arable soil that is available on Earth is limited and it is not renewable – or at least not renewable in human categories of time. The soil reformation rate is extremely slow: It is estimated that it takes almost 4000 years for 20 centimetres of agriculturally usable soil to form (Bai, et al., 2008). It is not always possible for people to actively rehabilitate soils, and it always involves a considerable amount of effort and capital.

Our soils are exposed to a wide range of different risks. These include erosion caused by wind and water, soil compaction, salination or acidification, and the loss of soil organic matter and nutrient depletion, frequently the direct consequence of a soil cultivation that ignores the principles of sustainability.

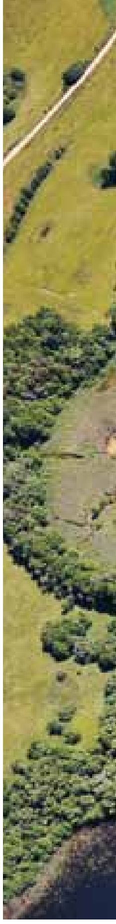
Additional dangers are the contamination of soils with organic and inorganic pollutants, urban sprawl and ground sealing. Ground sealing refers to soil being permanently covered by infrastructure elements (streets, parking spaces) and buildings. Areas affected by urban sprawl are lost to agriculture for the foreseeable future, and soils subjected to ground sealing lose most of their natural fertility for some time to come. What is remarkable is that the effects of urban sprawl and ground sealing are progressing globally, not just in areas subject to rapid population growth but also in countries where the population remains constant or is even declining.

In Germany, for example, the population declined between 2004 and 2010, yet over the same period, an additional 100 ha a day were lost to urban sprawl. Although this volume has gone down to currently just under 80 ha a day due to demographic changes and recent economic developments, this is still too much and also still far exceeds the target of 30 ha a day set by the federal German government for 2020. Around 38 % of the areas subject to this new urban sprawl are also built over or sealed, thereby losing their natural fertility beyond recovery.

It is difficult to assess the exact global situation with regard to soil degradation due to insufficient data. The data situation is likely to improve once the project ‚Economy of Land Degradation‘ has been completed. It was initiated in cooperation with the "Gesellschaft für internationale Zusammenarbeit" (GIZ, the German society for international cooperation) in 2012 on the basis of a publication by Nkonya et al. (2011).

We can safely assume, however, that soils are in an alarming state worldwide, and that the outlook is worrying. In the Millennium Ecosystem Assessment Report, the United Nations estimated that between 1950 and 1990, a third of all fertile soils worldwide were already affected by degradation. Globally, the main cause was erosion due to water and wind impact (Oldeman, 1994). Farmland erosion rates are one to two degrees above the erosion rates in areas covered by natural vegetation and also exceed the natural soil reformation rate by one to two degrees (Montgomery, 2007). Total annual soil loss due to all forms of degradation is estimated to amount to around 10 million ha (Pimentel, 2006).

Soil degradation already affects 1 – 1.5 billion people in the world, i.e. between 15 and 20 % of the world population (Bai, et al., 2007). Soil degradation significantly lowers the potential farmland yield. It is estimated that in Africa, yield losses due to soil erosion average 8.2 % (status quo 1995); assuming constant erosion rates, the yield potential is likely to have declined by as much as 16.5 % by 2020 in Africa (Lal, 1995). This adds additional fuel to the vicious circle of poverty, overuse and soil degradation. The links between poverty and soil degradation are already apparent (FAO, 2011c). Poverty and soil degradation, and also climate change, therefore have an additional adverse effect in terms of farmland productivity pressure.



Loss of biodiversity

According to various sources, there are between 5 and 30 million species of plants and animals worldwide. The majority of these live in the forest, including threatened species or species that are almost extinct. Although tropical rainforests now cover only 6% of the land surface, they are still the habitat of 50% of all global species. As yet, little is known about the species interaction in these rainforests, and they still harbour countless unknown species. The currently available data on biodiversity in cultivated soils (soil animals, fungi, algae and microbes) stems from only a few individual areas. European studies show a remarkable similarity of food network characteristics in relation to land use intensity (Hedlund et al., 2012).

In order to meet the increasing demand for raw materials produced by means of agriculture and forestry, semi-natural and species-rich habitats are directly and indirectly converted into pastureland or plantations. The conversion of natural and semi-natural ecosystems, including primary forests, motivated by farming and forestry needs is considered the main reason for the increasingly declining number of species. When the links between interconnected ecosystems are broken by large-scale deforestation, leaving only small islands of primary forests, the species interaction networks collapse and irreversibly accelerate this decline in the number of species. Due to the ploughing up of grassland and fallow land to increase biomass production, Europe is also experiencing further biodiversity loss. However, the increased intensification of agriculture and forestry productivity also leads to the loss of biodiversity and ecosystem services. The high input of pesticides and fertilisers, which affects the environment well beyond the actual application sites, endangers the continued existence of many semi-natural ecosystems. Restricting these agrochemical flows is therefore an important step towards the protection of biodiversity.

Biodiversity is also strongly and increasingly affected by climate change. It looks certain that biodiversity will severely decline overall due to the effects of climate change. This will particularly affect species living in semi-natural biotopes with little ability to spread further afield or whose habitats are not interlinked, as they cannot simply move on to somewhere else.

Humans determine the species composition on farmland. Due to the annual growing cycles, cropland offers many opportunities for adaptation to a changed climate by means of suitable crop and variety selection. Short

lifecycles (a few months or years) are also prevalent in livestock farming. Increasing the diversity of animal and plant species and their genetic profiles improves the chances of meeting the challenges posed by climate change. An extensive agrobiodiversity that includes, for example, disease or drought resistant, flood tolerant or in other ways stress resistant crop varieties and agricultural ecosystems lowers the risk of failed harvests. Alternative crops also unlock new exploitation methods.

A primary task is therefore the conservation and expansion of the spectrum of economic crops and farmed animal species and their intraspecific variability. This is best pursued in situ, as it is the fastest way for animals and plants to adapt to changed environmental conditions. Using genetically modified plants to increase biomass yield is not a likely answer. They are usually resistant against only one specific or a handful of stress factors, and unable to respond flexibly to changed environmental factors. Their use is also controversial, as too little is currently known about their impact on biodiversity. Invasiveness is another aspect to be considered when cultivating non-native varieties.

Furthermore, the implementation of the International Treaty for Plant Genetic Resources for Food and Agriculture should be pursued synergistically with UNCCD, CBD and UNFCCC (Vohland, 2008).

Competition for water

The location-specific availability of water is one of the restrictive factors when it comes to biomass production. Farming currently consumes most of the available global water supply; 70 % of all water consumed today is used for irrigation, the largest proportion of this in the so-called developing countries. The high water consumption for agricultural uses competes with the need for drinking water and an increasing industrial demand for water.

The demand for water for irrigation in order to produce food by means of agriculture will rise considerably by 2050 as the world population grows. The growing world population and the expected negative impact of climate change on regional water supplies will even increase the competition for water in future. Conflicts will above all come to a head in regions where water resources are already almost depleted today and/ or where the inhabitants already suffer a shortage of drinking water due to unmanaged water distribution or inadequate water management. In Southern, East and Southeast Asia, most of the potential for irrigation-based farming has already been fully tapped, likewise in the Middle East.

Considering the frequently to a large extent already almost exhausted local water resources, stated capacities for an expansion or intensification of biomass cultivation should therefore be carefully and critically examined. The large-scale establishment of new production sites as well as land use changes affecting extensive areas have repeatedly led to ‚water wars', caused by the fact that local water resources do not extend to meeting the demands of additional use, even if there is additional land which could potentially be used. Diverting water into new large-scale irrigation systems from the upper reaches of rivers, for example, or the creation of groundwater sapping eucalyptus plantations frequently leads to too little water being available to the local population for their use, thereby threatening their life-support systems. This kind of excessive appropriation of local water resources, whether caused by agriculture and forestry projects or even by a commercial exploitation of drinking water supplies, is increasingly viewed critically and frequently referred to as ‚water grabbing'. In this respect, the potential access to water resources is usually the basis for large-scale investments in land and in regions with limited water resources, and the actual decisive criterion.

> In Europe, the agricultural impact leads to a large number of surface and ground waters failing to reach a good standard.

However, the production of biomass not only depends on usable water; it also contributes directly to water contamination through the intensive use of fertilisers and pesticides. Nitrogen and phosphorus farming inputs cause the worldwide eutrophication of oceans and surface waters; nitrate from nitrogen fertilisers accumulates in the groundwater. In Europe, the agricultural impact leads to a large number of surface and ground waters failing to reach a good standard. Eutrophication and acidification are a threat to the hydroecology, but they have also had an adverse effect on water used for other purposes, for example drinking water, as impaired water quality is another factor that leads to a reduced water supply.

The future developments in terms of water consumption other than for farming purposes, water availability and climate change could develop into a serious global crisis. A shortage of water could have significant negative impacts on food production, food security, health and environmental quality.

Increasing energy and raw material shortages
Resource-intensive agriculture not only consumes fossil-based energy for the mechanisation and motorisation of the respective processes; most of the resource-consumption in this sector is related to mineral fertilisers, primarily nitrogen (N), phosphorus (P) and potassium (K), and the equally resource-intensive production of pesticides.

The extremely high agricultural yield increases achieved in the past century were accompanied by a drastically increased nutrient and energy input in agricultural production systems. Huge amounts of external energy and nutrients were imported into formerly regionally mostly closed energy and nutrient cycles. This development was especially pronounced as far as energy is concerned: Besides the actual primary energy source for the production of biomass, i.e. sunlight, there has been an increasing direct (through fuels, lubricants and electric power consumption) and indirect (through the manufacture of fertilisers and pesticides) input of fossil energy. In Germany, the proportion of costs related to energy (even excluding pesticide manufacture) for conventional maize and wheat cultivation now amounts to around 30 % of the total costs; in fact the indirect energy costs usually considerably exceed the direct energy costs (Klepper, 2011). Biomass production must increasingly regain independence from this huge external energy input, not only because of the damages caused to the environment due to this excessive input increase (Tilman et al., 2002) but also in view of the finiteness of fossil fuel sources and the fact that they are harmful to the climate. Organic farming can serve as a role model in this respect. Although organic farming frequently demands higher direct energy inputs, the indirect energy input is considerably lower due to the non-use of mineral fertilisers and pesticides. Overall, organic farming is therefore more energy-efficient than conventional farming (Mari and Changying, 2007; Williams et al., 2006).

A closer look at the nutrients used reveals that particularly the use of phosphorus should be viewed critically as it is not only an indispensable but also a finite resource. Based on a consumption estimated to increase by around 2.5 – 3 % annually (Gilbert, 2009), the global phosphorus reserves will probably be fully depleted in 50 to 125 years (Cordell, Drangert et al. 2009; Gilbert, 2009). The first sources to dry up will be the high-quality deposits, which would lead to the increasingly laborious exploitation of low-quality deposits. This not only increases input costs but also bears the risk of simultaneous inadvertent dangerous pollutant (cadmium, uranium) input (KBU, 2012). Urgent action is required to overcome the imminent shortage of phosphorus, which is particularly vital for food production and farming. Solution approaches are more efficient use (e.g. optimised extraction and input, lower application rates and crop rotation methods) and recycling, for example recovery from waste water, sewage sludge, sewage sludge ashes and animal by-products. However, this has so far been technically implemented on a large scale and also financially viable in only a few cases. Further efforts must be made to address and solve the existing technical problems and improve the financial viability of P-recycling.

> A closer look at the nutrients used reveals that particularly the use of phosphorus should be viewed critically as it is not only an indispensable but also a finite resource.

3.3 NON-SUSTAINABLE CONSUMPTION AND DIETARY PATTERNS AS DRIVERS

The existing consumption and dietary patterns in the industrial and also increasingly in the newly industrialising countries have generally been globalised; they rely on massive raw material and land imports from the less developed countries (‚piggyback regions', see Ch. 2.4). They cause extensive greenhouse gas emissions, soil degradation, environmental burdens as well as nitrogen emissions in soils and water and contribute directly and indirectly to the destruction of biodiversity through land use changes.

Imported protein feed and mineral nitrogen fertilisers in industrialised agriculture massively destabilise the nitrogen cycle. Worldwide, around four times the sustainably acceptable volume is converted into reactive nitrogen; agricultural practices are responsible for much of this. The overburdening of the nitrogen cycle leads to considerable damages to the environment on an international scale, and substantial costs.

The Ecological Footprint of dietary habits

The indicator ‚Ecological Footprint'[7], a comprehensive approach to the assessment of the ecological sustainability of foodstuffs, measures the volume of biologically productive land and water necessary to produce all of the resources consumed by an individual, a country etc., including waste absorption costs. The Ecological Footprint covers some of the main environmental issues related to the production of foodstuffs[8]. According to calculations by Meinhold (Meinhold, 2010) the Ecological Footprint of various foodstuffs differs vastly, depending on whether they are animal- or plant-based. Above all, meat and highly concentrated foodstuffs such as cheese have a sizeable Ecological Footprint. Plant-based products (for example fruit, vegetables) generally leave a very small Ecological Footprint. Animal-based foodstuffs require considerably more resources of all kinds and generate more waste.

The average meat consumption level varies greatly between industrialised and developing countries (data base 2005): The industrialised countries, whose inhabitants represent only 20 % of the world population, consume approximately 40 % of all meat produced worldwide, with an average of 82 kg/per capita/annum. In contrast, meat consumption in the developing countries averages at 31 kg/per capita. India has the lowest meat consumption with 5.1 kg/per capita/annum, an amount which has risen only slightly since 1980. Sub-Saharan Africa is the only region where meat consumption has not gone up between 1980 and 2005; in fact, it has declined by around 1 kg/per capita/annum to 13 kg/per capita/annum over this period. According to FAO projections, global meat consumption will rise by around 85 % by 2050, in the developing countries to an average 44 kg/per capita (FAO, 2009a).

A per capita comparison of meat consumption (Schmidt, et al., 2010) between the EU member states shows that Germany's meat consumption, with 88 kg/per capita/annum lies above the EU average (82 kg). Front runner in the EU is Denmark (111 kg/per capita), followed by Spain and Poland.

TABLE 4: Food consumed by the population of Germany per capita in 2008

	Consumption in Germany (in kg/per capita)
Wheat products	88.3
Meat products	88.2
Fresh dairy products/total dairy products	103.4
Fruit and vegetables	120.3
Potato products	62.1
Sugar products	47.3
Pulses	< 1

Source: statistical yearbook on nutrition, agriculture and forestry, 2011, p. 492 ff

On average, the inhabitants of Germany cause 11 tonnes of greenhouse gas emissions each every year, of which 1.5–2 tonnes can be allocated to the food they consume (Schächtele, et al., 2007). More than 40%, by far largest proportion, is caused by the consumption of animal-based food, whilst plant-based food causes only 8% (von Körber, et al., 2009). Overall, livestock farming for food production occupies extensive areas whilst also causing considerable environmental damage.

Meat consumption per capita is considerably higher in the industrialised than in the less developed countries. Considering that consumption levels once differed widely, meat consumption has gone up considerably everywhere around the world, except Africa, over the past few decades. The rising demand for fodder and feed for intensive livestock farming calls for additional land.

Releasing land by changing dietary habits

On the basis of various studies, this section analyses whether reduced meat consumption would affect global land availability. Is assumed that a reduction of the meat consumption in the industrialised counties, currently an average of 82 kg/per capita/annum (225 g/day) would not only bring health benefits and have a positive effect on the environment but also release land which could be used for other purposes.

Various studies have attempted to quantify the possible effects reduced meat consumption in the industrialised countries would have on the global food market (demand and supply mechanism, changed pricing structures on the meat and grain markets, effect on substitute foodstuffs and the extent of land use changes and land released etc.). The diverse range of the specific issues addressed and above all of the scenario assumptions, projection horizons, periods under review and exploration depth, and of the methods and models applied lead to widely differing results with regard to the extent of land released. Deutsche Biomasseforschungszentrum (DBFZ, 2008) calculations, for example, resulted in an extent of land released through a change in dietary habits that lies ten times or even more above the results of the other studies looking at reduced meat consumption. Due to the extremely high variance of the results, further research is needed in this respect.

Three selected studies and one qualitative analysis are briefly introduced below, and their respective results summarised.

Rosegrant et al. (1999):

Projection horizon 2020, projections based on the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) of how developments will affect global agricultural markets up until 2020. Reference scenario plus scenario with 70 % meat reduction in the industrialised countries.
Results: Reduction of global meat prices by 20 – 30 % and supply by 13 %, and 13 % increase of demand for meat in the developing countries. Feed grain prices go down up to 10 %, rice price constant, slight increase of wheat price. Grain consumption per capita in the developing countries remains largely constant, marginally positive effect on calorie consumption in the developing countries.

Stehfest et al. (2009):

Projection horizon 2050, method applied Integrated Model of Global Environmental Change (IMAGE), scenario a uniform global meat consumption of 34 kg/per capita/annum (marginally above the average in the developing countries).
Results: Slight increase of meat consumption in the developing countries, more pronounced decline in the industrialised countries, overall global decline in meat consumption by 37 % in 2050 in comparison to reference. Globally 42 % less pastureland and 9 % less cropland used for agricultural purposes.

Wirsenius et al. (2010):

Projection horizon 2030, based on the ALBIO (Agricultural Land use and BIOmass) model; in this scenario, 20 % of global ruminants are replaced by pigs and poultry.
Results: Globally 14 % less pastureland and 2.3 % less cropland used for agricultural purposes. Further scenarios with reduced meat consumption in combination with reduction of postharvest losses.

The qualitative analysis by **Grethe et al (2011) as well as Duman (2011)** – based on FAO (FAO, 2009b) studies and data – examines the effects of a 30 % reduction of the OECD countries' entire meat consumption on global food balances. Based on a meat consumption of 102 million tonnes (225 g/per capita/day) in the OECD (base year 2005/07), it is reduced by 30 % (overall reduction 30.6 million tonnes) for all types of meat. The net effects of a reduced meat production and the respective dietary adjustments, such a lower demand for pastureland but an additional demand for cropland for economic crop production, are calculated with the aid of a partial economic equilibrium analysis model consisting of isoelastic demand and supply functions for a set number of plant- and animal-based products and the respective market conditions.

Result of the calculations: A 30 % meat reduction in the OECD countries would release 30 million ha of cropland. The authors do point out that the quantification of the effects of a reduced meat consumption is extremely complex, and that these effects depend strongly on the various supply and demand interactions in a globalised agricultural market system. A decline in the demand for meat in the OECD countries impacts on international food prices and agricultural inputs, which would in turn have a retroactive effect on the production processes of a number of agricultural products. The above stated results therefore tend to apply to the extent of land released by a 30 % meat reduction in the OECD countries.

In 2012, the WWF Germany commissioned a study that examined to what extent a healthier diet or an increased awareness of dietary habits would affect Germany's Ecological Footprint (Noleppa, et al., 2012). Both scenarios, a healthier diet as well as an increased awareness of dietary habits, show that changing consumption behaviour could potentially lead to the release of a considerable extent of land.

Summary of the results of the studies analysed: A reduced consumption of meat (particularly beef) not accompanied by an overall reduction of calories consumed still leads to a lower demand for agricultural land. Pastureland would be affected to a far greater extent than cropland. The impacts on global agricultural produce prices and on the food demand in the developing countries reveal a high elasticity of demand for meat and a low elasticity of demand for grain. In the developing countries, low meat prices lead to a higher demand and improved nutrition (more protein).

A 30 % reduction of the meat consumption in the OECD countries, in our view realistically achievable, would release approx. 30 million ha of net cropland globally (according to Grethe et al., 2011, assuming existing production types), a potential area that is almost three times the size of Germany's present cropland, and which would equal 2 % of global cropland. Globally, the lower demand for meat in the OECD countries would lead to lower meat prices, the demand for fodder and feed and their prices would go down around the globe, and the meat consumption in the developing countries would go up.

High level of food losses and waste

According to a recent study commissioned by the FAO (Gustavsson et al., 2011), around a third of the food produced for human consumption worldwide is lost postharvest along the chain from production to end consumer (Gustavsson, et al., 2011). Postharvest food losses amount to approx. 1.3 billion tonnes per year, that is more than half of the grain harvested globally in 2010 (approx. 2.5 billion tonnes in 2010) (FAO, 2010b).

Postharvest food losses consist of losses incurred from the first stage of agricultural production right through to the end consumption in households. Postharvest losses amount to between 170 – 300 kg in the industrialised and developing countries. In the poorer countries, the losses mainly occur in the early and interim stages of the supply chain (production and distribution), whilst in the industrial countries, the losses sustained during production and distribution are augmented by significant additional losses at the end consumer stage. In Europe and North America, these postharvest food losses incurred through consumer behaviour amount to 95 – 115 kg per capita, whilst they amount to 6 – 11 kg/per capita and annum in Southeast Asia or (sub-Saharan)Africa (Gustavsson et al, 2011).

> Food losses amount to 1.3 billion tonnes per year, that is more than half of the grain harvested globally in 2010.

The huge amount of food ruined every year postharvest through losses and waste is ultimately an important driver of increasing resource shortages and environmental burdens; it must therefore urgently be contained.

3.4 OPTIONS FOR ADAPTATION TO A GROWING DEMAND

The central causes for the growing demand for agricultural commodities are the constantly growing world population's increasing need for essential material goods, the persistently resource-intensive consumption patterns in the industrialised countries – in particular the high proportion of animal-based foodstuffs – and their spread to the newly industrialising countries, and also the primarily politically induced expansion of biofuel production based on renewable raw materials.

> Degraded land often is a resource that is vital for the survival of the poor in rural regions.

On the one hand, the emerging quantity challenge can be met by pursuing the correlational increase of the supply, and on the other, through a more efficient and needs-oriented use and distribution of the available volumes of agricultural produce and forest products (combating hunger). Fundamentally, a quantity increase on the supply side can be achieved by expanding the production area, and/or through more intensive farming.

We agree with the German Scientific Advisory Board on Agricultural Policy[9] (WBA, 2012) that the situation requires government intervention, and that this is justified, as the use of natural resources through agriculture creates external effects and concerns global public commodities, and the political prioritisation of the issue of food security is called for on humanitarian grounds.

Increase of supply through farmland expansion
The debate on the expansion of farmland currently attracts much controversy. Due to the diversity of the respective local impacts, expansion must be assessed on a case-by-case basis. Expansion frequently has a significant adverse effect on the ecological value of the respective region, see for example the drainage and deforestation of the peat swamp forests in Indonesia and Malaysia[10]. However, initially, the conversion of natural grassland (even after long periods of non-cultivation) is usually also achieved at a considerable environmental cost, such as the release of carbon sequestered in soils and biomass or the destruction of the natural habitats of species potentially in need of protection or certain ecosystem functions. Foley et al. (2011) conclude that the existing environmental risks alone are a sufficient reason for refraining from a further expansion of farmland.

Use of devalued and marginal sites – the ‚degraded lands' debate
Whilst the conversion of ecologically valuable ecosystems for agricultural purposes is generally considered questionable, the redevelopment of land lying fallow for reasons of agricultural economics or marginal or degraded land is a less difficult issue. It is hoped that the use of these marginal and degraded lands will in some cases serve to mitigate land use conflicts.

Degraded land is characterised by the long-term loss of ecosystem functions and services caused by upheavals from which the system is unable to recover without intervention. The definition of land as marginal land, on the other hand, is determined by its worth in terms of agricultural production: Land which cannot be cost-effectively farmed under the existing framework conditions and with the existing cultivation techniques is referred to as marginal land. However, sometimes, these categories are also applied to extensive areas of land erroneously (Wicke, 2011).

