Globalands

Resource-Efficient Land Use – Towards A Global Sustainable Land Use Standard

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LAND USE TRENDS, DRIVERS AND IMPACTS

Key findings from a review of international level land use studies

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ZUSAMMENFASSUNG

In diesem Paper werden die Ergebnisse einer Querauswertung internationaler Studien zur Entwicklung der Landnutzung zusammengefasst. Die Querauswertung ergänzt die Analyse der Offizialstatistik im Rahmen des GLOBALANDS-Projektes, die von Lutzenberger (2012) vorgenommen wurde, sowie die Auswertung vorliegender Szenarioanalysen durch Fritsche (2012). Mit den drei Berichten ergibt sich ein breites, international tragfähiges Fundament für die weitere Arbeit.

Schlüsselaspekte in der Querauswertung internationaler Studien[1] sind: a) die Beschreibung der wichtigsten **Trends** in Land- und Flächennutzung, b) die Identifikation wichtiger **Treiber und Einflussfaktoren** sowie die c) kurze Charakterisierung der **Folgen** und d) des **Handlungsbedarfs**. In der Darstellung wird, soweit sinnvoll und möglich, auf eine ausreichende räumliche Differenzierung geachtet. Ausführliche Quellenangaben erlauben es, einzelne Aspekte genauer nachzuvollziehen. Die Dynamik absehbarer zukünftiger Entwicklungen wird in der Darstellung besonders berücksichtigt.

Die Hauptergebnisse der Querauswertung lassen sich in den folgenden zehn Punkten zusammenfassen:

(1) Die Umwandlung von Wäldern in Acker- und Weideland wird für die 1990er Jahre mit einem jährlichen Verlust von 16 Mio. ha angegeben. Sie setzte sich in den letzten fünf Jahren mit jährlich 12 Mio. ha fort. Die jährliche Entwaldungsrate hat sich durch Aufforstung, aber auch durch natürliche Ausbreitung von Wäldern vermindert. Trotz erfolgreicher Bemühungen einiger Länder um eine Trendwende bei den jährlichen Waldverlusten ist es nicht gelungen, die immer noch alarmierend hohe Rate der Entwaldung weltweit zu stoppen.

(2) Die Nachfrage nach landwirtschaftlich nutzbaren Flächen nimmt weltweit relativ rasch zu, die verfügbaren Agrarflächen gehen dagegen kontinuierlich zurück. Ursachen für den Rückgang der Agrarflächen sind die zunehmende Urba-

[1] Siehe 'References', Seite 22ff.

nisierung sowie Bodendegradierung und Wüstenbildung infolge von Übernutzung und nicht zuletzt von Klimaerwärmung.

(3) Bis 2050 soll die Weltbevölkerung von 7 Milliarden in 2011 auf 9-10 Milliarden wachsen. Der größte Teil des Bevölkerungswachstums (86 %) wird in großen urbanen Zentren in den Entwicklungsländern stattfinden, und hier v.a. in Afrika. Prozentual ist das Weltbevölkerungswachstum allerdings seit 1963 kontinuierlich zurückgegangen, von 2,2% auf derzeit ca. 1% jährlich. Die Pro-Kopf-Fläche des verfügbaren Ackerlandes hat sich mit dem Bevölkerungswachstum seit 1960 fast halbiert – und das, obwohl der Anteil der landwirtschaftlich genutzten Flächen an der gesamten Landfläche der Erde bis etwa Mitte der 1990er Jahre gestiegen ist.

(4) Ein wichtiger Einflussfaktor ist die Entwicklung von Fleischverbrauch und der für die Fleischproduktion als Tierfutter verwendeten Ölsaaten- und Getreidemenge. Getreide, das für die direkte menschliche Ernährung geeignet wäre, wird – vor allem in den reichen Ländern und rasch zunehmend auch in den Schwellenländern – als Viehfutter genutzt; im Hinblick auf eine umweltverträgliche Landnutzung und die globale Ernährungssituation sicher in einem nicht nachhaltigen Maß. Seit etwa sechs Jahren hat sich die Zunahme der Produktion von Tierfutter für die Fleischproduktion leicht abgeschwächt.

(5) Zentral für die weitere Entwicklung der Landnutzung dürfte natürlich auch die Produktion von Agrartreibstoffen aus Biomasse und des Anteils der dafür genutzten Agrarflächen sein. Die globale Produktion von Agrartreibstoffen ist in den letzten 30 Jahren rasant gestiegen. Zwischen 2000 und 2009 wurde die globale Produktion von Bioethanol vervierfacht, die Herstellung von Biodiesel verzehnfacht.