The bandwidth of the global extent of degraded and marginal land stated in the respective reference material is extremely wide, ranging from 300 million to 2.5 billion ha (Fritsche et al., 2010). According to Wickes (2011), the values for the potential global bioenergy yield from these areas as stated in the respective reference material range from 8-147 EJ.

The general assumption that degraded lands are currently not in use and that their reuse bears no ecological risks cannot be applied across the board. In reality, degraded land is often a resource that is vital for the survival

of the poor in rural regions, in particular in areas where land ownership is not formalised. Degraded land is used to cultivate crops but also extensively as pastureland and for the collection of firewood (Wicke, 2011). The ecological impact should also be carefully considered. For example, degraded soils are more susceptible to erosion and water stress, especially if the species of farm animal selected, the techniques and the practices have not been adapted to the land's vulnerability. In some regions, open, poor land is also often a diminishing habitat for a wide range of endangered species.

However, if care is taken to examine the local conditions and potential ecological and socio-economical impact beforehand, the recultivation of such areas can also be a sensible and valuable option. Certain crops and cultivation techniques, for example, can stop erosion and increase soil fertility. Land with an extremely high salt content, for example due to irrigation mismanagement, where conventional crops will not grow can be restored through the cultivation of special salinity tolerant varieties (see biosaline agriculture, Ch. 3.4). I.e. in these cases, unlocking the potential could be accompanied by multiple local ecological and socio-economical benefits. However, this usually calls for considerable infrastructure and technology investments that possibly depend on inter-governmental agreements, development cooperation projects and trade partnerships, a fact which must be taken into account in any potential assessments.

Although generally speaking, pastureland should not be converted to farmland for ecological reasons. Grass covered topsoils are immense carbon stores in the form of the organic matter contained in the soil substance. The conversion of pastureland transforms these carbon sinks into a source of greenhouse gases which would have to be added to the input-related farming emissions.

It should also be considered a given fact that in many places, the local water supply is a limiting factor when it comes to farming marginal lands (and increasing their productivity). Nutrients could be transported to the respective lands in the form of synthetic fertilisers – possibly despite an awareness of the adverse effects their use has on the environment. This option is usually not a viable one in regions where water is short. Artificial irrigation also bears risks such as the depletion of the major regional bodies of water, the contamination with fertiliser and agrochemical residues and deficits elsewhere.

In short, this means that the (optimistic) potential estimates in the course of the degraded lands debate should be viewed with not inconsiderable doubt due to existent but not recognised usage, local production factors, infrastructural difficulties, ecological risks and capacities, the local availability of the requisite workforce etc. The necessary analysis depth cannot be achieved by top-down approaches. Due to these deficits, the expectations with regard to their contribution to the supply increase should be pared down to a realistic quantity and not be relied on as a sound potential capacity, for the time being. Regardless of this, various benefits can accompany their exploration and sensitive restoration.

Increase of supply through land use intensification

The second basic approach to boosting the supply quantities lies in increasing the productivity of the land currently used as farmland. The potential that could be unlocked through closing the yield gap (the difference between the potential and actual yield of a piece of land) would probably be huge. Foley et al. (2011) assume that it would be possible to grow global food and fodder production by $2.8*10^{15}$ kcal (28 %) if the current yield levels of 16 important economic crops could be raised to 75 % of the potential yield on lands with a pronounced yield gap. If an increase up to 95 % of the potential yield were to be achieved, it would even be possible to increase productivity by 58 %.

Productivity increases as one way of being able to meet the growing demand for biomass in future could and should also be considered as an alternative strategy to land expansion, in view of the inherent precariousness of any estimates regarding land potential and with the objective of risk minimisation.

Although fundamentally, many practices for increasing productivity also harbour massive risks for the environment, depending on the respective local physiogeographic conditions (see also 3.2.). The respective crops, techniques and cultivation systems must therefore be developed and implemented with the local natural conditions in mind. In this respect, the practical adaptation process to the specific conditions can be calculated even less from a global perspective than global estimates with regard to land potentials and land use claims. In fact, a positive development towards increased land productivity requires a realistic assessment of the additional yields to be realised locally on the basis of adapted crops and the given restrictions in terms of the requisite resources.

From a global perspective, it seems basically advisable to forge ahead with the pursuit of increased productivity wherever a low factor input promises the most significant growth in yields. This particularly applies to Africa and parts of Latin America and Asia, where high additional potentials have been proven to be possible even with a low input of external means with the aid of a knowledge-based restructuring of the existing cultivation systems in an agriculture that consists primarily of smallholdings.

Land recultivation, crop improvement research

For a number of years, many hopes have been pinned on another approach, the breeding and cultivation of salinity tolerant plants capable of thriving in salinised soils (also plants suitable for aquafarming) and fit for human consumption or use as feed, fodder or fuel. There is a wide spectrum of these kind of plants, the so-called halophytes, which includes annuals as well as perennials and also shrubs and trees. Just as diverse as their range are the structural and physiological changes halophytes have managed to make in order to adapt their metabolisms to an overabundance of sodium and chloride ions. By crossbreeding existing plants, crop improvement researchers are working on the simultaneous introgression of more than one characteristic; however, this has so far proved difficult. According to the opinion of leading experts, we still have a long way to go before such crops as salinity tolerant rice or salinity tolerant grain will be available on the market (Rozema, et al., 2008). Nevertheless, generally speaking, salinity tolerant plants appear to be a promising option in terms of their future cultivation for the provision of a wide range of economic crops, particularly also plants for industrial and/or energy use. Although this field still calls for extensive further research (Rozema, et al., 2008), this research should indeed be pursued further.

Land investments/land grabbing

Essentially, foreign investments in the agricultural sector in developing countries are not a modern phenomenon; they were already the case in colonial times. How these investments in agricultural land should be viewed, however, depends entirely on their nature, i.e. who profits from them and what were the conditions that led to them being made.

Particularly in recent years, the international agricultural research in the context of the food security debate has emphatically highlighted the fact that investments into the agricultural sector of developing countries are a sorely needed necessity. Fundamentally, the reshuffling of the agricultural production factors manpower, soil and capital also represents an opportunity to drive regional development ahead. International investments in agriculture in developing countries can unlock opportunities, provided they take basic human rights and social, economic and ecological principles into account. The current acquisition of sometimes staggeringly huge areas of land, referred to as positive development promising farmland purchases or agricultural investments by its supporters, is often referred to as ‚land grabbing' by its critics, due to the frequently involved infringement of (human) rights.

Land grabbing in the last decade accounts for more than 230 million hectares, i.e. an area of the size of North West Europe.

The growing global demand for the resource land has increasingly attracted investor interest, particularly since the food crisis 2007/2008. On the one hand, government and private sector actors are making these investments in order to secure the local population's agricultural produce/biomass supply; on the other hand, price increases have turned the land itself into a lucrative asset and speculation property. The latter is mainly proven by the fact that so far, only around 20 % of the respective investment projects have actually used the respective land in a productive way (Deininger, et al., 2011). Sub-Saharan Africa is generally considered the most important region targeted by these dubious investments, or so-called land grabbing. However, the demand for land has also boomed in Eastern Europe. Land grabbing mainly affects countries with weak institutions suffering from bad governance and widespread corruption. According to the GIZ[11], over 227 million ha of land in developing countries, i.e. an area the size of North West Europe, have already been sold or leased over the past decade, or licences for their use have been granted, or the respective contracts are currently under negotiation. Over 130 million ha of this land are located in Africa. The lack of transparency and the secrecy surrounding these deals lead rise to the suspicion that the true extent of global land trade is much higher than that.

The actors are mostly international financial and the agribusiness sector investors from countries such as China, Saudi Arabia, Brazil, the United Arab Emirates, South Korea, India etc. (Anseeuw, 2011). Estimates regarding the extent of land grabbing vary greatly, and they are fraught with uncertainties, not least due to the lack in transparency when it comes to the respective contracts. The FAO's High Level Expert Panel (HLPE) estimates that international investors are currently involved in the acquisition and leasing negotiations for a total of 50 – 80 million ha of land (HLPE, 2011).

According to a generally increasing number of reports and respective information, many of these land purchases bring considerable disadvantages to the countries concerned and the local population. The consequences of land grabbing are extremely wide ranging and numerous cases (in Asia, Africa and Latin America) are well-documented: Local communities are broken up, many people lose access to the resources they depend on for their survival, not only pasture- and cropland but also water is grabbed. Land grabbing exacerbates the food insecurity experienced by the vulnerable sections of the population. Land grabbing can also cause various environmental problems. (Kaphengst, 2012).

The phenomenon of land grabbing has finally come to the international public's attention, thanks to news coverage about the negative impact on the people concerned and numerous protests in the respective countries. Various international processes are currently addressing the issue of defining regulations for these kind of land transfers.

With the UN Committee on World Food Security (CFS), established by the FAO in 2008, the process of defining voluntary guidelines with regard to land tenure under consideration of the interests of the various stakeholders to ensure food security and nutrition for all was set in motion. By means of a comprehensive

participatory process, the UN Committee on World Food Security (CFS) has developed Voluntary Guidelines on Responsible Governance Tenure of Land, Fisheries and Forests in the Context of National Food Security. These were completed in 2012. They represent the first international instrument that addresses this politically sensitive issue as a multi-stakeholder platform, and are primarily aimed at governments, representatives of private sector associations and the civil society. The federal German government (Federal Ministry for Economic Cooperation and Development, BMZ, and Federal Ministry of Food, Agriculture and Consumer Protection, BMELV) actively supports this process. The guidelines relate extensively to human rights; they represent an international standard for a responsible land tenure policy. They are not legally binding, nor do they contain any sanction mechanisms, yet their impact should not be underestimated (Kaphengst, 2012).

UNCTAD, Japan, the World Bank and the FAO also established the initiative PRAI (‚Principles for Responsible Agricultural Investment that respect Rights, Livelihoods and Resources') subsequent to the 2009 G8 summit. This initiative is aimed at implementing a legal and political framework for agricultural investment, and also hopes to provide some guidance to investors determined to act socially responsible. Due to aspects such as the fact that the principles presented so far do not directly refer to human rights issues, the EU considers their content inadequate and also believes that important stakeholders were not involved in their design to the extent they should have been.

> Land grabbing exacerbates the food insecurity experienced by the vulnerable sections of the population.

There is also a number of further, non-governmental initiatives and processes. It remains to be seen how effective these voluntary instruments are. Still, one positive aspect is that they serve to raise public awareness, and highlight land grabbing and investments in land in the poorer regions of the world as a pivotal, important ethical issue.

[7] The Global Footprint Network defines ‚Ecological Footprint' as follows: ‚A measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices.' It has thus been scientifically proven that humanity is overusing Earth. The Ecological Footprint refers to the capacity of the Earth's system and indicates how much biocapacity, measured in global hectares, is necessary for the provision of the resources consumed by one nation, one region, one household or one individual, and for the absorption of their waste. The Ecological Footprintis therefore an indicator of Sustainability, or of non-sustainability in the case of ecological deficits. The concept was initially formulated in 1994 by Rees and Wackernagel.

[8] However, the method is still far from perfect and therefore still leaves room for improvements. As yet, it has not been possible to take one important environmental aspect related to food production, GHG emissions other than CO_2, into account.

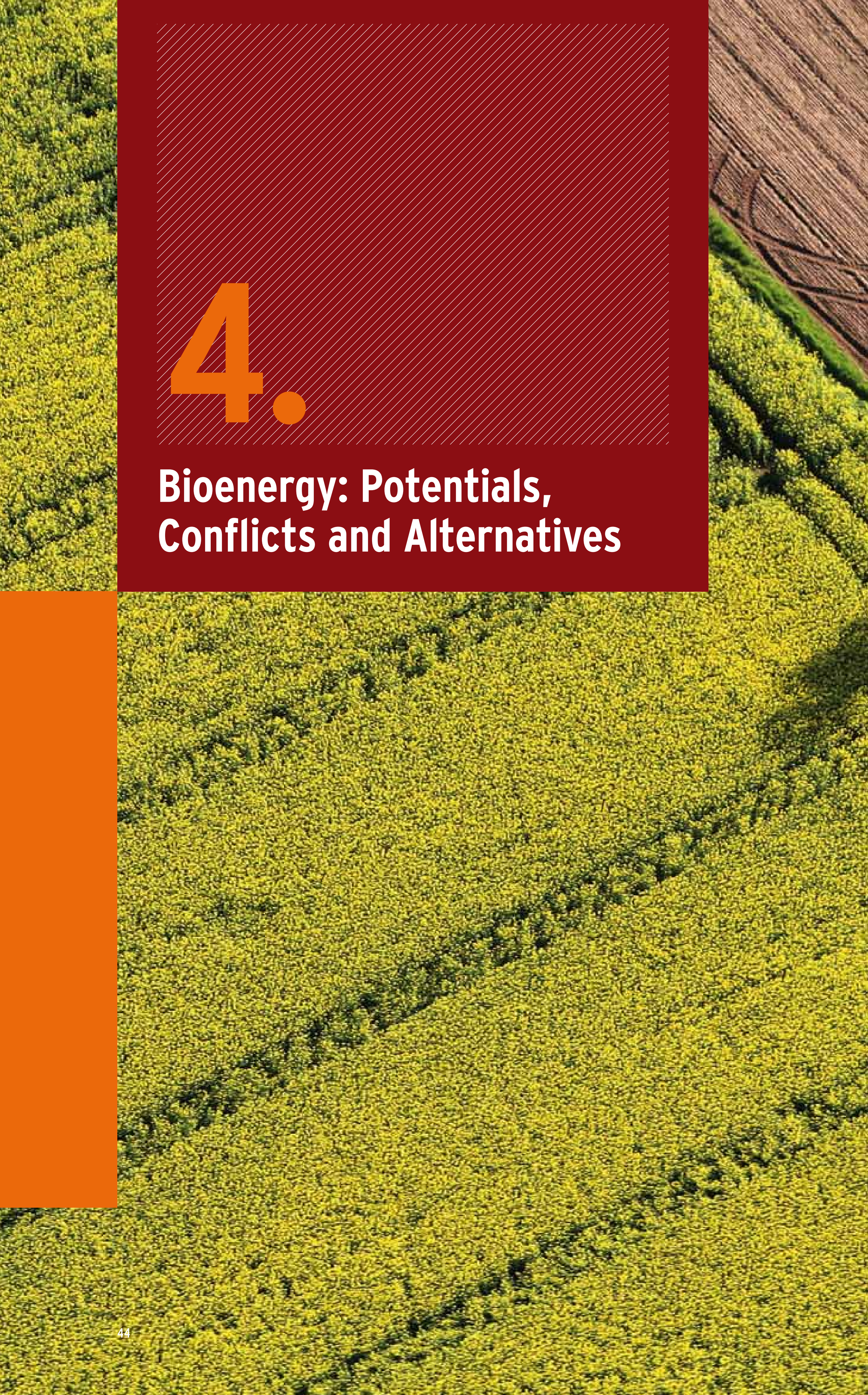
[9] Of the Federal Ministry for Consumer Protection, Food and Agriculture

[10] The expansion of farmland in Indonesia over the past 30 years has led to a 30 %, or 40 million ha, reduction of forest cover; in Malaysia, to a 20 % loss of forest cover, or 5 million ha (Wicke, 2011).

[11] GIZ lecture on World Soil Day, 6 December 2011, Berlin

4.

Bioenergy: Potentials, Conflicts and Alternatives



4.1 EXPANSION OF MODERN BIOENERGY USE

Present role of bioenergy in the energy mix
Renewable energies already met a sixth of the global final energy demand in 2009. With a total contribution of around 12.3 % of the worldwide final energy consumption, biogenic fuels are the dominant renewable resource. This high proportion is primarily due to traditional biomass use (BMU 2012).

In 2009, bioenergy contributed 10.5 % to the EU member countries' final energy supply from renewable sources (5.7 % of it from biomass/waste and 1 % from biofuels).

In Germany, 8.4 % of the final energy consumed in 2011 was generated from biomass; most of this can be allocated to the generation of heat using wood. Of all forms of renewable energy which, taken together, supply 12.5 % of the final energy, bioenergy therefore clearly makes the most extensive contribution (BMU 2012, Renewable Energy Sources in Figures).

Political goals and instruments for expansion within Germany and the EU
In order to increase the contribution renewable energies make to the European energy supply, bioenergy is also to be considerably expanded over the next few years. This expansion is driven primarily by the Renewable Energy Directive (2009/28/EC, RED) and the resultant National Renewable Energy Action Plans (NREAP). According to the NREAPs presented by 20 EU member states, there are plans to increase the contribution made by bioenergy to the final energy supply from 5.4 % in 2005 to 12 % in 2020, i.e. to more than double its share (IEEP, 2012). Furthermore, the EU Fuel Quality Directive (009/30/EC, FQD) sets GHG mitigation targets for the transport sector.

Germany has implemented these directives (RED and FQD) in the form of national legislation, for example in the form of the national biofuel quota. The biofuel quota act alters

§37a of the German Federal Emission Control Act (BImSchG). It states that a binding minimum quota of 6.25 % of all fuels used (per annum) up until and including 2014 should be biofuels; from 2015 onwards, it stipulates the minimum amount of GHG savings that are to be achieved through the use of biofuels. I.e. from 2015 onwards, legislation provides an incentive for an increasing use of biofuels that emit particularly low levels of GHG. In addition, ambitious targets have also been set independently at a national level. They are to be achieved with the aid of such measures as, for example, the new Renewable Energy Act (EEG) or the Renewable Energies Heat Act (EEWärmeG), and also with the Market Incentive Programme (MAP).

Modernising traditional usage in newly industrialising and industrialised countries vs. expansion
With an approx. 5 % share of land use and a 10 % contribution to primary energy in global analyses, the proportion of biomass used for energy generation (traditional and modern forms of usage) seems comparably low in terms of land use and energy supply. However, the way in which biomass is used to provide approx. 40 % of the world population with a basic energy supply is highly inefficient and often not sustainable, and offers an extensive potential for optimisation (see 2.3).

The situation in the southern countries, where the use of biomass to generate energy currently represents the prevailing means of access to energy is fundamentally different from the situation in the industrialised and some of the newly industrialising countries. Many of the southern regions still harbour an extensive potential for increasing usage efficiency and also for increasing biomass production yields in an ecologically sound way.

In the industrialized nations both land use intensity as well as energy and food consumption levels per capita[12] clearly move in ranges of entirely different dimensions. At the same time, in terms of volume, modern bioenergy usage is also growing most in these regions[13], usually triggered by substantial policy-related subsidies. Only in particular cases like Brazil dependency on subsidies is already becoming less marked, and biofuels are increasingly becoming more competitive as the oil price goes up.

This politically induced trend of growing bioenergy production has a global impact in the form of various social and environmental side effects and ecological interactions resultant from the links to the international agricultural produce and timber markets.

> In order to increase the contribution renewable energies make to the European energy supply, bioenergy is also to be considerably expanded over the next few years.

The complexity of these interactions makes it difficult to analyse the importance of modern bioenergy precisely. This is made exemplarily apparent by the controversies surrounding the quantification of the specific contribution bioenergy has made to the global expansion of cropland (see 3.4.) and the debate on the relevance of the factor bioenergy in terms of world hunger. Only a comprehensive survey of the import/export balances of all agricultural and forest commodities in order to take transferred impacts into account can supply a complete and therefore ‚honest‘ picture, even if the biomass used to generate energy is actually produced domestically, or somewhere else in Europe.

The positive growth prospects for modern bioenergy, not least the result of – inadequately differentiating – financial incentive structures has led to the short-term use of existing agricultural land and production structures, and to the research into and development of alternative raw materials and methods (residue recycling, more environmentally sound crop cultivation etc.) being neglected. This has led to the long known ecological and socio-economical problems that input-intensive agriculture causes being transferred to the use of biomass for energy generation, frequently even in an exacerbated form. It is therefore not surprising that a comprehensive ecological balance sheet produced by the Swiss interdisciplinary research and services institution for material sciences and technology development Empa (Eidgenössische Materialprüfungs- und Forschungsanstalt), for example, concludes that using biofuels to substitute fossil fuels generally simply results in a shifting of the environmental burden. In fact, the production of biofuels on the basis of cultivated biomass even represents the bigger risk as far as environmental impacts such as eutrophication, acidification or ecotoxicity are concerned (Empa, 2012).

For example, maize increasingly dominates crop rotation in some regions in Germany that are currently marked by a high density of biogas plants and high livestock levels. Even if most of this is used as fodder, its cultivation for energy generation in areas where such concentrated volumes are grown exacerbates an already ecologically unsound situation[14]. In contrast, the cultivation of alternative energy crops (e.g. cup plant, miscanthus) or alternative cultivation systems such as intercropping hedgerow planting and short rotation coppices (SRC) are clearly more beneficial in terms of the structural diversity in rural areas, agrobiodiversity, erosion control and soil fertility (BfN, 2010). Although perennial crops such as miscanthus or SRC (poplar or willow) tend to be susceptible to erosion in the first year, they already provide good erosion control from the second year onwards due to their dense root systems and the layer of mulch created by their fallen leaves (KBU, 2008). However, in terms of energy yield per ha, maize outperforms other, more ecologically sound crops, and current crop improvement research parameters dictate that changing to alternative crops would entail increasing the volumes of land needed. However, this debate must also be taken into account in the overall picture; bioenergy represents an extremely inefficient form of energy generation per se, compared to other renewable energy sources.

4.2 BIOENERGY POTENTIALS

Current studies offer widely differing estimates of the global potential for bioenergy resources. Based on an evaluation of various biomass and land use studies, the IPCC's Special Report on Renewable Energy Sources (SRREN, 2011) believes bioenergy to have the potential of generating 100–300 x 10^{18} J/a by 2050, under extremely favourable conditions up to 500 x 10^{18} J/a. Taking increasing land use competition and non-compliance with essential international sustainability standards with regard to land use into account limits the bioenergy potentials that could justifiably be reached if sustainability aspects are considered to approx. 100 x 10^{18} J for 2050, which would be the equivalent of double the current yield (IPCC, 2011).

The UBA's most significant conclusion after analysis of the extremely diverse studies on bioenergy potential is that these kind of estimates depend to a considerable extent on inherently uncertain factors and imply value judgements. For example, the extent of land used for meat production and the protection of biodiversity will require has to be estimated, and projections on the development of area productivity must necessarily be assumed.

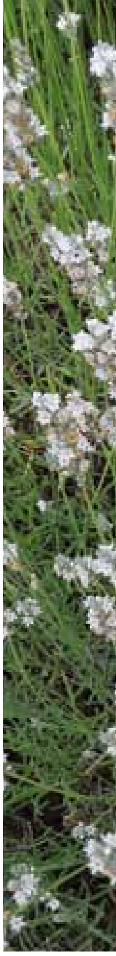
Although some extremes can be discarded immediately due to the estimates' obvious lack of plausibility (e.g. with regard to yield increases or land availability), a huge bandwidth of potential quantities still remains. The majority of the studies emphasise this fact. This bandwidth cannot be pared down further, or rather, any form of restriction tends to reflect the respective attitude towards risks and to taking the real collateral damages of bioenergy production fully into account. Likewise, the development of potentials is often based on ambitious requisite conditions such as effective regulations regarding the sustainability of feedstock production and trade.

National estimates regarding bioenergy potentials are also subject to the above mentioned fundamental methodological

difficulties. Experts, including Nitsch et al. (BMU, 2012), therefore emphasise the necessity of defining the ‚ecological limits' of such potentials quite clearly in order to take land use conflicts and environmental risks into account. The National Biomass Action Plan estimates that around 2.5–4 million ha of land in Germany could potentially be set aside for renewable raw material cultivation by 2020, assuming the degree of domestic contributions to food and fodder needs remains constant[15]. This equates to approx. 20–30 % of Germany's cropland. I.e. scenario dependent, the amount of land currently dedicated to bioenergy generation, around 2.1 million ha (FNR, 2012), equals approx. 50–80 % of the possible total.

An ecologically sustainable potential of around $1550*10^{15}$ J/a was calculated for Germany in the course of BMU pilot studies on the subject, based on a maximum of 4.2 million ha of land which could be dedicated to bioenergy production (approx. a third of total cropland), including around $800*10^{15}$ J/a energy from residues (BMU, 2012). The SRU (2007) estimates that by 2030, a mere 5 % of current primary energy consumption could be generated through the cultivation of renewable raw materials, even under favourable conditions (e.g. stationary use with CHP). Assuming the same area of 4 million ha, the feasible biofuel substitution quote that could be achieved would be even lower. The values calculated by the German government's Scientific Advisory Board on Agricultural Policy are equally low. For example, if the current mix of energy crops were to be cultivated on 30 % of all German cropland, this would cover a mere 2.3 % of the current final energy consumption (WBA, 2007).

This clearly shows that cultivated biomass, due to its low land use efficiency (see Figure 7 in Chapter 4.5) in combination with the extremely limited domestic availability of suitable land, can only contribute very marginally to covering our future energy demand, even if a substantial proportion of the cropland were to be dedicated to this purpose[16].



In the past few years, numerous studies have reached this conclusion, including WBA (2007), SRU (2007, 2011), German National

A study by the DLR shows that Germany's biogenic residues could potentially provide 202 TWhth of energy every year.

Academy of Sciences Leopoldina (2012). The targets currently defined in the respective policies can only be achieved through massive imports, which would be accompanied by an encroachment on land and resource use elsewhere (‚Ecological Footprint'). This in turn would be contrary to aspiring to the principles of sustainable development i.e. of securing the need satisfaction and natural life-support systems of all people and also of future generations[17].

Conflict free biomass potentials: Beyond biomass from potentially conflict-rich and input intensive cultivation, the use of biomass from other sources for energy generation is clearly less questionable; to some extent, synergy effects can be utilised, for example in the case of biogenic residues and waste, brash and arboricultural arisings and specialist crops. In this context, the term waste biomass includes agricultural residues, green waste from landscape maintenance and nature conservation measures, organic municipal solid waste and food processing industry waste as well as forestry residues, i.e. woody residues from pre-commercial thinning measures and the removal of dead and dying trees carried out regularly in order to produce high-quality stemwood, and also harvest residues (Klaus, et al., 2010). Using these materials has almost no serious ecological and socio-economic impact. Although these potentials are relatively low, they can certainly still fulfil an important function during the transformation to a future energy system.

The SRREN's global technical potentials from all biogenic resources for 2050, approx. 100–300 x 10^{18} J/a, mentioned above also include waste biomass (IPCC, 2011). The three decisive factors are: a) agricultural food and fodder production residues and by-products, both from cultivation and from further processing (15–70 x 10^{18} J/a) and b) animal excrements (5–50 x 10^{18} J/a) and c) organic

waste from other uses of biomass, for example organic household waste, recovered wood and waste paper (5->50 x 10^{18} J/a).

A study by the DLR[18] shows that Germany's biogenic residues could potentially provide 202 TWh_{th} of energy every year. The SRU based its scenarios for the study ‚Pathways towards a 100 % renewable electricity system' (2011) exclusively on residue utilisation, calculating generation potentials of 41.9 TWh/a from solid biomass in CHP plants and 26.6 TWh/a from biogas in CHP plants. The UBA study ‚Energy goal for 2050: 100 % renewable electricity supply' (Klaus, et al., 2010) states detailed potentials subsequently used in the various simulations, differentiated into fermentable residues and residues which can be burnt as they are. The fermentable residues, i.e. those suitable for biogas production, can provide 40 TWh/a (thermally, in the form of biogas)[19]. Precondition for fully exhausting the technical-ecological potential is the collection of all organic waste, which is not yet the case in Germany.

Combining raw material extraction with other conservation aims offers additional options for sustainable biomass collection. For example, the aim of climate protection through the creation of soil-based carbon sinks could be combined with the extraction of the surface biomass from these areas. This could take the form of integrated cultivation systems such as alley cropping systems, short rotation coppices, mixed wild herb or mixed crop cultivation, the cultivation of alternative crops such as cup plants or various herbaceous grasses, or even ‚paludicultivation' (the cultivation of wetland plants). The latter (from the Latin palus = marsh, swamp) has the advantage of allowing the extensive use of wetlands without drainage, or their use in combination with rehydration measures. In this way, the carbon sequestered in peat soils, so important for climate protection and commonly released through ordinary drainage and soil cultivation, could remain there. In an ongoing experiment, black alder trees have been cultivated on some of northern Germany's wet fenlands as a prospective source of woody biomass. Alternatively, herbaceous grasses (reeds and sweet grasses) can be cultivated and used for energy generation, although their contribution to the energy supply will remain marginal.

However, any debate with regard to the realisation of ecologically more sound potentials e.g. using biogas substrates from wild plants or biomass from plants grown in paludicultures should clearly prioritise climate protection and the conservation of biodiversity, and consider the realisation of energy generation potential as a useful side effect, rather than a purpose-oriented exercise to cover the energy demand.

This should, for example, be taken into account when deliberating on suitable incentive instruments.

4.3 COMPETING USES AND CONFLICTING AIMS

The drastic increase in the demand for bioenergy feedstocks in the form of cultivated biomass is provoking land use conflicts on international as well as national agricultural and timber markets, and changing the way in which land is used globally. The short term consequences, above all food, feed, fodder and fuel price fluctuations and increases, are the result of acute shortages. In the medium and long term, it seems extremely likely that an adaptation of global agricultural production and forestry to these changed demand and trade patterns will have negative impacts. These can, for example, take the form of habitat and biodiversity loss due to the conversion or eutrophication of ecosystems, the destruction of the carbon sink systems important for climate control, such as peat soils and forests, or the displacement of indigenous communities and replacement of traditional extensive land uses.

A rapidly growing use of bioenergy carriers that are also a direct source of food or fodder increases the risk of endangering the livelihoods of economically vulnerable sections of the population, and indeed of whole countries. The International Food Policy Research Institute (IFPRI) (Headey, et al., 2010), for example, believes that above all the rising prices on the maize market are a direct consequence of the fact that maize is also an energy crop. As the present demand for food and fodder will increase, it stands to reason that the requisite farmland will also grow in the medium and long term, either through direct expansion[20] or by way of changed land use (see Ch. 3.2). The gap in the supply can be partially closed by land use intensification, accompanied by its negative impacts, which we are – context dependent – already aware of, such as, for example the eutrophication and pollution of water bodies, soils and the air due to an increased use of fertilisers, or the contamination of environmental media with pesticide residues.

In summary, the central conflicts and adverse impacts associated with the expansion of modern bioenergy are:

- together with other factors, its contribution to food price increases and the resultant supply shortages in poorer countries in crisis situations (harvest failure),
- the expansion of farmland, either directly or indirectly (land use changes) into areas that need protecting (conversion of forests, drainage of peat soils, ploughing up of grassland and species-rich habitats etc. and
- the intensification of existing land uses with the usually inherent additional burdens for climate, environmental media and biodiversity.

Timber use conflicts in Germany: The growing demand for wood-based fuels has in part led to intensified forest use, both internationally and nationally. For example, the increased timber extraction in Africa is primarily driven by the use of wood as a fuel (FAO, 2011). However, the increasing use of wood in Germany is also above all caused by its growing use for energy generation (SRU, 2012). An intensified use of wood for energy generation, particularly the collection of logging residues or the harvesting of fully grown trees, can in part have a negative impact on the ecosystem functions and regeneration capacities of forests (e.g. Block et al., 2008; EEA, 2008; Englisch et al., 2009; Meiwes et al., 2008; SRU, 2012), so that the principle of sustainability is not always a given fact. In the medium term, there is the risk of a raw timber supply shortfall (DBFZ, 2011; Mantau et al., 2010), already hinted at today by the present timber sourcing conflicts between competing sectors (for example the timber industry and the energy sector). The DBFZ believes that demand could outstrip supply by 290 PJ (around 30 million cubic metres of solid wood) on the German timber market in 2050. Around 1.3 million ha of short rotation coppices (SRC) would be needed to cover this deficit. Currently, around 4,000 ha are managed as SRCs..

Land use conflicts are generally the result of the rising demand for biogenic raw materials and usually occur between different, in part newly emerging, sectors. Although the two areas of biomass usage for industrial and for energy generation purposes usually compete with the food or fodder production sector, they are also in competition with each other. Carus et al. (2010) summarise the debate regarding the competition for land for energy generation or industrial biomass use thus: ‚Whilst there are a number of alternatives in the energy sector, reliant on renewable energy sources such as wind and solar power, hydropower and geothermal power, the situation is much more precarious when it comes to the raw materials the industry needs. Sun, wind and water supply energy, but no actual matter and no raw materials for industrial processing‘. The limited supply of biomass should therefore always be used as efficiently as possible, and land use conflicts, market distortions and resource misallocations should be avoided or kept to a minimum with resource conservation and climate protection in mind.

4.4 INDIRECT LAND USE CHANGES (iLUC)

Researchers, and increasingly also policymakers, apply the concept of indirect land use changes in order to assess the global impacts of specific local land use decisions. This concept assumes that due to the additional demand for raw materials from growing sectors (e.g. bioenergy), previous outputs (e.g. food) are shifted to other areas on the strength of the assumption that the demand for these products will go down less than the demand for bioenergy. In consequence, the loss of the land used originally to produce the respective commodity is at least partially compensated by making new cultivation areas elsewhere arable, which leads to land use changes (particularly the conversion of forests and grassland to cropland).

The substitution of existing usage forms and the conversion of the land have various ecological and socio-economic consequences. Depending on the extent of the analysis, their causes can be explored further on a local, regional or global level. Although a price-driven farming intensification can in part also lower the amount of additional land required for the cultivation of biogenic raw materials, this usually leads to an increased use of agrochemicals with the corresponding environmental consequences. This, too, is an indirect effect of additional bioenergy production which has so far hardly been taken into account. Currently, scientific research focuses on the in part extremely high greenhouse gas emissions (GHG emissions) resulting indirectly from the land use changes that can be attributed to the production of biofuels. Further important and sometimes indirectly triggered effects are the loss of biodiversity as well as complex and all in all mainly negative socio-economic follow-on impact in the form of the transformation of rural life provoked by these dynamics[21].

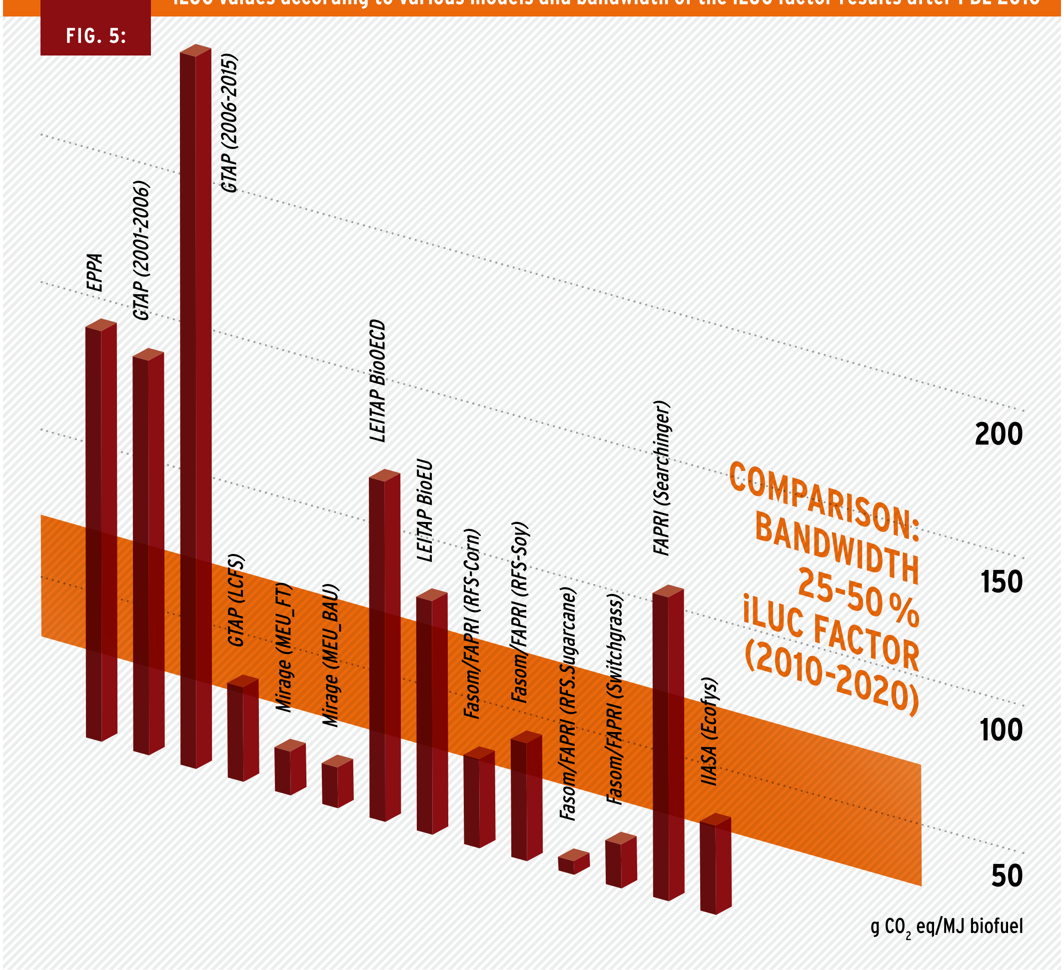
> Researchers, and increasingly also policy-makers, apply the concept of indirect land use changes in order to assess the global impacts of specific local land use decisions.

The outlined impacts are exacerbated both directly as well as indirectly by the additional demand for food and fodder for the production of biofuels, any kind of comprehensive evaluation should therefore take these into account proportionally, or at least partially. In the course of an UBA research project on Global Biomass (Fritsche, et al., 2010), the so-called iLUC factor for quantifying the iLUC impacts of selected types of biofuel was developed for the example of GHG emissions indirectly caused through the production and use of biofuels. This showed that, if iLUC emissions are also taken into account, many of the currently traded biofuels do not meet or just meet the minimum savings demanded by law; ergo one central argument for the government subsidies these products enjoy, i.e. climate protection, no longer applies.

Besides the UBA approach of calculating an iLUC factor, which is based on a determinist method, numerous studies on the quantification of iLUC impacts have been published over the past year. Most of these are based on complex economic balance models. With few exceptions, these studies also show iLUC and the resultant GHG emissions to be a high risk. The above mentioned iLUC factor's emission values equal the other study results' mid-range values (see illustration).

The inclusion of indirect impacts when assessing land use decisions has provoked a controversial debate at an international level. The European Commission has also looked at the issue of iLUC within the scope of a further definition of the sustainability criteria (these will be addressed in more detail further down) in the Renewable Energies Directive (RED). On the basis of various studies[22] and after extensive consultation, it confirmed the pertinence of iLUC, or rather, of the resultant risks (2010). An updated study (Laborde, 2011) carried out within the scope of the impact assessment of the legally binding biofuel quotas for all EU countries has reconfirmed this.

FIG. 5: iLUC values according to various models and bandwidth of the iLUC factor results after PBL 2010



Source: Netherlands Environmental Assessment Agency (PBL, 2010)

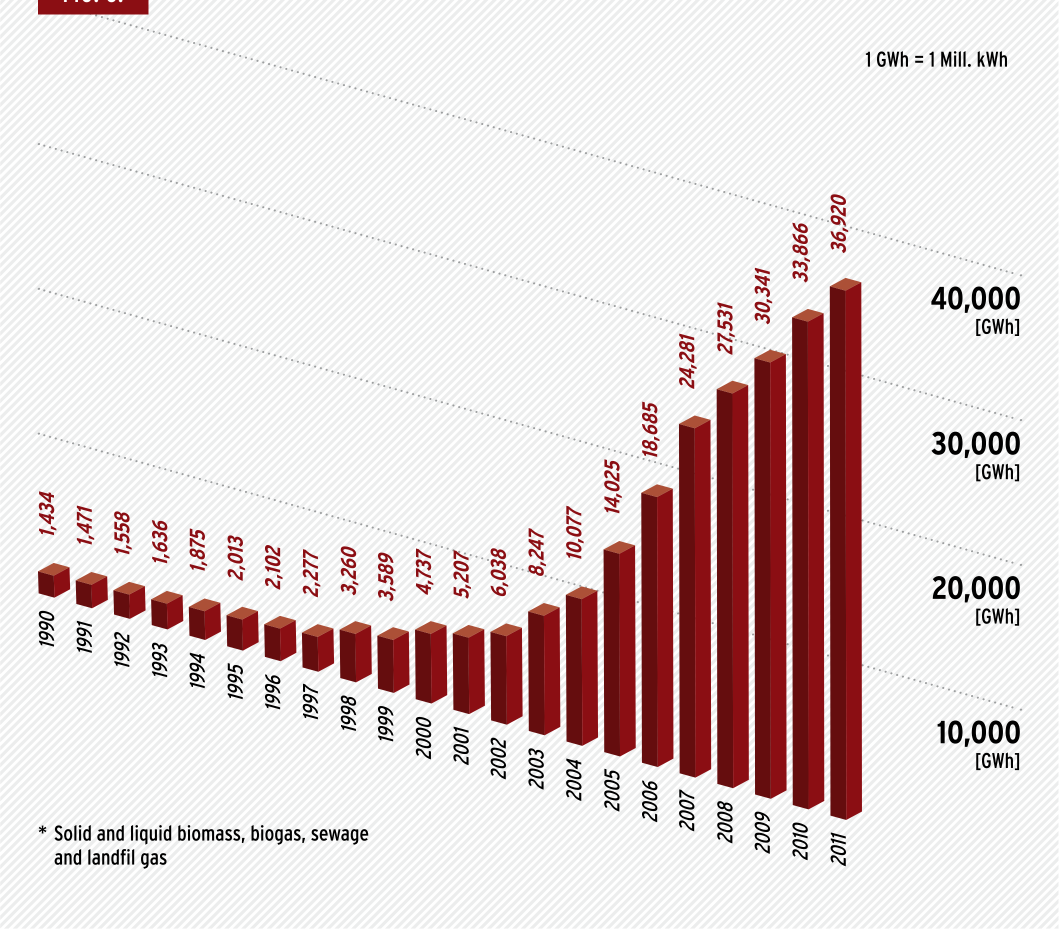
4.5 BIOENERGY IN THE VARIOUS FIELDS OF APPLICATION AND POSSIBLE ALTERNATIVES FOR GERMANY

Bioenergy presently carries some weight in Germany's final energy consumption. At the end of 2011, bioenergy supplied 6.1 % of the electricity consumed, 9.5 % of the energy used for heating, and 5.6 % of fuel in the transport sector (BMU, 2012). We will address each of these sectors in the following.

Bioenergy in the electricity generation sector
In the field of electricity generation, bioenergy has gained in importance over the past few years. The following illustration shows the development of electricity supplied by German biomass plants. It reveals that between 1990 and 2011, the number of plants has increased from 1,434 to presently approx. 36,920. This number includes plants that depend on solid and liquid biomass as well as biogas, landfill and clearance gas, and organic waste.

As the illustration referred to shows, these 36,920 biomass plants contributed 36.9 TWh to the electricity supply in 2011, of which the largest proportion, 47 %, came from biogas, and solid fuels of biogenic origin, which contributed slightly over 30 %. In the electricity sector, the contribution of the various types of biomass made to the overall final energy consumption amounted to: 2.9 % for biogas, 1.9 % for solid fuels of biogenic origin, 0.8 % for organic waste and 0.2 % for liquid fuels (the equivalent of: 17,500 GWh; 11,300 GWh; 5,000 GWh and 1,400 GWh)[23]. Feed-in tariffs paid out under the Renewable Energy Act were paid for a total of 25,146 GWh of biomass-generated electricity.

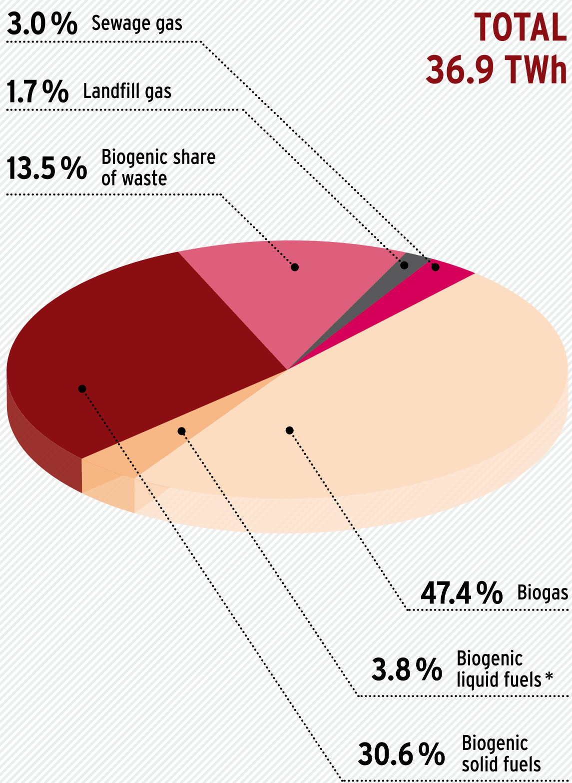
FIG. 6: Development of electricity supply from biomass* in Germany



* Solid and liquid biomass, biogas, sewage and landfil gas

source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); as at March 2012 all figures provisional

FIG. 7: Structure of biomass-based electricity supply in Germany 2011



* Vegetable oil included
1 TWh = 1 Bill. kWh
Deviations in the totals are due to rounding

Source: BMU-KI III 1 according to working Group on Renewable Energy-Statistics (AGEE-Stat); as at : March 2012; all figures provisional

In many European and German energy scenarios, bioenergy is accorded an important role in the electricity sector over the next few decades. However, the UBA believes that – potentially – only a marginal amount of bioenergy would be needed to achieve a 100 % renewable energy based electricity supply (Klaus et al., 2010). From a technical point of view, the use of biomass is not necessary – neither in the interim period nor in the long term – in order to ensure safe and reliable grid operation as there is a range of alternatives. In the interim period, this can easily be provided by gas-fired power stations, and in the long term by hydrogen and methane produced with the aid of renewable electricity.

Bioenergy in the heating sector

In Germany, heating supplied by renewable energies is currently based almost entirely on biomass. As the following illustration shows, biomass contributed just under 91 % of the renewable heat generated in Germany in 2011, which is the equivalent of 138.4 TWh.

As in the field of electric power generation, many of the energy scenarios again accord major importance to the contribution of bioenergy to renewable heat. However, in principle, producing renewable heat does not necessarily have to depend on the use of biomass. Once the existing savings potentials in buildings have been fully exhausted, regenerative heat can also be supplied by solar thermal energy, geothermal energy, regenerative electricity, regeneratively generated hydrogen or methane. Due to the wide range of alternatives and the potentially declining amounts of heat required to heat rooms, it is again not necessary to use biomass in this energy area, from a technical point of view, neither in the interim period nor in the long term. This was also demonstrated in an UBA study for 2050, which contained a model for a purely electricity-based meeting of all heating needs with solar-powered heat pumps (Klaus et al., 2010).

Bioenergy in the transport sector

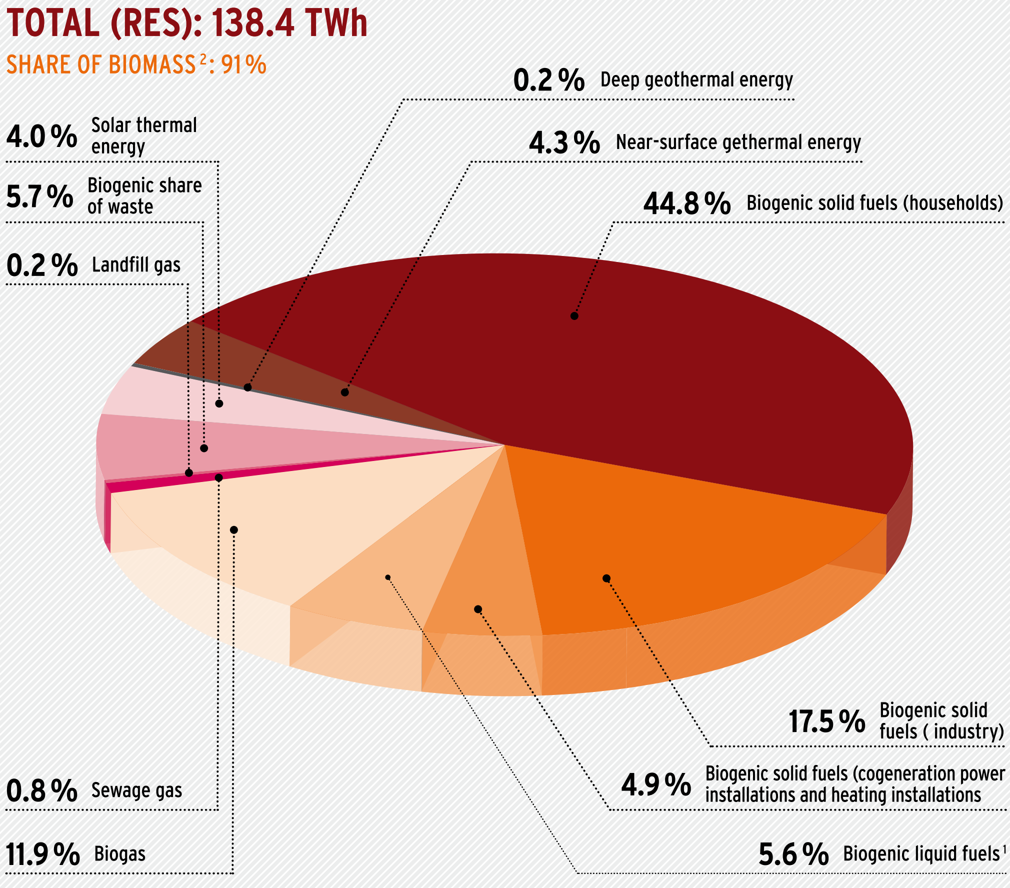
Many hopes were pinned on the growing use of biofuels in the German and European transport sector. Some of these have by now been disappointed. Due to the inclusion of indirect land use changes, the hoped for GHG savings are not as considerable as anticipated (see Ch. 4.4), or have in part even been overcompensated. The dependency on imported oil could only be superseded by an (increased) dependency on biomass imports, which is an uncertain alternative, considering the likely escalation of the global competition for land and resources. The advantage that their introduction requires only marginal technical and infrastructural investments in comparison to other technologies still applies.

Another argument frequently quoted in order to justify the continued pursuit of achieving set biofuel expansion targets is the issue of their (ir-)replaceability in the transport sector. This issue usually entails at least two dimensions: On the one hand, the technical feasibility in realistic timespans and investment requirement ranges must be a given. On the other hand, it must be possible to exploit the respective raw material potentials in an environmentally and socially compatible way.

According to UBA estimates[24], the transport sector‘s primary energy consumption will globally amount to 468 x 10^{18} J in 2050, compared to a maximum global bioenergy potential of 100 x 10^{18} J/a. Today, approx. 55 million ha of global farmland are already dedicated to the cultivation of bioenergy crops, mainly for biofuel production. Depending on the energy crop cultivation location, type and regime, the estimated land yield amounts to 50 – 250 x 109 J/ha/annum. The following deliberations assume a median energy yield of 140 x 109 J per ha.

A current UBA comparison of the energy consumption in the individual transport sector categories (see Appendix 2) shows that in 2010, cars were responsible for the highest consumption figure, in quantitative terms, with a good 1.3 x 10^{18} J (2010), way ahead of marine traffic (approx. 430,000 x 10^{12} J) and aviation (approx. 363,000 x 10^{12} J). On the one hand, UBA estimates regarding energy consumption development in 2030 and 2050 based on an expert‘s report on the concept of zero greenhouse gas emissions in the transport sector by 2050, ‚Treibhausgasneutraler Verkehr 2050‘ (Öko-Institut, 2012), show that commercial vehicles will clearly consume less energy in future, due to efficiency gains

FIG. 8: Structure of renewables-based heat supply in Germany 2011



[1] Vegetable oil included [2] solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste

RES = Renewable Energy Sources

Deviations in the totals are due to rounding

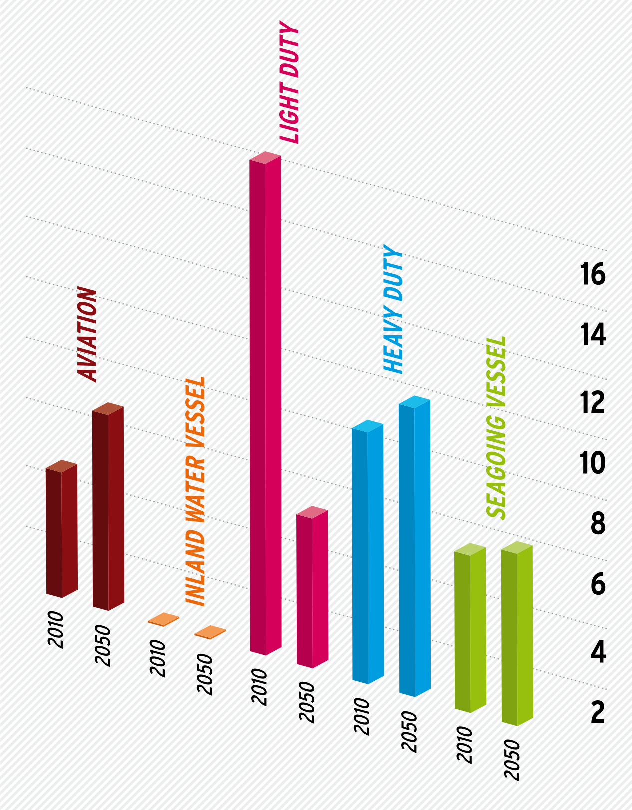
Source: BMU-KI III 1 according to working group on Renewable Energy-Statistics (AGEE-Stat); as at: March 2012; all figures provisional and technical advances. The same applies to marine traffic. On the other hand, the aviation energy demand is expected to increase dramatically by 2050 to over 500,000 x 10^{12} J. This means that aviation will in future consume a major share of the liquid fuels.

From today's perspective, aviation will still rely on (propeller)-turbines in 2050. Considering the current research status and the long product cycle, the fleet of 2050 cannot be expected to feature other drive concepts (e.g. electric drive) to a notable extent. Whilst cryogenic/liquid hydrogen (H2) may be used as a fuel for short distance flights, it must be assumed that long distance traffic will continue to rely on liquid fuels.

Land requirement for the production of biofuels for German and international passenger and goods traffic

The following illustration shows the land volumes required to produce sufficient biofuel to fully cover the primary energy demand of all German passenger and goods traffic in 2010 and 2050. The calculation of these land requirements considered energy saving effects through improved efficiency, traffic avoidance and transfer. A conversion efficiency of 60 % and a median (relatively high) land yield of 140 GJ/ha was applied.

FIG. 9: Land use requirements for biofuels for german final consumtion in Mio ha



(Source: UBA 2012, own calculations)

Outlook on the transport sector 2050

From today's perspective, in 2050, a zero GHG transport system entirely reliant on renewable energies (RE) could be achieved through a fuel mix consisting of regeneratively generated electricity, RE converted into hydrogen (e-H2, electric-hydrogen) and liquid e-fuels (synthetic liquid fuels produced with regeneratively generated electricity and CO_2) as well as, to a limited extent, liquid biofuels produced from residues and secondary raw materials.

A 60 % conversion efficiency was assumed both for electricity and also for the conversion of unspecific biomass into hydrogen (H2, cryogenic/liquid) or liquid e-/biofuels.

- For reasons of efficiency and the associated minimisation of the primary RE demand, regeneratively generated electricity should above all always be used directly (e.g. railways, battery electric vehicles) – wherever technically possible.
- Secondly, H2/FC systems (H2/FFC for hydrogen fuel cell) should be used – again wherever technically possible – as these offer the highest level of energy efficiency besides the direct use of this electricity.

The use of liquid fuels and/or internal combustion engines is expected to extend only to areas where either of these two options does not appear to be a sensible choice for technical and/or financial reasons – both for the foreseeable future and in the long term.

Purely theoretically, if the volume of energy required to fuel all global traffic were to be provided entirely by biofuels generated from cultivated biomass, and assuming central European yield ratios, this would result in around 5.5 x 10^9 ha of land being required for its production in 2050. The above stated land requirement proves that it is practically not possible for biofuels from cultivated biomass to supply the total volume of energy

needed for the transport sector due to the huge extent of land that would have to be dedicated to this purpose. Or, in figures, the land used for biofuel production today would have to be multiplied by a factor of 100 in order to be able to do so. Even working on the assumption that by 2050, biofuel GHG will have been mitigated by approx. 60 % as a result of sustainability certification, this would still not be enough to achieve the requisite GHG reductions in the transport sector as these, from a climate protection perspective, would have to amount to over 90 %. The contribution which the transport sector must make to climate protection cannot be achieved alone through the use of cultivation-based biofuels. The further development of 3rd generation biofuels also harbours substantial uncertainties as far as costs are concerned, i.e. at present, it is completely unclear exactly how much this CO_2 avoidance will ultimately cost. It is therefore essential to develop further alternatives for a zero GHG fuelled transport sector. If biofuels cannot make a significant contribution to climate protection, other options for a zero GHG energy supply for the transport sector must be explored. The fundamental challenge, as far as the transport sector is concerned, is that the overall efficiency of the transport system must be significantly increased. All potentials in terms of traffic avoidance, transfer and increased technical efficiency must be fully exhausted.

Long distance aviation will still continue to rely on liquid fuels, even in the long term. In principle, a partially bio-based fuel supply using residues and secondary raw materials could be an option if the respective efficiency aspects were favourable and under the precondition that harmful ecological and social impacts could be eliminated through the strict monitoring and control of sustainability criteria and potential land use conflicts. A globally applicable certification system would have to be established in order to be able implement this.

> Aviation will in future consume the major share of the liquid fuels.

Aviation emissions have roughly double the climate impact per energy unit than ground traffic emissions – this applies equally to biogenic as well as fossil fuels. Further measures besides the further development of airframe systems and drive technologies are therefore urgently required in order to achieve the aviation related GHG reduction targets. The aviation specific consumption figures could be reduced by up to 50 % by 2050 through a combination of appropriate technical and organisational measures[26].

Bioenergy in emissions trading
The emissions trading scheme regulations couple the emission of greenhouse gases in the European Union with the obligation to issue annual emission rights equal to the actual emissions generated in the previous year through the carrying out of activities that fall under the emissions trading law. The EU emissions trading scheme includes emission-intensive energy generation and industrial plants as well as aviation. Certificates in the form of emissions rights must be issued, each representing an emission allowance of one tonne of carbon dioxide equivalent (CO_2e).

In 2010, allowances related to approx. 45 million tonnes of solid and over 3 million Nm^3 of gaseous substances of purely biogenic origin or of at least partially biogenic origin were traded alone in Germany. The by far largest proportion of the biomass used for this was waste biomass (mainly recovered wood and waste from the paper and timber industries). In 2010, the use of these materials of purely biogenic origin generated an estimated 25 million tonnes of CO_2 emissions. This was the equivalent of around 5 % of the total volume of emissions in the German emissions trading sector. This proportion can be expected to increase substantially in the near future, not least in line with the development of emission allowance prices. Out of necessity, the corresponding demand will also have to be covered by imports into the European Union (cf. Dena, 2011). Furthermore, RWE, for example, has already increased the volume of biomass used in its plants for electric power generation (also outside Germany) from 0.9 million tonnes in 2007 to 2.3 million tonnes in 2010, and intends to expand these capacities further (RWE, 2012). Vattenfall (2011) and E.on (2010) are also planning to expand the use of biomass for energy generation further.

Specific surface area energy yields of various renewable energies
In a comparison of the various options with regard to the use of renewable energy sources, the question of the respective area size required is an important criterion as particularly fertile land represents an increasingly scarce resource, potentially associated with respective distribution conflicts. Two important aspects must be taken into account here. One is a qualitative aspect that takes into account the type of land dedicated to the respective purpose and any potential alternative usage options. In the context of the land use debate, the dedication of fertile cropland to energy crops seems far more problematic than, say, the fact that roof spaces are occupied by solar PV systems, as their installation does not entail usage conflicts. The second aspect relevant to respective deliberations is the question of surface area efficiency. Natural energy flows inherently show a low specific surface area density (BMU, 2012). However, there are considerable differences between the specific surface area energy yields achieved by the different methods of using renewable energies (see illustration). It is clearly apparent that solar and wind power technology delivers substantially higher specific surface area energy yields than the cultivation of biomass for energy use (see also WBA, 2007).

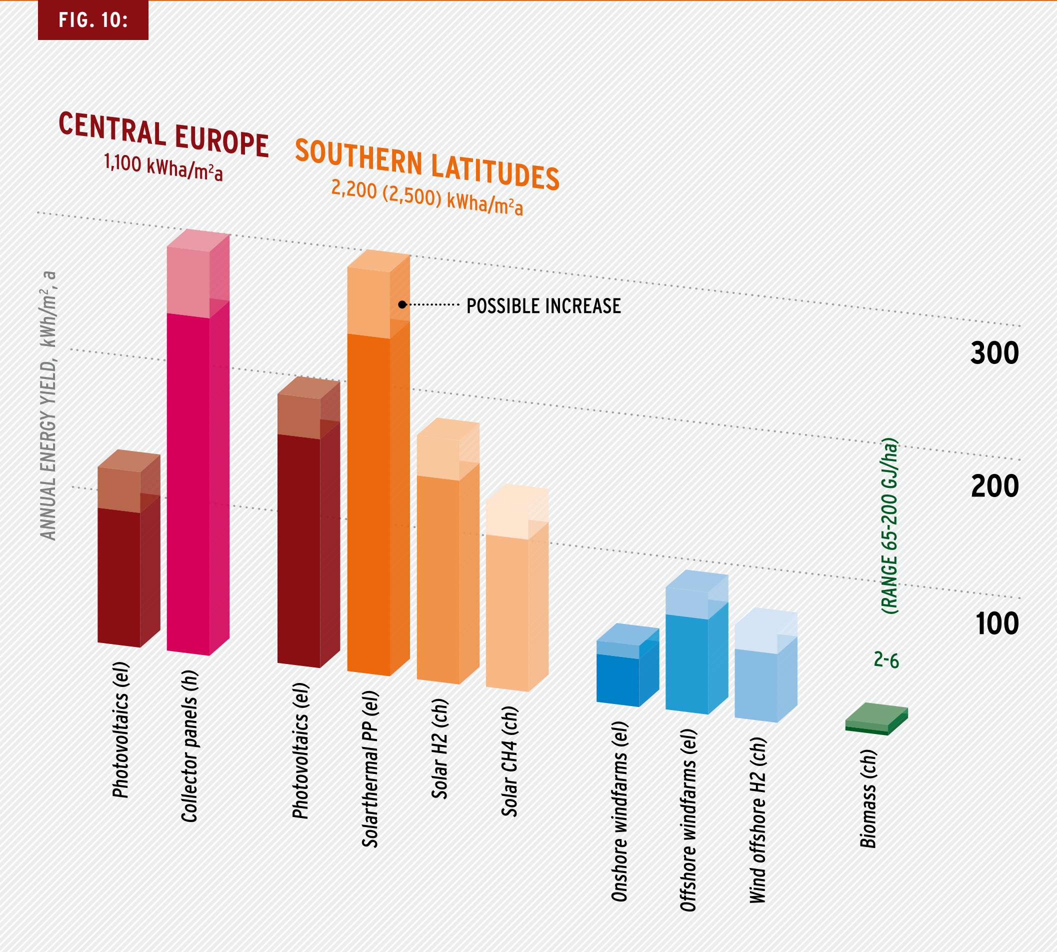
This also applies to the conversion into qualitatively similar energy carriers. For example, solar power can generate more hydrogen or methane per specific surface area unit than storable bioenergy carriers (BMU, 2012). Essentially, this picture does not change even if agricultural productivity increases are taken into account.

Summary of conclusions regarding bioenergy
Considering the problems accompanying bioenergy expansion (e.g. area availability, ecological impacts), a decisive criterion to be taken into account in any energy policy related deliberations is the question of alternatives to bioenergy. Even in an energy system that relies completely on renewable energies, the use of biomass for energy generation is not vital for supply security.

In all likelihood, it will also be essential to reduce energy consumption, increase generation efficiency and restructure the energy system on the basis of regeneratively generated electricity. Germany‘s energy demand could in fact be met fully with regeneratively produced electricity as well as the regenerative chemical energy carriers produced by means of electrolysis methanation and other catalytic processes. This is the conclusion of a project researching the possibility of a GHG-neutral Germany 2050, ‚Treibhausneutrales Deutschland 2050‘ (Klaus et al., 2010).

Land and marine transport could also become fully GHG-neutral by 2050, on the basis of a fuel

FIG. 10: **Typical area specific energy yields of renewable energy sources and their range**[27]



Source: BMU (2012)

mix consisting of RE electricity, hydrogen[28] (e-H2) and liquid fuels generated from RE electricity, as well as, to a limited extent, liquid biofuels produced on the basis of recovered materials and residues. However, this path would still require the large-scale import of electricity, hydrogen or hydrocarbon even if all potential energy savings measures were effectively realised. These imports could and should come from regenerative energy sources.

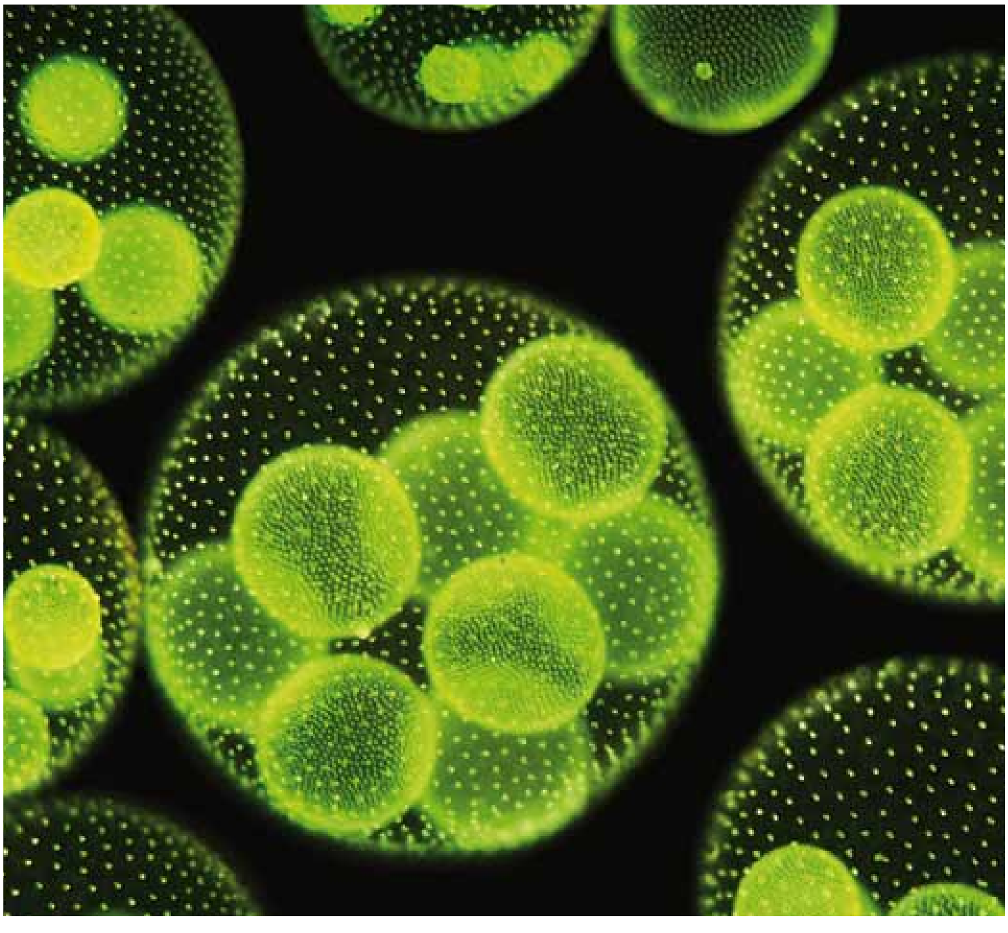
In the area of aviation, on the other hand, it seems unlikely that a 100 % GHG-neutral fuel supply could be achieved by 2050; fossil fuels will probably still have to be relied on in this area and will therefore have to be reserved for aviation use. Liquid e-fuels (synthetic fuels on the basis of RE electricity and CO_2) will probably play a role, but only to a limited extent, as will biomass on the basis of recovered materials and residues and also, possibly, provided by other forms of biomass. With regard to the latter, it must be a given precondition that the above mentioned criteria with regard to sustainability, efficiency and consideration of competing land uses are met.

Excursion on the Use of Algae

The use of microalgae as a raw material for organic refineries has recently been intensively researched, as their photosynthetic capacities can achieve considerably higher efficiency levels than the biomass traditionally cultivated. Under optimum growth conditions, microalgae can convert up to 5 % of the solar energy they absorb into chemical energy, land plants on the other hand only 0.5 – 1 %. Just like land plants, microalgae can also provide biodegradable biofuels. As algae and cyanobacteria produce a number of secondary catabolic products, they are also suitable for chemical and polymer extraction. The use of microalgae is currently mostly realised at laboratory level.

As algae can be cultivated on non-arable areas all year round, their use for the production of fuels or chemicals is unlikely to lead to land use conflicts triggered by conventional biomass production.

Specialising exclusively on the production of biofuels is not yet a financially viable option; the current aim is therefore a simultaneous extraction of expensive chemicals in algae biorefineries. Three pilot projects that envisage the cultivation of microalgae on 10 ha are currently being subsidised at EU level. These projects are pursuing the replacement of fossil fuels with bio-based fuels. This field offers scope for extensive further research, both from a technical point of view and also with regard to ecological and economic evaluation.



[12] It is extremely important that the qualitative mix (cue meat and dairy product consumption) is taken into account when referring to ‚consumption levels‘.

[13] Modern bioenergy usage refers to the use of solid, gaseous and liquid biomass as a secondary energy carrier in order to generate heat, electricity, combined heat and power (CHP) and fuels (IPCC; 2011).

[14] The maize plant has special morphological and agroecological properties which, above all in combination with bad land management and large-scale cultivation, must be judged as negative with regard to soil protection, groundwater and agroecological diversity (e.g. late germination and little ground cover, which increases the risk of erosion; tolerance of high nutrient input, which makes nutrient overload possible; self tolerance and therefore suitability for monocultivation). Furthermore, the regional dominance of the existing maize fields and their aesthetic effect on the countryside has received extreme criticism from the broad public (the ‚maization‘ of rural areas), and the crowding out of other uses (e.g. dairy farming) due to drastically increased farmland rental prices is also frowned upon.

[15] The wide bandwidth of the potentials stated is the result of the unavoidable methodological difficulties described above.

[16] Biomass cultivation for energy use must take the relatively low land use efficiency level compared to all other renewable energies into account, and the fact that it has a low potential in terms of substitution. Biomass cultivation for energy generation makes an inefficient contribution to climate protection, compared to other options (i.e. high cost of each tonne of avoided CO_2 equivalents).

[17] The German National Academy of Sciences Leopoldina (2012) arrived at Germany‘s overall balance by comparing the
national primary products (NPP) with the biomass consumed. This comparison revealed that Germany is already a net importer of biomass 17equalling around a third of its consumption level. An expansion of the cultivation of biomass for energy generation would shift this balance even further towards a trade deficit.

[18] ‚Nature Conservation-Plus‘ scenario. The DLR study in turn refers to the study ‚Stoffstromanalyse zur nachhaltigen energetischen Nutzung von Biomasse‘ (substance flow analysis for the sustainable use of biomass for energy generation) for its waste biomass figures (ÖI, UMSICHT, IE, IFEU, IZES, TUBS, TUM; commissioned by the BMU, 2004).

[19] Most of this originates from animal excrements and litter (24 TWh/a) and, to a lesser extent, from organic municipal waste and sewage sludge (6 TWh/a each). Residues that can be burnt without further processing have a primary energy content of 162 TWh/a. Approx. 50 TWh/a comes from timber cultivated for this purpose and from smallwood, 19 TWh/a from recovered wood, 15 TWh/a from woody industrial residues and approx. 15 TWh/a from straw.

[20] In a study on global land acquisition, Anseeuw et al (2011) state that 203 million ha of land were traded between 2002 and 2010, mainly in Africa (134 million ha) and Asia (29 million ha). According to this study, 78 % of the land traded for which the intended use is known is designated for agricultural production, approx. 3/4 of it for growing energy crops. The remaining 22 % include extensive timber plantations. Overall, bioenergy can therefore be considered one of the main drivers of the transformation and expansion of global land and forest use (Anseeuw et al. 2011).

[21] Both new usage forms on land that is already being used for agricultural purposes and the conversion of additional land also displace the users specialised on the traditional form of cultivation, frequently women, as the traditional usage forms disappear. For example, large-scale land acquisitions push pastoralists into forest regions, which leads to conflicts with smallholders and forest product users. In the course of these displacement dynamics, many of the traditional land users lose their natural life-support systems and move into the cities, which are growing worldwide. In consequence, frequently labour-intensive but sustainable forms of land use that take the local conditions into account are often forgotten or cannot be pursued any longer due to the lack in manpower.

[24] See Appendix 2.

[25] Other gaseous fuels could also be used instead of hydrogen (H2), for example methane. Whether H2 or CH4 will be used to fuel, for example, heavy goods vehicles or ships will depend mainly on the respective costs (e.g. of (high temperature) fuel cells, methanation, infrastructure). This has no significant impact on the results of the deliberations.

[26] TU Berlin 2008 (commissioned by BMU); Zusammenfassende Darstellung der Effizienzpotenziale bei Flugzeugen unter besonderer Berücksichtigung der aktuellen Triebwerkstechnik sowie der absehbaren mittelfristigen Entwicklungen (FKZ UM 07 06 602/01, summary of aircraft efficiency potentials under specific consideration of current drive technologies and foreseeable medium term developments).

[27] 5 MW plants, installation density 20 MW/km^2; relation to total area (EL: electricity, H: heat, CH: chemical energy store).

[28] Instead of hydrogen, other gaseous fuels such as methane could be used. Whether hydrogen or methane will be used to fuel, for example, heavy goods vehicles or ships will depend mainly on the respective costs (e.g. of (high temperature) fuel cells, methanation, infrastructure). This has no significant impact on the results of the deliberations.

5.

Key Action Fields for Sustainable Biomass and Land Use

Biomass is a renewable but limited resource whose utilisation is associated with a high conflict potential. The cultivation of biomass requires resources that are already in short supply, above all arable land, water, energy and a few other, finite resources (for example phosphorus). In the near future, the global demand for these resources will exceed the available (regenerative) capacities; the amount of land available per capita for each member of the world population is continuously decreasing. This raises distribution issues which need to be resolved under consideration of ethical aspects. Food security must take precedence over the production of renewable raw materials if the basic principles agreed in the United Nations Development Goals are not to be jeopardised[29]. To avoid a further destabilisation of Earth's overall system, global land use must fundamentally change.

Key courses of action for a sustainable development of land use are

- the requisite transformation of the industrialised countries agricultural land use and food production systems by converting to a resource-conserving, environmentally compatible economic strategy and consumption behaviour.
- the cessation of global deforestation and the protection of primary forests and other ecosystems vital for carbon sequestration and the protection and conservation of global biodiversity, and the permanent protection of currently still intact ecosystems,
- the expansion of land use planning at a national and at an international level as an important steering instrument in order to prioritise the various land use requirements,
- soil protection in order to safeguard the production basis,
- the integration of qualitative and quantitative water management into sustainable land use.

Measures intended to advance sustainable land use development should be aimed at designing the framework conditions in such a way as to

- offer incentives for sustainable production and consumption,
- raise supplier and consumer awareness and consciousness of the consequences of certain lifestyles, and above all of certain dietary habits.

The main starting point for food security, one of the core aims of sustainable biomass production and the conservation of natural resources, is the reduction of poverty as poverty is the main reason for malnutrition and hunger. Not only the global availability of food but also the access to food is vitally important in this respect. Combating poverty is therefore at least as important as setting the requisite environmental policy targets. Combating poverty also contributes to environmental protection as many forms of non-sustainable land use are caused by poverty.

5.1 PROTECTING AND CONSERVING ECOSYSTEMS AND THEIR FUNCTIONS

Protecting forests and using them sustainably
Forests are vital for the maintenance of natural life-support systems all over the world. A large proportion of the global animal and plant species lives in forests, for example. Natural and semi-natural forest ecosystems are therefore indispensable for the protection of biodiversity. Forests are important elements of the global carbon cycle and climate system, and contribute in many ways to regional climate control. The various protective functions fulfilled by forest ecosystems contribute decisively to ensuring that our daily needs are met.

Deforestation must therefore urgently be stopped for a number of reasons; the conservation of biodiversity and compliance with the 2 C climate target[30] are the primary aims. Primary forests should therefore be strictly protected, and they should only be used in a traditional manner. Existing international processes and instruments such as the REDD+ mechanism should be relied on to ensure this.

Globally, forests that are already being used must be managed strictly according to the sustainability principle which, as we understand it, also particularly covers the maintenance of ecosystem services. Sophisticated certification schemes for sustainable forest management and the use of certified timber are a suitable instrument for global implementation and must be expanded. With respect to global land use, one key focus is to be found in the area of climate protection policy. Deforestation must stop as soon as possible, although not only for this reason.

In terms of quantity, timber is the most important renewable raw material, both at a national as well as at an international level. The feedstock growth targets set by the federal German government in various strategies and action plans (e.g. Forest Strategy 2020, the ‚Charta for Wood', the national action plan for the industrial use of renewable Raw Materials) and the climate policy related (e.g. Forest Strategy 2020, National Biomass Action Plan), increasing use of wood to generate energy will result in a continuously rising demand for wood-based raw materials in Germany. The potentially increasing productivity pressure on forests may be subjected to as a result of this harbours the risk of negating much of the progress and changes already achieved in terms a more environmentally sound use of forests (e.g. the establishment of stable mixed forests), and of exacerbating current objective and usage related conflicts. For example, full-tree harvesting or of the use of brushwood can result in an overuse of existing forest stands, especially with regard to nutrient balances, which would not be the case if forests were used purely quantity-based (i.e. growth is used). Full-tree harvesting or of the use of stock wood leads to considerable additional impairment of the soil structure. The increased use of logging machines can also have negative impacts as the soil is compacted by the weight of these machines.

In order to maintain both the productivity and the ecosystem services of forest ecosystems as well as their economic importance and also achieve the whole-scale safeguarding of biodiversity under uncertain climatic conditions, a sustainable, multifunctional forest management must be established in commercially exploited forests. The Federal Environment Agency believes that essentially, an environmentally compatible, nature-oriented sylviculture is the only way possible way forward. Safeguarding the carbon store forest should be made a priority at a national level. Yield increases must only be achieved within the scope of the soil's natural capacities for nutrient resupply. The artificial input of nutrients should only be resorted to in exceptional circumstances, and as a forest rehabilitation measure in cases where the nutrient supply is inadequate due to previous negative impacts.

A range of UBA research projects therefore address the development of sustainability requirements in order to ensure that the use of biomass such as wood, for example, has a positive climate balance and does not contribute to renewed environmental burdens or an exacerbation of existing environmental problems.

Advancing soil protection

Soil is an essential, finite commodity whose renewal timespan exceeds humankind's scale of conceivability. For this reason, regulations are needed to ensure that the volume of soil lost due to degradation caused by non-sustainable forms of soil management, contamination and sealing (i.e. being built over) does not exceed the amount of soil created in the course of natural processes in the long term.

> Soil is an essential, finite commodity whose renewal timespan exceeds humankind's scale of conceivability.

Beyond this, efforts must be made to reverse the damage which has already been done to the soil as much as possible. Examples for this are the unsealing of infrastructural elements which are no longer required, and the rehabilitation of contaminated sites. Measures such as these usually require extensive capital investment and effort, which underlines their necessity, and also the fact that their initial prevention is the preferred option, both in ecological as well as economic terms.

How the soil is treated is primarily a decision made by private sector stakeholders, although sometimes also by governments. In most cases, however, the consequences of soil degradation not only affect the soil's owner but also the general public. Water erosion not only leads to the loss of soil fertility at a local level (‚on-site' damages) but also to the eutrophication of surface waters, which in turn has serious consequences for the ecology of the respective bodies of water and biodiversity (‚off-site' damages). The degradation of organic soil substance due to the destruction of the humus layer through crop rotation and the insufficient re-input of agricultural organic residues has negative impacts on the local soil structure, but also leads to the soil not being capable of fulfilling its function as the second-largest active carbon store on Earth to the required extent. Instead, it is turned into an additional source of CO_2 that accelerates climate change.

In times of a global agricultural market and cross-border migration, any regionally restricted food production breakdown, for example in the Sahel zone as a result of soil degradation and desertification, also impacts on other, not actually directly affected, regions. These examples highlight the fact that the consequences of non-sustainable soil use have an effect far beyond the actual property

borders and even beyond national borders. The conservation of soil fertility and the ecological soil functions is therefore not only in the interest of private stakeholders and national governments but is also a matter of global concern.

Soil protection should therefore be advanced not only at a national, but also at a European level – for example through the adoption of the EU Soil Framework Directive and through a respective review of the Common Agricultural Policy. Further action is also required at a global level, as the current international agreements, above all the UN Convention to Combat Desertification but also the UN Convention on Biological Diversity and the United Nations Framework Convention on Climate Change have so far addressed only some soil protection issues and have not managed to develop the requisite level of effectiveness.

For this reason, the first step is to ensure that more attention is paid to the relevance of the soil issue at an international level, and that a global communication and cooperation process is initiated which covers scientific and political as well as legal aspects. This also includes a comprehensive global report regarding soil state and development trends to provide policy advisory bodies and the respective decision-makers with a reliable decision-making basis.

The UBA believes that at a global level, the issue of soil protection will require global governance in the long term; a global governance that also encompasses internationally binding soil protection regulations.

Protecting and promoting biodiversity

One of the core objectives of the CBD‘s Strategic Plan for Biodiversity 2011 – 2020[31] and the EU biodiversity strategy to 2020 (2011)[32] is that biodiversity concerns must be taken into account in all areas of policy-making. The German National Biodiversity Strategy (2007) also reflects this goal. Safeguarding the natural life-support systems of a wide range of plant and animal species through sustainable land use and the close cooperation of farmers and the forestry industry with nature conservation organisations are stated as agriculture and forestry – including bioenergy production – quality objectives, and supported with suggested measures. Changes in land use patterns, for example the large-scale conversion to energy crop cultivation, are to be examined ex ante with respect to their agreement with these objectives if they are publicly funded. The further development of indicators as well as monitoring systems and processes for monitoring the success of biodiversity measures is to be constant.

The history of central Europe‘s countryside proves that all in all, anthropogenic land use does not necessarily have to lead to a reduction of habitat, species and genetic diversity. Anthropogenic land use can even result in the creation of a range of new habitats that provide life support systems for a larger number of species than before. Although these kind of processes tend to result in highly-specialised species being replaced by generalists.

To utilise the potential a structure-rich cultural landscape has to offer for biological diversity yet also conserve the habitats of endangered species, different courses of action should be pursued. The remaining natural and semi-natural habitats must be protected to an adequate degree. In the process, the unavoidable consequences of climate change can only be met at least in part if the protected areas are linked to each other in a better way.

It is at least equally important for land use to include additional environmental and nature conservation measures. In terms of the generation of biogenic raw materials, the solution lies in expanding the spectrum of cultivated crops and cultivation systems and replacing the currently widespread monocultures.

For the protection of biodiversity the spectrum of cultivated crops and cultivation systems should replace the currently widespread monocultures.

Numerous courses of action for the protection of biodiversity have already been explicitly elaborated in other sections of this chapter, or they were taken into indirect consideration. This has revealed that there are obvious synergies with other protection and sustainability objectives. The following covers additional important aspects for the worldwide protection of biodiversity. Certification schemes can promote the broad application of these principles (see 5.5). Spatial/ecological planning: In view of the increasing productivity pressure and the growing number of land use conflicts, it is vital that the significance and the potentials of the global ecosystems if they are used sustainably are determined with recognised scientific methods. This is a requisite precondition for being able to identify priority areas for the various uses with the aid of regional and landscape planning methods, and to formulate the requirements for their protection and sustainable use. Depending on the degree of protection they deserve and their individual sensitivities, the appropriate measures and instruments must be selected to allow environmental protection and nature conservation aims to be integrated into the cultivation methods or, where necessary, to leave certain areas completely untouched so that they can develop naturally. Besides primary forests, adequately sized areas with particularly valuable natural characteristics of other ecosystem types, such as steppes and savannahs, species-rich grasslands, peatlands, wetlands and riparian zones as well as areas farmed in a traditional way must be conserved and linked to each other. In as far as possible, degraded and devastated regions should be recultivated and renaturalised. In these cases, biomass production can also go hand in hand with the promotion of biodiversity.

There is a huge backlog in this action field in many countries. Land ownership often has to be clarified first, and legal foundations have to be created. The implementation is often hindered by the political situation or extreme poverty, but also by a lack of administrative structures and control mechanisms as well as lack of knowledge. Together with the other European partners, Germany can support the CBD goals in the area of agricultural production and forestry with targeted development and foreign policy, financial support and knowledge transfer. The quantification, mapping and, in as far as this is a sensible measure and comprehensibly possible, the valorisation of ecosystem services represents an important contribution to the clarification of the value of intact ecosystems and their species and gene diversity in comparison with other forms of land use to allow this value to be taken into account to a greater extent in future. Optimised cultivation systems: Whilst the overall goal must be the worldwide establishment of integrated, i.e. environmentally sound, cultivation processes in all regions, certified organic farming deserves special promotion as a particularly biodiversity-friendly production method. It should above all be supported in regions where it is the only method that allows the utilisation of cropland or grassland in the long term. In this context, the conservation and use of regional economic crop species and varieties is also an important aspect, as they have adapted to the respective situation. In the long term, they often provide more stable yields than most of the high performance varieties bred for intensive farming, yet only require a low investment of resources and energy. Besides these agrobiodiversity measures on a species and gene level, a landscape with an extensive structural diversity also contributes to habitat diversity. It therefore represents a third aspect with regard to biodiversity. Depending on location suitability, a wide range of perennial and annual plants, multiple cropping, agroforestry, energy grasses and short rotation coppicing could contribute to this, and allow alternating spatial and periodical use. In many regions of the Earth, some of these cultivation systems are still present as traditional usage forms. In Europe, they are currently being rediscovered, developed further and augmented by innovative forms of cultivation. However, at present, they are still only practiced on a relatively small proportion of Germany's farmland. This field requires extensive research and development.

Dealing with water scarcity and improving water quality

In many regions with unfavourable climatic conditions, irrigation is a precondition for the cultivation of food and raw material crops. A high level of agricultural water consumption affects the availability of water for other uses and water-dependent ecosystems. Managing agricultural water demand is therefore also a central element of sustainable land use. Lessening farming-related water contamination cannot be achieved by means of direct technical intervention in the respective groundwater, surface waters or oceans but must start with a mitigation of on-site farming nutrient and pollutant inputs. Measures that reduce the contamination of water resources caused by farming must be implemented locally and address the root causes of the various problems.

Qualitative and quantitative water management therefore involves:

- controlling the agricultural water demand and land use intensity in river basins within the scope of integrated water management,
- regulating water usage and access rights for the common good, i.e. ensuring that all land users have access to water and that agricultural activities do not prevent the use of water for purposes other than farming,
- setting land use priorities in regions where water is scarce. Food security must also take precedence over raw material and energy crop production,
- reducing water usage intensity i.e. lowering the water extraction rates for agricultural purposes and minimising diffuse pollutant/nutrient inputs through closed nitrogen cycles and water-friendly cultivation methods appropriate to the respective location.
- linking agricultural policy concepts and rural development plans closely with other policy areas (environment, health, economy).

Financial instruments should be applied to provide incentives for an economical and efficient water and fertiliser use in agriculture e.g. through taxation, water levies or by subsidising irrigation and storage technologies.

Developing managed land use further

Land use planning, which is an important steering instrument for the prioritisation of the various different demands to be met by the available land (e.g. cultivation of food and fodder crops, crops for industrial use and energy generation, nature conservation and climate protection) must be advanced both at a national and an international level. Responsibly implemented, it can contribute to securing the basic needs of those who cannot rely on purchasing power to meet them. As a rough guideline for land use planning, food production should always take precedence over the production for industrial or ultimately energy generating purposes, and the production volumes never exceed the respective ecosystem's capacities.

> Landuse planning is a steering instrument for the prioritisation of the different demands by available land and must be advanced both at a national and international level.

The UBA's involvement in the global land use debate extends to activities such as highlighting and accompanying productive international processes (for example GBEP, global soil policy debate) in the form of research and development projects, thereby contributing to the further development of these processes.

5.2 STARTING THE TRANSFORMATION OF CONSUMPTION BEHAVIOUR AND DIETARY HABITS IN THE INDUSTRIALISED COUNTRIES

The western industrialised countries must contribute significantly to reducing our resource and energy consumption, and thereby to the avoidance of environmental burdens, by changing their populations' wasteful lifestyles and consumer habits.

Sustainable dietary habits: Relying increasingly on plant-based products

Sustainable dietary habits encompass the entire food consumption system, from production, processing, packaging, transport and retail to purchasing behaviour, food preparation and consumption right up to the disposal of waste. A transformation of the dietary habits to mainly plant-based, seasonal and regional produce as well as a reduced meat consumption, for example in line with German society for nutrition research recommendations, will also be accompanied by a number of positive secondary effects (on health, energy, the environment, land). The production of non-processed fruit and vegetables in the respective season requires relatively little energy input. The processing, transport and storage of food, on the other hand, is usually associated with a higher resource investment or consumption (e.g. greenhouse gases, pesticides, energy, water, packaging materials).

Reduction of meat consumption: A plant-focused diet is considered clearly more beneficial, not only from a nutritional perspective (the German society for nutrition research (DGE) recommends that around three-quarters of all food consumed should be plant-based) but also as far as the environment is concerned, as the production of plant-based food requires relatively little energy input: On average, it takes two-and-a-half to five times as much energy to produce livestock-based products as it does to produce plant-based products. A more plant-based diet coupled with an overall reduced meat consumption contributes to achieving the climate protection goals through the avoidance of nitrous oxide and methane emissions from livestock farming and the reduction of the extent of land dedicated to the cultivation of fodder crops. However, livestock farming must not be shifted to other countries where it is responsible for higher emissions per product unit than in Germany. In this respect, the federal German government/BMELV should place more emphasis on informing the public about the correlations with appropriate measures (in kindergartens, schools, with campaigns etc.).

Preference of certified organically farmed products: Organic farming is usually accompanied by numerous environmental benefits compared to conventional farming (v. Löwenstein, 2011; Taube, 2006). Organically farmed food also has a much better climate balance (CO_2 equivalents per g/kg of produce) compared to products produced by means of conventional agriculture (Öko-Institut, 2007). In the EU, the basic requirements for organic products are anchored in EU legislation (Directive (EC)834/2007). They form the basis for eco-certification and labelling within the EU. In a global context, the Federation of Organic Movements (IFOAM) actively promotes organic farming.

In central Europe, organic farming methods usually achieve lower yields than conventional methods; in other parts of the world, organic farming can also achieve higher yields. That is why organically farmed products are more expensive in the retail shops here. The willingness to pay higher prices for organically farmed products is limited in a population used to low food prices. Practical instruments to stimulate the demand are educational measures and campaigns to promote sustainable consumption behaviour, for example nutrition education in schools and kindergartens. The consumption of organic products should be encouraged in, for example, public canteens, hospitals and schools.

Consuming responsibly and more economically, accompanied by a raised awareness of ‚piggy back land use', is a simple, first step. We suggest the following measures to encourage responsible consumption:

- educating and informing; motivating consumers to pursue sustainable dietary habits through educational offers and information campaigns,

- supporting transparent and sustainable product labelling,
- reducing harvest and postharvest losses and food waste.

Minimising food losses and waste

Against the background of a rapidly growing demand for food and the necessity of volume and efficiency increases in primary agricultural production, addressing food loss and waste reduction potentials becomes an urgent issue. There are already respective efficient solutions along the entire food chain. The measures to be undertaken and the respective levels of action differ in the developing and the industrialised countries. Whilst technical, infrastructural and organisational measures are required at the producer level, the consumption behaviour must be addressed and changed at consumer level through information and educational measures, for example.

Establishing regional economic and material cycles

The land use systems must regain a regional focus in order to at least attempt to close the globally and regionally delinked material cycles. To achieve this, it is important that regional economic and material cycles are established. This is not about protectionism and the compartmentalisation of national agricultural sectors but about the development of ecologically sound and socially compatible economic strategies in all countries. In view of the extensive nitrogen flows, important respective approaches or measures in Europe are livestock farming stocking rates as well as the regulation of agricultural nitrogen imports (N), i.e. mineral fertiliser inputs (KLU, Kommission Landwirtschaft am Umweltbundesamt, 2011 S. 37) and feed and fodder imports.

Controlling livestock farming stocking rates

The livestock stocking rate per land unit is an important influencing factor on nutrient flows in agricultural ecosystems; it is an indicator of the risk of water nutrient inputs (nitrate) and emissions released into the air (ammonia, nitrous oxide, methane) as well as nutrient accumulation (phosphorus) in the soil. In some EU regions, livestock stocking rates are too high[33]. This kind of livestock concentration demands extensive fodder imports (accompanied by potentially negative environmental impacts and land use changes in the producing countries) and too excessive phosphorus and nitrous oxide balances and low nutrient efficiency in the excrements when the slurry is applied as fertiliser. The emissions impact negatively on the biotic environment (through nutrient input into semi-natural oligotrophic ecosystems, through eutrophication and through displacement of species living in nutrient poor biotopes).

By limiting the livestock stocking rate, the resultant slurry is restricted to a level that makes closed nutrient cycles and the efficient use of slurry as a fertiliser possible and leads to a reduction of the need for synthetic fertilisers. The target stocking rate for the EU is less than 2.0 manure units per hectare of land (MU = manure unit = annually 80 kg of nitrogen contained in the animal excrements). If the livestock stocking rate is in excess of 2.0 MU per ha land, it is no longer possible to efficiently recycle all of the nutrients produced. Restricting stocking rates is easily implemented and controllable (documentation requires little effort, farms can already provide all the necessary data).

Investigating tax-based regulation options and applying them

Financial instruments such as the taxation of meat and animal-based food or the protein feeds and nitrogenous mineral fertiliser trade can create incentives that motivate producers and consumers to consume more responsibly and economically. In this context, it is important to address both the demand and the supply side by means of a coherent overall concept whilst at the same time avoiding double taxation.

> Land use systems must regain a regional focus in order to close the globally and regionally delinked material cycles.

Instruments that provide incentives for reducing the nitrogen input in agricultural production include a nitrogen tax on mineral nitrogen fertilisers, the taxation of surplus nitrogen and also the taxation of protein feeds. A ‚fat tax' and the phasing out of tax concessions for animal-based food, on the other hand, are aimed at altering consumption patterns. A nitrogen tax represents a key instrument for mitigating the nitrogen input into the environment. This levy on nitrogen could be designed in a number of different ways (UBA, 2009).

Nitrogen tax on mineral nitrogen fertilisers: A nitrogen tax on mineral nitrogen fertilisers addresses the issue at fertiliser production (manufacturer) and import (trade) level. The reference quantity here is kg N. The effectiveness of a tax, i.e. the reduction of the nitrogen input, will only be given if the set rate is appropriately high. Experience reports and studies from different countries are already available. Sweden has taxed mineral fertilisers since 1984, Denmark since 1996, the levies have clearly reduced the use of mineral fertilisers. In Sweden, for example, a taxation rate of 30 % of the mineral fertiliser price resulted in a seven percent reduction (Möckel, 2007). If the price of mineral fertilisers was taxed at 50 %, Germany's agricultural nitrogen surpluses could be expected to go down by 18 kg per hectare annually, or 300 Gg of nitrogen in total (Umweltbundesamt, 2009).

The nitrogen tax should be introduced concurrently with a protein feed tax to ensure that crop cultivating farmers do not enjoy any unfair advantages over livestock farmers. Just like the nitrogen tax, a tax on traded (imported) protein feed can easily be collected via the feed trade. Both taxes should be introduced at the same time. A limitation to the mineral nitrogen tax alone would mainly affect crop cultivating farmers. From an environmental protection perspective, this would be counterproductive as numerous environmental problems caused by the agriculture sector are due to intensive livestock farming at high stocking rates.

Taxation of nitrogen surpluses: A taxation of nitrogen surpluses[34] would also take the slurry input into account; this would provide an incentive to use less fertiliser per se. A mitigation of farming nitrogen surpluses would reduce GHG emissions and improve water quality as well as the protection of biodiversity. With MINAS (‚Mineral Accounting System'), the Netherlands have introduced an individually calculated tax due on the nitrogen and phosphorus surpluses produced by each farm[35]. The Dutch experience has shown that a sophisticated monitoring system is needed to calculate this individual tax.

The funds raised by taxing imported nitrogen and protein feeds should be used for such purposes as the promotion of legume cultivation. The on-site cultivation of legumes for the production of protein-rich feeds releases nitrogen into the soil which subsequently planted crops can draw on. It is also important to encourage legume research, as this field has been almost completely neglected over the past few decades in Europe due to their only marginal cultivation. Only a permanent expansion of their cultivation will motivate the seed breeding companies to work on variety development (yield capacity, protein content, resistance of certain varieties).

Fat tax: In October 2011, the Danish government introduced a ‚fat tax'. It was the first country in the world to do so. It is a tax of around 16 Danish kroner (approx. 2.50 euros) that is levied on each 1 kilogram of saturated fatty acids. This makes food containing saturated fatty acids more expensive; the price for a packet of butter or half a litre of whipping cream, for example, has gone up by 30 to 35

cents, or just under 20%. Meat and cheese prices have gone up by three to six percent, depending on fat content. The experiences made with the introduction of a tax on saturated fatty acids in Denmark should be evaluated and the introduction of a similar tax in Germany should be considered, provided this turns out to have a positive impact on the environment (see also SRU 2012).

The phasing out of tax concessions for animal-based foods is another approach that addresses the demand side. In many countries, most meats and other animal proteins and fats as well as a range of other foods, currently attract a lower rate of value added tax. This is also the case in Germany, for example, where they are taxed at the lower rate of 7%. Although this has social reasons, the reduced rate value added tax must nevertheless be considered as negative, in view of the high climate burden and other adverse environmental impacts caused by livestock production. A climate-compatible diet should be rewarded, rather than a climate-harming diet. The lower value added tax rate regulations should be reviewed with ecological aspects in mind. Making animal-based food more expensive through the application of the full value added tax rate can motivate consumers to consume less animal-based products, and invite their substitution with plant-based products.

5.3 U-TURN IN EU AGRICULTURAL AND CONSUMER POLICIES

Linking public subsidies to the supply of public goods and services

The agricultural sector is the biggest subsidy recipient in the EU. At the same time, the legitimacy of the EU‘s common agricultural policy, which is the central redistribution and steering instrument in the agricultural sector, is increasingly being questioned. It is starting to look very much as if a consensus had been reached that reforms are necessary (SRU, 2009 S. 4). Focusing agricultural subsidies on the provision of public goods must be the guiding principle of the coming reform. Besides numerous environmental concerns, this would also lend the appropriate weight to climate protection in agriculture. Instead of subsidising climate-burdening products and production methods, the common agricultural policy should promote a low-emissions agriculture.

The European agricultural policy is the EU‘s most ‚communitised‘ policy field. With 56 billion euros, it is the EU‘s most substantial single item of expenditure, consuming 40% of Brussels‘ entire budget. The EU agricultural policy is based on two pillars whose first, which appropriates approx. 75% of the available funds, is designed to secure a fair standard of living for the agricultural community with the aid of direct payments. It also serves the implementation certain market measures. The second pillar promotes rural development both within and outside the agricultural sector, or at least, that is the intention! This refers to measures such as agricultural environmental programmes, including the promotion of organic farming (2nd key focus environment/landscape) and investment subsidies for modern technologies or production and processing methods (1st key focus competitiveness).

The EU agricultural policy actually already contains the structures needed to allow the entire Community to switch tracks in the area of land use. In the course of the first ‚agricultural forum‘[36], the Federal Environment Agency initially voiced its criticism of the transfer of income from the 1st pillar as early as 2001, and called for the granting of public funds to agriculture to be coupled with the rendering of public services in return.

The demand formulated in 2001 with respect to the European agricultural policy still applies: Public funds must be used for the production of public goods. In view of the rising world market prices, the income support farmers receive by way of direct payments loses its legitimacy. In the course of the imminent reform for the period 2014 to 2020, these direct payments should therefore be given an eco-component (‚Greening') that goes beyond the respective legal requirements. In the longer term, the pillar architecture must be replaced by a fund for the financing of agricultural environmental services. The direct payments must then be abolished; if necessary, their abolition could be accompanied by social cushioning measures. The current CAP reform process promises improvements that go in the right direction; however, fundamental changes such as the breakup of the pillar structure are not likely to be initiated until after 2020.

However, for as long as these direct payments continue to exist, they should be linked to cross compliance (direct payments-obligations) with regard to meeting the following ecological minimum standards (assuming their effectiveness has been verified): Restriction of the nitrogen balance, restricted livestock stocking rates, the conservation of permanent grassland, restriction of the maximum proportion of any one crop type on croplands, and the making available of ecological compensation areas. In addition, extensively used grassland areas are to be integrated into the first pillar's subsidy system (KLU, 2011). Further demands that go beyond these would be a minimum proportion of legumes in the crop sequence, the promotion of the exclusive use of on-site produced feeds in livestock farming and the payment of a grazing premium.

In its current position statement, the Agriculture Commission at the Federal Environment Agency (KLU) has stated that it believes the European Commission's published Common Agricultural Policy (CAP) regulatory proposals for the period 2014 – 2020 to contain

a number of good approaches. However, although this is essentially the case, a more detailed look reveals that they are rather half-hearted; it is therefore questionable whether they will in fact be sufficient to reach the goal of the reform (KLU, 2012).

Supporting the spread of adapted techniques and organic farming

Adapted farming techniques aim for the use of low-emission methods and processes that reduce the burden on the soil and the water supply and do not affect biodiversity. Recycling management plays an important role in adapted farming. Soil-friendly and water-saving cultivation methods (for example mulching or soil cultivation aimed at conservation) can minimise the release of carbon and lower the risk of erosion. Within the scope of an overall assessment of the sustainability of cultivation methods, the potentially conflicting aims of other environmental measures must be taken into account. The increased use of herbicides in soil cultivation methods aimed at conservation exposes local bodies of water to an increased input risk. A sustainable use of pesticides therefore calls for a reduction of intensive use down to the necessary minimum. In the EU, the framework Directive 2009/128/EC (‚Sustainable use of pesticides'), for example, calls for the use of pesticides in agriculture to be limited to an environmentally sound degree.

Organic farming is the best-known example of the use of adapted methods and procedures. It has gradually become an established agricultural cultivation system, although its practices are nevertheless considered to be undergoing constant further development. Organic farming is a dynamic economic strategy model in which ethical criteria which ensure that nature is interacted with in a by and large well-balanced way take precedence over the pursuit of economic efficiency and income generation. It is characterised by mainly closed nutrient cycles as well as the non-use of mineral nitrogen fertilisers and synthetically manufactured pesticides. In the area of livestock farming, organic farms are also subject to stricter rules than conventionally farmed agricultural enterprises. Organic farming is therefore considered to be a particularly resource-friendly and environmentally compatible form of agriculture (UBA 2002).

At a national level, the organic agriculture programme Bundesprogramm Ökologischer Landbau ought to be continued; at EU level, it should be assessed to what extent funds from the so-called second pillar of the agricultural policy are available for realising the European Action Plan for Organic Food and Farming more efficiently. Although its content has been agreed on paper, there is currently no specific allocated budget. In Germany, the demand for organic products currently already considerably exceeds local production capacities. For the time being, the key focus of the measures for the promotion of organic farming in Germany should therefore lie in subsidising the conversion of existing farms in order to utilise the potentials the existing demand offers as far as possible for domestic organic farming enterprises.

> Organic farming is the best known example of the use of adapted methods and procedures.

Above all, organic farming also unlocks opportunities for the southern countries suffering from food insecurity. To meet the growing demand for biomass, land yields must be increased. An ecologically compatible intensification of agriculture offers much scope for increasing productivity, particularly in the developing countries[37]. To achieve this, the use of the existing techniques and systems should first be optimised (closure of yield gaps through research, education, advice and improved access to capital for smallholders) before new ones are developed and implemented. Particularly in cases of low soil fertility, remote location (bad transport connections), or a lack of capital and of cheap labour, an awareness of the principles of organic farming can help to improve soil fertility and soil water retention capacity, and thereby the yield capacities as such. Implementing further measures for the mitigation of greenhouse gas emissions and also for the adaptation to climate change calls for substantial investments into the infrastructure, into the monitoring of weather extremes, and into the development of early warning systems and

disaster risk reduction strategies. Adaptation measures include, for example, increasing the diversity of production methods and on-site structures, a more efficient use of limited water resources, the development of drought-tolerant crops, the use of tree varieties which are particularly resistant to fires, storms, and climate change, and the planting of species-corridors to encourage species migration. The conservation of grassland and peatlands as CO_2 stores (tilling ban) is also an important climate protection measure.

Intensifying agricultural cultivation systems in a an ecologically sound way

At the same time, sustainable agricultural productivity increases are also an urgent requirement, above all in the southern countries. Increased agricultural production and improved storage facilities are of primary importance for regions and people subjected to food insecurity, particularly for smallholders. In this situation, an increased supply leads to improved food availability, sinking consumer prices and higher incomes for the producers. The reduction of food waste in the industrialised countries, and of postharvest losses in regions with uncertain food security, increases the availability of food for consumers per se.

In the IAASTD‘s renowned 2008 report on global agriculture, a number of scientists confirm that if the present opportunities were fully exploited, there would be sufficient food available to not only feed the 7 billion people currently living on Earth but also the world population of 9 billion forecast for 2050 (IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development), 2008). In this respect, the so-called smallholders and their support in order to guarantee food security will play a key role in future. To achieve this, an ecologically compatible productivity increase of the agriculture in the southern countries is an important factor. Independent of this, the agricultural systems prevalent in the industrialised countries (production and consumption) must be systematically converted in order to reduce the existing negative ecological impacts and social distortions.

Educational support, advice and the granting of microcredits can contribute to increased productivity and increased efficiency through the use of more up-to-date techniques. The promotion of crops which have so far been neglected, improved soil farming, the upgrading of degraded cropland, and the avoidance of postharvest losses and food losses through better storage facilities are starting points which, taken all together, can contribute to the improvement of the global food situation.

5.4 ESTABLISHING STRUCTURES FOR THE EFFICIENT USE OF BIOMASS FOR INDUSTRIAL AND ENERGY GENERATION PURPOSES

Expanding industrial biomass use – multiple use
With the Biomass Action Plan (Bundesregierung, 2009), which includes the action plan for the industrial use of biomass, the federal German government has proven its commitment to increasing the efficiency of industrial biomass use. The resultant growing biomass demand is faced with a limited potential of available biomass. The available biomass should therefore be used several times over and highly efficiently in order to achieve the set sustainability goals as best as possible. This leads to the conclusion that biomass, prior to being used to generate energy – must initially be used as industrial feedstock – i.e. for the manufacture of products. Instead of the currently prevalent cultivation of biomass for direct conversion into bioenergy, a system for cascading utilisation should therefore be established in future, i.e. biomass should be recycled several times before the resultant waste and residues are used to generate energy.

‚Cascade utilisation‘ refers to a raw material recycling strategy, or the recycling of products manufactured from these raw materials, in order to allow them to be used several times over in a cascading sequence as efficiently and for as long and as often as possible, and only use them to generate energy at the end of the feedstock lifecycle. During this process, the respective feedstock runs through so-called cascade utilisation, i.e. it is used at gradually decreasing value creation levels. This increases raw material productivity (Umweltbundesamt, 2012).

One utilisation cascade already partially established is the recycling of wood. Initially, wood is turned into furniture or timber for construction purposes, for example. At the end of these usage cycles, it serves as the basic raw material for the engineered wood industry, provided it is conformant with the legal requirements[38]. It is used to generate energy only after the product made from this particular, already recycled raw material reaches the end of its lifecycle. Ideally, the raw material is used several times over after each cascade stage through recycling. Utilisation cascades for other raw materials (for example bioplastics) remain to be established. Paper recycling is also an illustrative example for the efficient and multiple use of biomass. Under optimum conditions, wood fibres can be used up to six times for paper production. This considerably reduces the respective demand for wood, water and energy.

Another concept for efficient biomass use currently increasingly discussed is the simultaneous creation of industrial feedstock and products for energy use as well as food and fodder through the utilisation of the whole plant in so-called biorefineries. In 2012, the federal German government published a ‚Roadmap Biorefinery‘[39] in order to advance these concepts. However, many of these concepts are currently still only at the research and development stage; it is therefore not possible to assess them comprehensively at this moment in time. As yet, it is particularly difficult to determine the ecological advantages offered by the products manufactured in this way in the course of their entire lifecycle.

In cooperation with those involved in the respective research and industries, the federal German government should therefore continue to fully exploit all options in order to design the use of biomass as sustainable and efficient as possible (subsidy and incentive programmes etc.) and advance the establishment of the respective usage cascade structures.

Currently, Germany imports around two-thirds of the agricultural raw materials used as industrial feedstocks; above all ‚traditionally‘ used biomass such as plant oils, cotton and other natural fibres and natural rubber (Carus, et al., 2010). These raw material imports have often been pre-processed, or they may even be semi-finished products that have already been pre-treated in their country of origin or in third countries. The targeted promotion and implementation of modernisation strategies in the respective countries and technology cooperation or technology transfer represents an important potential contribution to efficient, sustainable and environmentally sound biomass use, both in terms of biomass cultivation as well as its industrial use.

Realigning bioenergy production in Germany

Looking at the global population growth trends in conjunction with, on the one hand, the changing dietary habits and energy consumption levels that are approaching those of the industrial countries and the progressive global environmental problems (climate change, loss of biodiversity, impairment of ecosystem functions and ecosystem resilience etc.) and the dwindling resources (water shortages, salination, erosion, gaps in the phosphorus supply etc.) on the other, it becomes clear that productive land will gradually become an increasingly scarce and valuable resource whose exploitation demands careful consideration, in view of the environmental and social impacts.

We have illustrated the fact that the use of cultivated biomass as a contribution to the energy supply lays claim to disproportionately extensive amounts of cropland, and that the amount of land needed for bioenergy generation far exceeds the amount of land needed for wind and solar power generation. This also applies even if there were a willingness to accept the cost of the ecological consequences of a further intensification of the local agriculture. Wherever possible, energy from cultivated biomass should therefore be replaced by these alternatives, providing there are no other good reasons to the contrary.

> The input issues (where will the biogenic raw materials come from?) are often sidelined with reference to the value of bioenergy as a regulation and storage medium.

The analysis in Chapter 4.5 has revealed that in many areas, we can largely do without bioenergy. Due to the extremely limited potentials of bioenergy, technologies for the conversion of wind and solar power into chemical energy carriers will be needed in any case. On the one hand, these must then be capable of fulfilling regulation and storage functions within the energy system[40] and, on the other, they must be suitable for use in the transport sector as an – equally renewable – alternative to biofuels besides electric mobility.

The input issues (where will the biogenic raw materials come from?) are often sidelined with reference to the value of bioenergy as a regulation and storage medium. Of course it is true that bioenergy, in terms of its properties, is fundamentally suitable for balancing fluctuating renewable energy sources. However, as its potential – as illustrated – is extremely limited, bioenergy can never make the requisite contribution to fully covering the supply of the electricity as and when needed in any case. Also, this potential benefit does not justify the careful avoidance of the resource issue. Again the rule applies that the benefits of bioenergy should be limited by the potential environmental and social advantages and not vice versa. However, the less problematic biomass waste and residues should be used for the generation of regulation and storage energy. Biogas improved to natural gas quality should be used to advantage within the existing infrastructure.

The Federal Environment Agency is therefore of the opinion that the use of cultivated biomass, including raw timber, for energy generation should not be expanded further. Beyond this, strategies and measures should now be developed and initiated in order to be able to completely dispense with energy from cultivated biomass in the medium and long term (excepting energy from conflict-less biomass potentials, see Ch. 4.2).

In contrast, the recycling of organic residues and waste biomass[41] for energy generation must be advanced. Their use does not lay claim to any additional land and, as far as we are currently aware, it does not have any serious negative impacts on the environment – providing care is taken to ensure that nutrient and particularly humus balances are not adversely affected by this additional biomass extraction. The use of waste materials and residues particularly merits promotion if it is accompanied by additional positive side effects. This is, for example, the case in slurry fermentation[42].

This[43] results in the following recommendations for the definition of energy policy goals:

1. short term: No further expansion of first generation biofuels and biogas plants on the basis of ecologically unsound biomass[44],
2. medium term: Moving high-value raw material inputs and croplands to alternative, less problematic raw materials and land areas; if at all possible to land that does not provoke land use competition or that is to be preferred for other protection reasons,
3. short to medium term: De-escalating usage conflicts and preparing a basis for the establishment of utilisation cascades through increased R&E measures for the development of marketable production technologies for the so-called 2nd generation, or biorefinery concepts for the efficient use of residues and waste materials,
4. realisation of the needs-oriented input of electricity generated from biomass in order to balance wind and solar power fluctuations,
5. long term: R&D into alternative RE and storage technologies, particularly ‚power-to-gas' technologies,
6. long term: For the most part abandoning the cultivation of biomass for energy generation if this releases productive sites or sites that should primarily be used for industrial biomass cultivation purposes; if at all possible, exclusive use of non-objectionable biogenic raw materials.

The outlined transformation can be brought about in part by a respective adaptation of the REA; however, it should also be accompanied by agricultural policy directives. Although the latest amendment of the REA provides clearly stronger incentives for the use of waste materials and residues than the previous versions, and does not drive the use of cultivated biomass to the same degree as before[45], it is as yet difficult to assess whether this comparatively marginal alteration of the incentive structure will develop sufficient impact. We believe that the feed-in tariff currently paid for Class I input materials[46] is still too high, and that it ought to be completely dispensed with in the course of the next amendment for the sake of consistency. The current path in favour of the use of waste materials and residues must be advanced more clearly in order to establish the preferable cascade utilisation. Using waste materials and residues not only equals the implementation of the respective energy supply goals but also a practicing of certain principles with regard to, for example, waste treatment or nature conservation.

For bioenergy plants that are already in operation, an incentive structure should be created to make the switch from ecologically and socially disadvantageous raw materials, land use and cultivation systems to less objectionable raw materials lucrative.

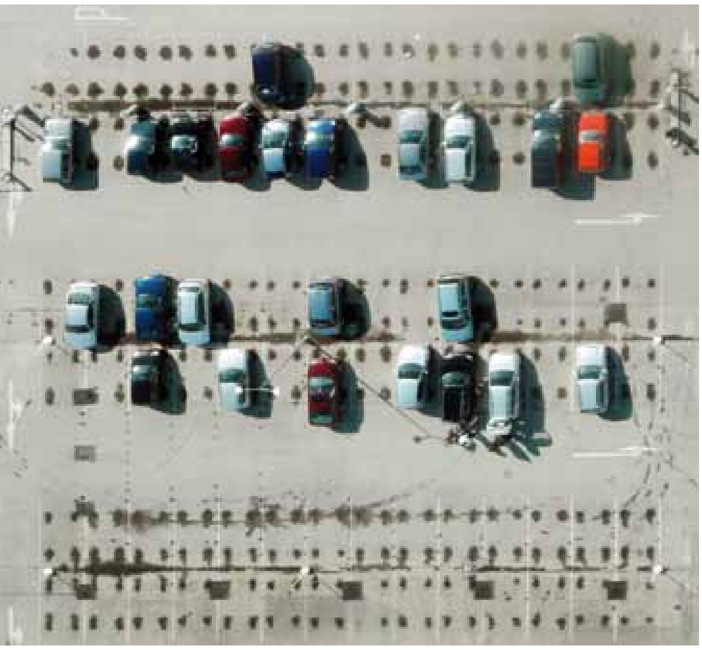
Optimised mixed wild herb crops, mixed crops, specialised crops such as cup plants[47] or hedgerows should replace problematic crops in order to reduce the environmental costs, even at the expense of area energy yield. Beyond this, further options for conflict-less biomass extraction from measures that primarily serve other protective purposes such as, for example, paludicultivation, should be tested and intensified through appropriate subsidies, as well as accompanied by ecological and economic research[48].

In order to avoid the further stimulation of the unfavourable global dynamics resultant from the policy-driven expansion of modern biomass use, the national and international quotas must be amended. The targets should be brought in line with the amount of verifiably non-objectionable biomass on offer (i.e. primarily residues and waste materials), rather than attempting to increase the production levels up to the (too) ambitious targets.

Energy scenarios and strategies should mostly refrain from including imports, as it seems unlikely that it will be possible to adequately, i.e. fully, monitor compliance with sustainability standards in the production of biomass even in the future, particularly in non-European countries (see Ch. 5.5), and the available potentials could be needed by those other countries to meet local demand. It should further be examined whether subsidies should be granted only to specific raw material groups which do not lead to land use conflicts and do not cause any indirect land use changes.

Even if an amendment or abolishment of certain set targets currently seems unwise for political reasons, the present, problematic path must not necessarily be pursued further. The current European policy framework still provides plenty of scope for a containment of the adverse consequences of the current bioenergy dynamics. This should be fully exploited, which calls for strategies and solutions with regard to how this could be met if other paths are followed:

- In the transport sector, the GHG savings quota, or the minimum quota of renewable energies (RE) stipulated by the EU, could and should not be achieved through the absolute increase of biofuel volumes but through the reduction of the transport sector's total consumption of energy, for example by means of more efficient vehicles. This would increase the relative proportion of biofuels (and other RE technologies) whilst the absolute volume would remain stagnant.
- The RED also permits the achievement of the RE minimum quota through electric mobility. As already illustrated in Chapter 4.5, the Federal Environment Agency considers full or partial battery electric mobility to be an important option in terms of energy utilisation in the transport sector, as well as hydrogen and fuel cell systems on the basis of RE electricity. Rather than permitting the problematic path ‚1st generation biofuels' to become entrenched on the strength of the respective subsidies, the research into and development of these, from a social and ecological perspective more sensible, technologies should be advanced.
- The biofuel quota in the German national legislation (§ 37 a BImSchG) is still questionable even in the revised version, which focuses on GHG emission mitigation. However, although the intention of providing an incentive for the use of biofuels that are low in GHG emissions by changing the relative minimum quota of biofuels into a minimum GHG saving (applicable as of 2015) is essentially to be welcomed, this revision could turn out to be counterproductive. If, for example, iLUC-emissions (see Ch. 4.4) are taken fully into account, and this results in correspondingly lower potential GHG savings per unit of biofuel, this could lead to the potential GHG savings being achieved through a considerable expansion of the proportion of biofuels in quantitative terms.



The UBA therefore not only believes that the efficiency must increase as soon as possible, but also that the biofuels quota must be abolished, or that it must be substituted as soon as practicable, either with a quota for the overall proportion of renewable energies or a (technology-independent) minimum GHG savings quota in the transport sector, which would then have to be met with other RE technologies.

Practical measures to achieve the above mentioned targets could be:

BIOFUELS

Nationally:

- short term: Freezing the national biofuel quota at the currently realised admixture amount (or, even better, slightly below this),
- short term: Monitoring compliance with the biofuel quota as per § 37 BImSchG in three year intervals (rather than annually), purpose: price peak compensation,
- medium term: Gradual lowering of the biofuel quota to a level that allows its achievement solely through the use of non-objectionable raw materials. This should be ensured through the introduction of a progressively increasing sub-quota for the use of waste materials and residues and ‚special raw materials' (plants which are particularly important for nature conservation, green landscape maintenance waste etc.) up to ultimately 100 % of the biofuel quota; purpose: providing an incentive for getting the second generation technology market-ready,
- medium term: Technology-independent renewable energy (RE) quota in the transport sector analogue to the EU Commission's stipulations,
- NREAP (National Renewable Energy Action Plan): To achieve the RED's RE target despite the stagnation and long-term degression of 1st generation biofuels requires a review of the strategy to make it possible to meet this target. In this respect, the foremost priority should be efficiency and thereby the reduction of the total demand, not least in order to reduce the requisite absolute RE contribution. Beyond this, rail transport should show a certain quota of electric mobility powered by RE.

At EU level:

- RED: Renewed urging for iLUC inclusion,
- NREAP: The EU Commission should call on the member countries to review their NREAPs with the aim of achieving the RE quota not primarily through biofuels,
- Fuel Quality Directive (FQD): The EU Commission should extend its R&D programmes on electric mobility, e-methane etc.

R&D

- Pushing ahead with the use of battery electric vehicles and hydrogen/fuel cell drives,
- clear prioritisation of the promotion of power-to-liquid R&D (supply of liquid e-fuels from regeneratively generated electricity (along the lines of power-to-gas procedure),
- more effective promotion of R&D into the provision of 2nd generation fuels from residues and waste materials.

BIOGAS

Next REA amendment:

- New plants: Abolishment of the Class I input materials feed-in tariff (EVK); these are primarily renewable raw materials (RRM), if necessary through the re-categorisation of some ecologically non-objectionable materials such as, for example, moving the fodder beet bonus to EVK II, which would automatically prohibit the use of renewable raw materials in new plants[49]; goal: preventing a further policy-based expansion of areas dedicated to the cultivation of renewable raw materials (particularly maize) for biogas,
- For existing plants: Design an attractive conversion offer for the feed-in tariffs; new feed-in tariff structure with a more substantial difference between EVK I & II, i.e. it will probably only be possible to increase the EVK II feed-in tariff (ecologically more advantageous materials); purpose: Making the use of more environmentally sound substrates more attractive than renewable raw material fermentation[50],
- Needs-oriented input: Assessment of whether the REA 2012 incentive structure (market bonus and flexibility bonus) develops sufficient impact and whether, if necessary, accompanying measures must be taken to meet the objective.

R&D:

- Clear prioritisation of the promotion of power-to-gas technology R&D (generation of e-hydrogen and e-methane from regenerative electricity), as these alternatives are more flexible and, in the long term, harbour greater potential than biogas plants as far as the regulation energy market is concerned.

5.5 CERTIFICATION – THE AMBIVALENCE OF RISK AND OPPORTUNITY

The certification of products and production methods offers certain opportunities for steering the production of (agricultural and forest) commodities into a socially and environmentally sounder directions, but it also has clear limitations. If a certification scheme is to have a positive impact in the long run, its criteria must on the one hand be adequately designed in terms of content, and on the other the reliable monitoring of these standards must be ensured. If, for example, the criteria on which the assessment depends cover only some parts of what the concept of sustainability entails, or if the requirements for meeting the criteria are too undemanding and inappropriate, they are unlikely to have the intended steering effect on the production to the requisite degree (‚low-level standards'). In contrast, if sophisticated standards are not verified to the required degree (for example through external monitoring), or the sanction mechanisms are ineffective, then the credibility of a certification scheme is not adequately given. A ‚too much' of systems and labels with varying degrees of ambition can also negate the desired orientation and steering effect through confusion and ‚unfair competition', unless the respective minimum level is backed up by regulations. This is the case, for example, for organically farmed food, where the respective Council Regulation (EC 834/2007) provides such reassurance.

Ultimately, even a highly sophisticated and credibly monitored (sustainability) certification scheme cannot solve the quantity issue, which is actually a distribution problem.

Dysfunctional certification schemes, i.e. those which contain either incomplete or ineffective criteria or schemes where the verification procedure is not sufficiently reliable, harbour the principal risk of suggesting an advantageousness that is de facto not given (so-called ‚green washing'). This harms consumers and – if existing – alternative, ambitious initiatives.

Inherent limits: Biomass supply sustainability certification differs from the certification of unusual products and production methods. Land use impacts and correlations are complex, and in part quite difficult to translate into the kind of quantifiable and practicable criteria and indicators requisite for certification. Many of the negative consequences do not take the form of a measurable event on the respective land but occur only at other levels or in the course of interaction with other factors. This means that in this respect, it is difficult to identify effective indicators for the agreed principles. One example of this is the challenge of dealing with shifting or displacement impacts, the protection of biodiversity or the guaranteeing of the right to food at a farmer or woodland manager level.

If the legal obligation to prove compliance with adequate, uniform standards with regard to the protection of humans and nature were successfully introduced for the entire biomass supply (including industrially used biomass as well as food, fodder and feed) at a European level, it would give the market a clear signal and would also be an obvious incentive to improve both the domestic as well as the international production. However, there would nevertheless be a risk of the sounder potentials being used for the European market, whilst agricultural and forest products of a less sound origin would be used to satisfy the demand elsewhere. I.e. at the end of the day, the desired effect would, in the worst case scenario, be marginal.

All stakeholders (politicians, consumers, producers etc.) must be aware of these inherent limits to certification. Certification provides information on whether certain criteria were complied with in the production process. Ultimately, even a highly sophisticated and credibly monitored (sustainability) certification scheme cannot solve the quantity issue, which is actually a distribution problem. Even if it can be ensured in specific cases that the respective agricultural commodity was indeed produced environmentally-friendly and under

consideration of the local workers' rights, a high demand in the rich countries can in fact bear the risk that those whose needs are not backed up by purchasing power have to go without the respective supplies. Ensuring that the needs of present and future generations can be met, which is one of the key principles of sustainable land use (see 1.2), cannot be achieved through certification. This must be solved in another way. Certification is therefore a necessary precondition for the assessment of agricultural produce and forest products, but it is not sufficient as such.

Sustainability certification of biomass for energy use

There are numerous voluntary or binding certification initiatives in the bioenergy production industry for setting certain sustainability standards and ensuring compliance with these, not least due to the increasing pressure related to public acceptance.

For example, the globally-focused Global Bioenergy Partnership (GBEP), which consists of high-ranking stakeholders from 23 partner states (including the major bioenergy trading states) as well as 13 international organisations, agreed 24 sustainability indicators for bioenergy production in late 2011. The GBEP hopes to raise the international awareness of these indicators to an even greater degree, and to contribute to the realignment of the political framework conditions for the development of the bioenergy sector with ambitious sustainability criteria in the long term.

Beyond this, ISO standards that comply with international trade law, meaning that their respective implementation could attain far-reaching legality, are currently being developed. At the moment, it does not look as if the present process for negotiating a standard for the use of biomass for energy generation is likely to achieve satisfactory results with respect to an effective protection of environmental resources and ecological functions, or the safeguarding of human rights and the protection of vulnerable sections of the world population.

The sustainability requirements for liquid biomass and biofuels have been defined in the EU-RED. The member states may count the respective bioenergy contribution towards the achievement of their biofuels quota or greenhouse gas savings targets and subsidise the respective production only if these criteria are complied with. This also applies to imported and liquid biofuels. Amongst other stipulations, the directive includes the stipulation that certain areas that are worth protecting may not be used for biomass generation. For example, biomass may not originate from land gained through deforestation, or land designated as grassland with a high level of biodiversity, or land made available through the drainage of peatland[51].

Assessment: In terms of content, the RED criteria are as yet incomplete. They should, for example, be extended to include water and soil protection criteria, methods for taking indirect effects into account, and various social criteria. The fact that the requirements in relation to the CAP only apply to biomass cultivated within the EU is also a flaw. The RED criteria are nevertheless an interesting first step towards an initial assessment with regard to the development of binding sustainability criteria, providing the requirements are expanded to include other application areas in order to prevent shifting effects.

Implementation of the RED sustainability requirements: Commercial certification schemes monitor specific producers in order to ascertain whether the sustainability criteria have been met. These would in turn first have to be approved (‚accredited') by the EU: The EU Commission has already accredited numerous voluntary schemes. Eight of these schemes can already be applied Europe-wide or worldwide in order to verify the compliance with RED criteria. A further 18 schemes are awaiting accreditation. The various schemes differ widely from each other with respect to their content-related requirements, their practical monitoring requirements (‚credibility'), the actors involved, the raw materials analysed, their spatial focus etc. Both the large number of accredited schemes and their complexity as well as their specific designs attract increasing criticism. There appears to be a tendency for scheme providers to attempt to gain a competitive advantage by interpreting the requirements as loosely as possible.

Germany has implemented the RED in the form of national legislation through the ordinance on requirements pertaining to sustainable production of bioliquids for electricity production (BioSt-NachVO) and biofuel sustainability (BioKraftNachV). The Federal Office for Agriculture and Food (BLE) is responsible for the monitoring of the respective certification schemes.

Assessment: The UBA considers the implementation of the directives at a European level as generally still unsatisfactory, as this has led to the emergence of a number of certification schemes, some of which must be considered to be not sufficiently credible. Not all schemes call for external monitoring, for example. It remains to be seen how the situation develops and what steps the EU Commission will take. An evaluation of the effectiveness of the sustainability requirements on the basis of empirical data is therefore still outstanding. Despite the numerous positive partial results within the scope of the discourse on how the production could be designed more environmentally and socially sound, it is starting to appear obvious that voluntary approaches cannot replace binding legal directives but are in fact rather the precondition for ensuring that certain environmental and ethical minimum standards are adhered to in the production process.

Expansion of certification to include solid and gaseous bioenergy carriers

At present, there are no sustainability requirements for the production of solid (e.g. wood chips) and gaseous (e.g. biogas) bioenergy carriers for power and heat generation, neither at a European nor at a national level. The UBA believes this must be remedied as soon as possible, and that the respective criteria must be as ambitious as possible. The respective competency regarding the issuance of a directive for power generation from biomass has already been conferred in § 64b of the REA 2012.

The UBA believes it to be of central relevance that the conservation of nutrient and carbon stores in the respective local soils is bindingly stipulated for solid biomass (e.g. wood and straw) as a precautionary measure. Key issues here are, amongst other aspects, the conservation of the sink function of forests and organic soils as well as the protection of the important functions of agricultural and forest residues in order to maintain soil fertility. Beyond this, the biodiversity in the environments explored for these purposes must be better protected through respective rules and regulations. In this respect, management rules that ensure this are as important as binding regulations on land ownership and usage rights, as these are frequently overlooked, particularly in view of the fact that the local population may use the various forest resources in a wide variety of ways. At the very least, existing sustainability criteria should also be applied to gaseous energy carriers for power and heat generation.

Remediable biomass certification deficits
Comprehensiveness: As far as the certification of biomass for energy generation is concerned, one currently still outstanding yet principally resolvable accompanying measure is the extension of the respective principles to include all aspects of the sustainability concept. In many cases, it is difficult to directly relate some of the central elements of the guiding principle, such as food security and biodiversity protection, to the issue on hand. This problem could be solved through the integration of preventative measures.

A further challenge that seems surmountable is the consideration of GHG emissions caused by indirect land use changes. Their inclusion is necessary in order to realistically assess the impact of biofuels and other bioenergy carriers on the global carbon cycle. According to the most recent findings, the contribution bioenergy makes to GHG mitigation may well be significantly lower than originally thought. In some cases, the emissions may even exceed those of the substituted fossil equivalent (see also Ch. 4.4). These findings must not be ignored or even negated, but serve to highlight the urgent need for political action.

Verification: In as far as there are deficits, these can easily be overcome, assuming the respective protagonists' willingness to do so. In this respect, an independent verification by third parties is fundamentally to be preferred over forms of voluntary commitment or mutual assessment by the responsible market participants. Any exceptions should always be acceptably justified and, if possible, contain additional appropriate monitoring mechanisms. The frequently cited argument of excessive administrative efforts and costs can no longer be accepted as an adequate argument for the foregoing of external monitoring; in fact, the aim of a certification which those concerned find credible and transparent must be the central issue.

Participation: Considering the specific characteristics of each region and the wide range of needs and interests of the various stakeholders particularly in complex, global production chains, it is also important to ensure that those representing the interests of the (local) stakeholders are involved to a sufficient degree in the setting of the respective standards. Especially for global processes, it would be desirable if the local expertise were taken on board when determining the principles, criteria and indicators, and was thus made verifiable within the scope of an obligatory impact assessment of existing and planned projects.

Emissions trading – development of sustainability standards for biomass
The emissions trading scheme treats biomass users preferentially by releasing them from the obligation to issue emission allowances. However, in the case of liquid biofuels, this exemption only applies if they have been sustainably generated in accordance with RED stipulations. In contrast, no such standards currently apply to solid and gaseous biomass. In emissions trading, they are therefore still exempt from the obligation to issue emission allowances, even if they have not been produced sustainably.

> The UBA believes it to be of central relevance that the conservation of nutrient and carbon stores in the respective local soils is bindingly stipulated for solid biomass (e.g. wood and straw) as a precautionary measure.

The accordingly continual incentives due to the lack of valid RED sustainability criteria for also using non-sustainable solid and gaseous biomass in emissions trading must be eliminated. In view of the likely intensified use of solid and gaseous biomass, it is therefore necessary to extend the application area of the RED, and to stipulate ambitious and binding sustainability criteria for these forms of biomass, too. If they do not comply with these criteria, their use in emissions trading must no longer be exempt from the issuance obligation. The presently already considerable use of biogenic waste materials plays a special role in emissions trading. This is generally to be welcomed, and should not lose its special status due to the lack of proof of sustainability. On the other hand, it must be ensured that the non-permissibility of offering incentives, as regulated in the RED, is not circumvented by declaring non-sustainable biomass as waste. Reliable certification schemes are therefore needed, which allow the recyclers of biogenic waste materials to prove the sustainability of these materials also at the very end of cascade utilisation.

The purchase of emission allowances though international climate protection projects: International climate protection projects are aimed at a more economical generation of emission allowances. Providing these allowances are issued for the cultivation or use of biomass and are then subsequently used to meet the European emissions trading issuance obligation, they also represent a financial incentive that does not contravene the Renewable Energies Directive. For international climate protection projects, the volume of allowances for emission mitigation that is to be issued is always reduced by the emissions beyond the project limits, and therefore also beyond the so-called upstream chain. For projects that use biomass, this means that for example the emissions caused by the transport from cultivation area to user are deducted from the volume of allowances issued. Further sustainability aspects are already partially taken into account through the criteria for arable land. In the medium term, the aim should be to bring these in line with the revised, more ambitious sustainability criteria recommended in this report.

Also, whenever new international climate protection instruments are designed, they should set ambitious criteria for the sustainability of biomass use at an early stage.

5.6 ECONOMIC, TRADE AND DEVELOPMENT POLICIES

Closer supervision of the trade in agricultural products

Over the past few years, the global food markets have been marked by rising and increasingly volatile prices. According to an analysis by the International Food Policy Research Institute (IFPRI), this development was driven mainly by the increasing use of agricultural products for the manufacture of fuels, the increased frequency of extreme weather events due to climate change, and an increase in commodity forward contracts pertaining to agricultural goods (von Grebmer, et al., 2011). In 2008, the OECD[52] already predicted that the growing volumes of commodity forward contracts would be a new and permanent price volatility factor. Their impact is intensified by the fact that the majority of the staple foods traded on the world market is produced in only a few countries. Local crop failures and political decisions can therefore have extremely serious consequences[53]. Over 70 % of maize, and also of rice, is grown in only five main cultivating countries. Prices can also be drastically affected by important export countries limiting their exports when shortages seem imminent. According to IFPRI, up to 30 % of the price increases over the first six months of 2008 can be ascribed to trade restrictions. This is exacerbated by the fact that the globally available grain reserves are at a historic low, and there is currently no realtime information on the volumes of food globally available, which could prevent overreactions to moderate fluctuations in demand and supply (von Grebmer, et al., 2011).

To counteract the problem of excessive volatility, measures must be taken that, on the one hand, address the causes of price peaks and, on the other, ease the frequently fatal dependency on food prices vulnerable sections of the world population are subjected to.

A transparent trade with agriculture-based financial products can contribute to safeguarding against price fluctuations and mitigate some of the risks, thereby ensuring market stability. Over the past few years, the number of financial transactions that are based on agricultural raw materials has grown considerably[54]. In this way, financial actors such as banks, agricultural raw material based funds or hedge funds have gained more influence

over prices. Ultimately, however, the financial actors cannot influence the prices in the long term. Although there is still some danger that the increasing number of agricultural raw materials based financial products, in conjunction with lacking market transparency, encourage an intensified price volatility.

However, due to their essential import for the health and the survival of the poorest, agricultural raw materials are not an investment form like any other. Such agricultural raw materials based financial products should therefore be subject to much stricter regulations. The commodity futures markets must fulfil their original function of outbalancing risks again, and business sectors that evidently pose a risk to the food supply for the poor must, if necessary, be prohibited.

The European Commission has initiated steps for mitigating the impact of extreme food price fluctuations through increased controls and more transparency in the trade with agricultural goods. This particularly includes a control of the off-market trade, which is currently completely unregulated and non-transparent. What is also important is that the reporting becomes more transparent. For example, issues such as how the reserves are stored in the individual countries, how much of these reserves are in private hands and what the government-owned proportion is etc. are vitally important for combating hunger and should therefore be openly revealed and discussed for ethical reasons. The decline in government-owned reserves over the past few years suggests that they are mainly in the hands of businesses. If their reporting on the volume of stocks held is not sufficiently transparent, the overall information regarding the global supply situation becomes inadequate. Any regulation must therefore be aimed particularly at preventing speculation on the basis of insider information, market influencing and manipulation.

To help people to protect themselves better against the impact of high and instable prices, social security systems must be strengthened further, and the international community's respective competencies must also be improved to allow effective action in emerging crisis situations, such as the 2007/08 and 2010/11 price crises. Economic and trade policy should be in line with the aims of the development policy goals, rather than counteracting these.

Regulate land grabbing

Existing approaches which address and steer international land acquisition, large-scale land sales to investors (land grabbing) and land speculation (acquisition of land for the purpose of reselling after value has increased) should be supported and advanced further.

As hunger is primarily a rural problem (70% of those suffering from permanent hunger live in rural areas), and around 40% of the world population rely mainly on farming to survive, hunger can often be overcome only through regional self-sufficiency. The access of the rural poor to soil, water and other means of food production is the deciding factor when it comes to implementing the human right to food. The chances for national food self-sufficiency are greatly diminished if a nation‘s land is no longer available for domestic food production. This in turn increases the dependency on expensive food imports. Considering the social, ecological and economic challenges, land grabbing must be exposed and controlled. The FAO‘s respective activities (development and implementation of the voluntary guidelines) as well as the relevant efforts undertaken by the World Bank, some governments and also non-governmental organisations must be accelerated and supported. The federal German government must continue to actively support the implementation of the Voluntary Guidelines on Responsible Governance Tenure of Land, Fisheries and Forests in the Context of National Food Security.

Cooperative efforts with regard to food security

Due to the worldwide competitive land use situation, particularly in the agricultural production sector, any opportunities for intervention are frequently limited by local laws and tax-based leverage (problem WTO). Competition in other areas of the economy through, for example, comparative cost advantages leads to production relocation, which frequently results in the export of environmental burdens. To prevent such effects and extend the scope for government legislation, treaties defining, for example, comparable standards for products or production methods, should be agreed with major trading partners.

The correlation between economic performance and hunger is a negative one. Countries with a high gross national income (GNI) per capita, which is an important benchmark for economic performance, usually have lower world hunger index (WHI) values, whilst countries with a low GNI per capita tend to show higher WHI values. Although this is not always the case. Conflicts, diseases, unequal income distribution, bad governance and the discrimination of women are factors which can make the hunger situation in a country worse than indicated by the GNI. Vice versa, sweeping economic growth, a strong agriculture and improved gender equality can raise the hunger index above the value indicated by the GNI. Government policies should also increasingly take the indirect causes of malnutrition and hunger (such as limited access to healthcare as well as inadequate provision practices and dietary habits) into account, as these are exacerbated by poverty and a lack of gender equality. Strategies for combating poverty that are aimed at reducing inequality are therefore as much a part of fighting malnutrition in early childhood as political measures for improving the healthcare and food situation, and the social status of women and girls (FAO 2011a and b).

Educational support, advice and the granting of microcredits can contribute to increased productivity and increased efficiency through the use of more up-to-date techniques. The promotion of crops which have so far been neglected, improved soil farming, the upgrading of degraded cropland, and the avoidance of postharvest losses and food losses through better storage facilities are starting points which, taken all together, can contribute to improving global food security.

Ecological and socio-economic further development of international trade law

According to Article XX GATT 1994, environment-related regulations are recognised international trade restrictions.

Article XX paragraph (b) states that ‚nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures necessary to protect human, animal or plant life or health‘. In addition, Article XX paragraph (g) permits the undertaking of measures relating to ‚the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption‘. Trade restrictions on the basis of social and other human right protection aims are controversial (Fritsche, et al., 2010).

How the term ‚like products‘ is to be interpreted has been the subject of an ongoing dispute between the member states. According to GATT/WTO regulations, ‚like products‘ may not be treated discriminatorily. Which criteria are decisive for products to be categorised as ‚like‘ or ‚unlike‘ has also been a controversial issue that the various WTO Panels cannot seem to agree on; or rather, it is an issue still not resolved to everyone‘s satisfaction. Particularly one issue that is extremely relevant for environmental protection, namely whether environmentally damaging impacts of production and processing methods that do not leave any traces in the finished product justify an exemption from the obligation to equal treatment remains unresolved.

According to the current status of WTO legislation, environmental protection is not an independent product differentiation criterion (Panizzon et al., 2010). The WTO‘s Appellate Body (2010) comments on this decisive but unresolved issue as follows: „For instance, governments may want to discriminate between wood products derived from sustainably grown forest and wood where the production method is unknown. Under such a scenario, the determination of the likeness of the two types of wood may be particularly challenging‘ (WTO, 2010).

That it is certainly possible to differentiate on the basis of production and processing method aspects whilst complying with the WTO regulations is exemplified by the TRIPS agreement (‚Agreement on Trade-Related Aspects of Intellectual Property Rights‘), which differentiates products according to their compliance with or disregard of copyright infringements in the course of their production.

The international trade law and the institutions of the WTO must be developed further and reformed in order to give more relevance to overriding issues which concern everyone involved, such as the Development Goals, environmental and climate protection. Free trade must be brought in line with ecological and social minimum standards, and must not stand above these, as is currently the case.

5.7 POLICY RECOMMENDATIONS FOR A SUSTAINABLE USE OF GLOBAL LAND AND BIOMASS RESOURCES AT EUROPEAN AND INTERNATIONAL LEVEL

Major root causes of poverty and hunger are the enormous resource consumption in the industrialised and newly industrialising countries, and the subsequent destruction of the environment and nature. The global population growth trend, yield development and changing dietary habits are clear indicators that, on the one hand, biomass production must in future be more efficient and sustainable in order to meet the increasing needs of a growing world population. On the other hand, besides land volume and productivity, the decision what this biomass is used for (plant-based food, meat production, industrial feedstock or energy generation, regional distribution, loss and waste factor, multiple use of biomass through cascade utilisation) impacts significantly on the global availability. In June 2008, Germany confirmed its commitment to the worldwide fight against poverty and hunger with an ambitious measure bundle. It should continue to be actively involved in this fight.

The UBA recommends that the federal German government should:

- remain committed to the principles of sustainable development, and to actively encourage the implementation of the guiding principles of sustainable land and biomass use. Equally important and mutually dependent aims in this respect are the protection and conservation of ecosystem functions during land use with optimum integration of the various land and soil functions and securing the need satisfaction and natural life-support systems of all people and also of future generations. For the purpose of providing food security, food production must be given precedence over the production of renewable raw materials.

- take on a pioneering role in the transformation of the consumption and dietary patterns at a national level. Aims in this respect are sustainable, responsible consumption, the reduction of the meat consumption as well as the mitigation of food waste. An ecological, climate-friendly diet should be rewarded through economic and tax-based instruments, i.e. the value added tax rate for products that harm the environment or the climate should be increased, or respective taxes should be levied. These measures should be accompanied by educational and advisory measures on the promotion of sustainable consumption behaviour as well as measures aimed at increasing the sales of organic products and low-meat menus in public institutions,
- with regard to the EU common agricultural policy, work towards the integration of a strong and binding ecologisation component for direct payments (first pillar of the CAP) as well as towards increased support for rural development (second pillar of the CAP) with a corresponding redistribution of funds. Any future spending of public monies should be coupled with the supply of public goods and services, and sustainable technologies and methods should enjoy increased subsidies,
- undertake a realignment of the bioenergy policy. In this respect, the incentives for using cultivated biomass for energy generation must not be extended further; instead, the use of waste materials and residues according to the cascading utilisation principle should be advanced,
- become actively committed to soil protection on European and an international level. This encompasses reviewing the German position with regard to an EU Soil Framework Directive and actively encouraging the setting of a Sustainable Development Goal (SDG) with soil reference,
- contribute internationally to the concept of a sustainable, resource protecting land use. To achieve this, Germany should become actively involved in the development of a sustainable global land management system, supported by targeted R&D activities and cooperative efforts/partnerships,
- with regard to economic and trade policy, call for these to be fundamentally changed to agree with the climate goals of the world community and support the implementation of the UN Development Goals and the Sustainable Development Goals currently being developed. Free trade must be brought in line with ecological and social minimum standards. Governments and regulating bodies must join forces against investor abuse of the commodity futures markets and control the speculation with foodstuffs. The government should continue to actively support the implementation of the UN-CFS ‚Voluntary Guidelines on Responsible Governance Tenure‘[55],
- with regard to development policy, work towards an adaptation of all transfers as per the goals defined in the IAASTD report. All development political activities should be critically examined and brought in line with the IAASTD report[56], whose recommended approach is the conservation and promotion of indigenous knowledge and the empowerment of smallholders. Good governance requirements and clear property rights should be linked to development political measures. Where necessary, respective reforms particularly favouring smallholders should be initiated,
- with regard to research funding, it supports cooperative efforts that also have a positive impact on food security in the long term; these include projects on the promotion of resource conservation and resource efficiency.

[29] The Scientific Advisory Board on Agricultural Policy (WBA) at the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) recently pointed out quite rightly that the right to food is one of the human rights that is most infringed on worldwide (Wissenschaftlicher Beirat für Agrarpolitik, 2012 S. 3).

[30] The 2C climate target refers to the aim of international climate policy to limit global warming to less than two degrees Celsius above the pre-industrialisation level. The 2C climate target is the political definition of the objective set in Article 2 of the UN Framework Convention on Climate Change (UNFCCC), ‚to achieve ... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.' It was officially recognised for the first time at the United Nations Climate Change Conference in Cancún in December 2010.

[31] COP 10, Nagoya 2010, Decision X/2: Strategic Plan for Biodiversity 2011 – 2020 and the Aichi Biodiversity Targets, (http://www.cbd.int/doc/decisions/cop-10/cop-10-dec-02-en.pdf).

[32] ‚Our life insurance, our natural capital: an EU biodiversity strategy to 2020' {SEC(2011) 540 final}{SEC(2011) 541 final}

[33] More than 2.0 units of manure per hectare of farmland. One unit of manure equals 80 kg N or 70 kg P2O5 of animal excrements.

[36] Agricultural forum ‚Vorschläge für eine neue Agrarpolitik in Europa', proposals for a new European agricultural policy, October 2001. The agricultural forum 2001, a broad alliance of environmental protection, animal welfare, consumer protection and agricultural organisations, was the first such body to present joint proposals and demands for a new agricultural policy in Europe. In doing so, the organisations triggered a public discourse on the fact that a major U-turn in agriculture was needed at a European level. Major environmental organisations such as NABU (Nature and Biodiversity Conservation Union), BUND (Friends of the Earth Germany), the WWF, the European Nature Heritage Fund EURONATUR and others, as well as the Deutscher Tierschutzbund animal welfare organisation, the Federation of German Consumer Organisations as well as various agricultural organisations (Naturland, Bioland, the farmers' association Arbeitsgemeinschaft bäuerliche Landwirtschaft - AbL) were involved in the discussion of the forum's demands and recommendations. These recommendations were then developed further into proposals by the Federal Environment Agency in cooperation with EURONATUR and the AbL in the course a joint project.

[37] See the British Royal Society (2009) on the term ‚sustainable intensification' cited in (WBA Wissenschaftlicher Beirat für Agrarpolitik, 2012). The Scientific Advisory Council proposes the term ‚sustainable productivity increase', which refers to the aim of ‚increasing the food supply and the quality of this supply whilst conserving the natural resources and using them as efficiently as possible – under consideration of social issues and animal welfare.'

[38] Due to pollutant contamination or wood preservation treatments, not every bit of recovered wood is also recyclable; currently, around 30 % of the recovered wood collected is used again for industrial purposes (Dehoust, et al., 2010).

[39] See federal German government Biomass Action Plan(Bundesregierung, 2009).

[40] Gas power plants could fulfil the balancing function in the interim period.

[41] Including landscape maintenance materials, park maintenance clippings etc.

[42] Methane, ammonia and nitrous oxide emissions from slurry storage are avoided whilst energy is provided at the same time.

[43] These goals were defined primarily under consideration of the results of the deliberations on global land use.

[44] Unless they are cultivated for other protection purposes, for example the promotion of agrodiversity through mixed wild herb cultivation, peatland protection through paludi cultivation and green landscape maintenance waste (see 4.2).

[45] The feed-in tariff depends on the version of the REA applicable at the moment of commissioning. Feed-in tariff changes do not affect plants already operating.

[46] Class I input materials mainly refers to the type of biomass whose use is remunerated with a particularly favourable tariff in the form of a renewable energy bonus in the REA 2009: Energy crops such as, for example, whole grain crops and maize.

[47] An adequately thorough assessment of the ecological compatibility of the cup plant, above all over longer periods, currently remains outstanding; it is therefore not possible to make any recommendations with regard to large-scale cultivation at this point in time.

[48] SRU Environmental Report 2012, Chapter 7

[49] Less strict alternative: Abolishment of the input material related feed-in tariff for the EVK I, or rather, re-categorisation of renewable raw materials into EVK 0 so that only the basicfeed-in tariff is paid.

[50] In the context of the REA pro rata feed-in tariff debate, however, it should be ensured that in instances where other protection aims such as, for example, biodiversity protection, are paramount, the financial incentives should not impair the REA pro rata feed-in tariff.

[51] The respective cut-off date is the 1st of January 2008. All areas deforested, drained or converted before this date are exempt.

[52] www.oecd.org/dataoecd/54/42/40847088.pdf

[53] This year's failed maize and soy harvests in the USA are perfect examples for this. In 2011, the USA produced over 30 % of the global harvests of these agricultural products, and supplied over 40 % of the worldwide exports (IFPRI press statement: ‚Effectively Responding to the Drought in the United States can prevent another Global Food Crisis', released 6 August 2012).

[54] Agriculture-based financial investments reached a high of 450 billion dollars in May 2011. (German NGO Forum on Environment & Development – Newsletter 1/2012 p. 8).

[55] United Nations Committee on World Food Security

[56] The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), published in 2008, is the result of a so far unique cooperative effort of the UN and other international organisations, 60 governments and over 400 scientists from all over the world. It calls on the world community to effect fundamental changes in farming in order to curb rapidly rising prices, hunger, social inequality and ecological disasters. Conclusion of the report: The old paradigm of an industrial agriculture with a high energy and chemical input is no longer appropriate. Essential elements of a future-oriented agriculture are the full integration of local and indigenous knowledge; the empowerment of women, who carry the main burden of agricultural work in the developing countries, and a research focus on smallholder-oriented and agroecological farming methods.

6. Summary

Land and other natural resources for the production of agricultural produce and forest products are being subjected to increasingly fierce pressure due to the rising worldwide demand for these commodities. Important drivers of this problematic issue are a growing demand for essential material goods through the increasing number of people, the sustained resource-intensive consumption patterns of the industrialised countries and their extension to the newly industrialising countries. Along with the rising incomes, the per capita claim on resources in some newly industrialising countries is slowly reaching the level of the earlier industrialised countries, although there is still a clear divide.

> Beyond the supply-oriented steering approaches, the use and distribution of agricultural and forest goods must be fundamentally reviewed and realigned.

The ecological and socio-economical consequences of this spiralling demand are diverse; in many places, they exacerbate the critical state of the productive and regulative function of global ecosystems, even though the achievement of one of the central goals of Sustainable Development – the permanent eradication of the persistent hunger in some regions of the world – is nowhere in sight. The strongly fluctuating agricultural product prices, the increasing value of fertile land and agricultural commodities as speculation objects in the recent past, the price-related hunger crises in 2007 and not least, the land grabbing phenomenon are indicators of the amplification of this problematic issue and, at the same time, highlight the urgent need for action.

One fundamental challenge in the process of increasing biomass availability to cover the growing demand are the frequently concomitant negative environmental impacts up to a destruction of the long-term productivity of the agricultural and forest systems, which is absolutely contrary to the intra- and intergenerational component of the guiding principles of Sustainable Development.

If an increased supply is pursued by means of farmland extension, this is often done at the expense of other protected goods, above all of biodiversity, and of ecosystems essential for climate regulation. The renewed use of marginal and degraded land is also not non-objectionable per se. High environmental costs can be the consequence of an intensification of the production to increase land productivity if this is not done under consideration of the respective agricultural and forest system‘s capacity for bearing ecological burdens and its buffer capacity. Nitrous oxide emissions, contamination with pesticide residues and the eutrophication of the soil, the air and bodies of water, diverse forms of soil degradation such as the depletion of organic carbon, salination, loss of the fertile topsoil through erosion, loss of agrobiodiversity, and a growing scarcity of agriculturally usable water resources are just some of the symptoms that can be associated with non-sustainable production increase and agriculture expansion. Intensified forest exploitation also harbours risks, such as negative nutrient balances and the loss of the forests‘ carbon sink function. The ecological compatibility of increased agricultural and forest production is one of the most important tasks for the international environmental, agricultural, trade and development policies.

Beyond the supply-oriented steering approaches, the use and distribution of agricultural and forest goods must be fundamentally reviewed and realigned. In regions where the normal diet consists to a disproportionately high degree of meat and other animal products, an increase of the proportion of plant-based food should be pursued. The containment of the losses in the food production-consumption chain is another relevant, ethically non-objectionable starting point for demand reduction. To mitigate usage conflicts with regard to the use of biomass for food, industrial purposes and energy generation in order to use the available biomass as efficiently as possible, regulations must be developed and implemented to ensure a cascading utilisation of

biomass. The use for energy generation must be the last stage.

The cultivation of biomass for energy generation as a contribution to covering the high energy consumption in the industrialised countries demands disproportionally extensive areas of productive farmland. With wind and solar energy, more efficient alternatives in terms of area yield are available, at least in Germany. The problematic issue of their fluctuation cannot be fully compensated by bioenergy, due to the extremely limited energy potential of cultivated biomass. E.g. alternative storage and load-balancing technologies such as ‚power-to-gas‘ must be developed in any case. In the transport sector, biofuels can again cover only a marginal proportion of the demand, accompanied by an acceptance of the ecological and social-economical risks (‚indirect land use changes‘). Biofuels should therefore be relied on only where a replacement of fossil fuels with less objectionable technologies such as, for example, electric drive systems, hydrogen fuel cells or wind and solar power based e-methane is not yet in sight.

The guaranteeing of ecological and social minimum standards for the supply of agricultural produce and forest products by means of an adequate and functioning certification system is one way of making a valid and important point in terms of production. However, extremely challenging preconditions are required for certification to be effective. Their reach and effectiveness are clearly limited, and as a tool, certification also harbours risks, mainly in case of inadequate implementation. Certification should therefore not be overrated. International trade law should be reformed in such a way as to support ecological and social minimum requirements, rather than hindering their implementation.

The reawakened awareness of the value and finiteness of natural resources has refuelled the debate on what a Sustainable Use of Global Land and Biomass Resources would have to look like, and what changes would have to be initiated in this respect in order to reach the defined goals. The present report should be considered a contribution to this discourse. The Federal Environment Agency still views the visions and fundamental principles formulated in 1992 in the Rio Declaration on Environment and Development as a valid basis and a reference frame with regard to the definition and implementation of sustainable development and resource use. The Rio Declaration states that all people – those alive today as well as future generations – are entitled to a healthy and productive life in harmony with nature. Coming close to this guiding principle now needs action at various levels and in various fields. The present report illustrates some of the paths towards this goal.

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APPENDIX 1: Industrial and energy generation use of renewable raw materials worldwide, reference year 2008

RAW MATERIAL	AREA IN IN 1,000 ha	PRODUCTION IN 1,000 t	MAIN RAW MATERIAL (IN %)	MAIN RAW MATERIAL (IN 1,000 t)	PROPORTION OF USE (IN % OF TOTAL USE)			AREA (IN 1,000 ha)		PRODUCTION (IN 1,000 t)	
	2008	2008			INDUSTRIAL USE	FOOD/FODDER	ENERGY	INDUSTRIAL USE	ENERGY	INDUSTRIAL USE	ENERGY
Bamboo	22,000	20,000	95	19,000	39	11	50	8,580	11,000	7,410	9,500
Cotton (fibres)	31,340	23,316	95	22,150	100	0	0	31,340	0	22,150	0
Cottonseed	30,190	43,060	10	4,306	1	99	0	302	0	43	0
Cassava	18,677	232,462	77	178,996	4	93	3	747	560	7,160	5,370
Flax fibres	361	512	100	512	100	0	0	361	0	512	0
Barley	56,512	155,053	50	77,527	3	96	1	1,695	565	2,326	775
Jute and similar fibres	1,306	2,833	95	2,691	100	0	0	1,306	0	2,691	0
Potatoes	18,081	325,558	82	266,958	7.9	92	0.1	1,428	18	21,090	267
Coconuts	11,230	60,713	20	12,143	65	30	5	7,300	562	7,893	607
Linseed	2,410	2,170	35	760	99	1	0	2,386	0	752	0
Maize	161,105	826,224	65	537,046	10	75	15	16,111	24,166	53,705	80,557
Natural rubber	8,956	10,569	95	10,041	100	0	0	8,956	0	10,041	0
Oil palm fruit	14,649	206,989	22	45,538	28	53	19	4,102	2,783	12,751	8,652
Rapeseed	30,820	58,061	35	20,321	1	90	9	308	2,774	203	1,829
Rice, unpolished	159,250	685,874	70	480,112	0.5	99.5	0	796	0	2,401	0
Castor-oil beans	1,542	1,603	42	673	10	90	0	154	0	67	0
Rye	6,669	17,700	50	8,850	3	93	4	200	267	266	354
Sisal and similar fibres	443	372	100	372	100	0	0	443	0	372	0
Soy beans	96,180	230,581	15	34,587	4	91	5	3,847	4,809	1,383	1,729
Sunflower seeds	24,839	35,657	34	12,123	5	92	3	1,242	745	606	364
Triticale	3,854	13,875	50	6,938	3	95	2	116	77	208	139
Wheat	222,758	683,406	50	341,703	3,3	96	0.7	7,351	1,559	11,276	2,392
Sugar cane	24,257	1,736,271	10	173,627	5	75	20	1,213	4,851	8,681	34,725
Sugar beet	4,286	222,022	15	33,303	5	93	2	214	86	1,665	666
Wood	3,952,000	2,916,576	95	2,770,747	52	0	48	2,055,040	1,896,960	1,1440,789	1,329,959
TOTAL (EXCLUDING WOOD)	951,715	5,594,881						100,498	54,822	175,651	147,926
TOTAL (INCLUDING WOOD)	4,903,715	8,511,457								1,616,440	1,477,885

Source: Table 2 from Raschka et al. (2012)

APPENDIX 2: Use of biomass in the transport sector – an initial estimate (UBA 2012)

REPORTED DATA GERMANY	AVIATION		INLAND WATERWAY VESSELS	SEA-GOING VESSELS Proportion of German sea transport in global goods transport	RAIL TRANSPORT	PASSENGER CARS	COMMERCIAL VEHICLES	OTHER TRANSPORT (motorised two-wheeled vehicles, buses, other)	MOBILE MACHINERY (construction industry and farming)	SAVINGS THROUGH PLANNING POLICY BASED MEASURES
	In Germany	In other countries								
Energy consumption 2010 in TJ (Source: TREMOD, excluding sea-going vessels)	Kerosene: 26,956	Kerosene: 335,291	Diesel: 10,213 Biodiesel: 679	~ 420,000 (calculated according to data supplied by Oko-Institut)	Diesel: 12,768 Biodiesel: 849	Petrol: 772,688 Ethanol: 29,652 Diesel: 467,192 Biodiesel: 36,324	Petrol: 6,261 Ethanol: 240 Diesel: 634,012 Biodiesel: 49,294	Petrol: 13,306 Ethanol: 510 Diesel: 65,019 Biodiesel: 5,055	PETROL: 4,168 DIESEL: 90,786	
Fuel consumption 2020 in TJ (Source: TREMOD, excluding sea-going vessels)	Kerosene: 30,468	Kerosene: 488,312	Diesel: 11,291 Biodiesel: 1,687	(calculated according to data supplied by Oko-Institut)	Diesel: 10,950 Biodiesel: 1,636	Petrol: 487,640 Ethanol: 54,182 Diesel: 522,666 Biodiesel: 78,100	Petrol: 3,078 Ethanol: 342 Diesel: 742,454 Biodiesel: 110,941	Petrol: 12,671 Ethanol: 1,408 Diesel: 55,401 Biodiesel: 8,278	PETROL: 3,781 DIESEL: 88,627	Reduction of passenger transport volumes by 10% compared to current trend
Fuel consumption 2050	Hydrogen: 27,000 (=45,000 electric power)	Liquid fuel 500,000 (=832,000 electric power)	11,680 – 13,627 (efficiency 30 – 40 %)	~ 460,000 (at 2.0 %/a) and 50 % efficiency) (as per target EU White Paper on transport policy 50 % of 2005: ~ 240,000 permissible)	9,440	415,000 (270,000 electric power, 95,000 fl. fuel, 50,000 H2 primary energy electric power ~500.000TJ ^=139TWh for electric power+ RE fuels at 14 % more transport volume compared to 2010)	A 30 – 40 % reduction leads to a consumption of 0.82 – 0.95 MJ/tkm. This would equal an energy consumption in 2050 of 715,860 – 829,350 TJ.	58,319	69,306	Reduction of passenger transport volumes by approx. 18 % compared to current trend
Requirement for liquid fuels	Liquid H2: 27,000	500,000	no	no	4,720	95,000	yes	28,631	34,653	
Replacement of fossil energy carriers possible?	yes	yes	yes	yes	yes	yes	yes	yes	yes	
Examples?	Hydrogen	e-methane and other hydrocarbons	e.g. through e-methane/ hydrogen	e.g. through e-methane/ hydrogen	e.g. through e-methane/ hydrogen	Renewable electricity, Renewable biofuels H2	Renewable biofuels H2	e.g. through e-methane/ hydrogen	e.g. through e-methane/ hydrogen	
Energy required for traction in 2050:										
Demand for regulating energy in 2050 for transport: 3,676,000 TJ or 1000 TWh										

Authors: UBA Dept. I 3: Frank Wetzel, Andrea Fechter, Katharina Koppe, Gunnar Gohlisch, Nadja Richter, Andreas Ostermeier, 2012)

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