(6) Die Ausweitung konkurrierender Landnutzungen (insbesondere Energiepflanzenanbau) erklärt, zusammen mit der Spekulation in Nahrungsmittelmärkten, den sowohl auf globaler als auch auf regionaler Ebene zeitweise rasch verlaufenden Anstieg der Nahrungsmittelpreise.

(7) Der bisherige Anstieg der Agrarproduktion ist im Wesentlichen auf die gestiegene Produktivität der Agrarflächen zurückzuführen: Die Hektarerträge von Getreide, Mais und Reis sind in den letzten Jahren kontinuierlich weiter gestiegen, bei Mais und anderem Grobgetreide allerdings stärker als bei den für die direkte menschliche Ernährung global gesehen quantitativ bedeutsameren Grundnahrungsmitteln Weizen und Reis, deren Erträge in den großen Anbauländern der OECD stagnieren.

(8) Die weltweiten Treibhausgasemissionen nehmen, begünstigt durch Landnutzungsänderungen und den steigenden Bedarf an fossilen Brennstoffen, weiter zu. Wenn auch die indirekten Klimafolgen in der CO_2-Bilanz berücksichtigt werden, führt nicht nur die Herstellung von Biodiesel aus Palmöl, das überwiegend von Plantagen auf abgeholzten Waldflächen kommt, sondern auch aus Raps und Soja zu mehr CO_2 in der Atmosphäre als herkömmlicher Diesel.

(9) Der zunehmende Bedarf an Ressourcen (z. B. Flächen, Wasser, Wälder, Ökosysteme) hat zu einer immer stärkeren Erschöpfung und Verschlechterung natürlicher Ressourcen geführt, und der Verlust an biologischer Vielfalt sowie die Entwaldung schreiten in alarmierendem Tempo fort. Die Übernutzung und Verschmutzung von Wasserressourcen führen zu immer gravierenderen Problemen, und im Jahr 2025 könnte ein Drittel der Weltbevölkerung von Wasserknappheit betroffen sein.

(10) Die Auswirkungen des Klimawandels (z.B. sich verändernde Niederschlagsverhältnisse und Anstieg des Meeresspiegels) können zu einer erheblichen Verschärfung bestehender Umweltprobleme führen. Eine Reihe von Entwicklungsländern, deren Wirtschaft weitgehend von der Landwirtschaft und bäuerlicher Subsistenzwirtschaft abhängt, haben unter Wüstenbildung und Bodenverschlechterung zu leiden.

Die wichtigsten Einflussfaktoren sind die Verbrauchs- und Produktionsmuster in Industrieländern sowie das Wirtschaftswachstum, v.a. in Schwellenländern. Beide Einflüsse führen weltweit zu einem nicht nachhaltigen Verbrauch natürlicher Ressourcen, teils irreversiblen Schädigungen der Umwelt und zum Klimawandel. Die Umweltbelastungen und -folgen werden noch verschärft durch Bevölkerungswachstum sowie teils unbeabsichtigte oder indirekte negative Politikeinflüsse.

EXECUTIVE SUMMARY

This paper summarizes some key data and conclusions from a range of analyses and reports related to global level land use change. Emphasis is on publications from the main institutions engaged in this sphere. The idea is to document the common ground in existing studies as well as identifying differing views, should they exist. The sources are provided where text and data are taken over from the original publications.

Focus is on major trends in land use, the main influences and drivers, impacts, and need and broad scope for action. The paper is to complement the analysis based on official land use statistics produced by Lutzenberger (2012), and the scenario result analysis by Fritsche (2012). It is expected that the more informed discussion of land use change will support, and orient, further work around potential interventions and appropriate governance structures.

The main results of the review can be summarized with the following ten points:

(1) The historical expansion of cultivated land and pastures has largely been at the expense of forests. During the 1990s there has been an average loss of 16 million ha of forests per year. In the last five years the figure decreased to approximately 16 million ha per year.

(2) The rapidly increasing commercialization of all types of food, bioenergy and industrial crops will add to the demand for land. The competition between municipal and industrial demands for land and water will intensify as the scarcity of natural resources increases. Also intrasectoral competition within agriculture – between livestock, staples and non-food crops, including liquid biofuels, will become much more pervasive. Some expansion will still be possible in Sub-Saharan Africa and Latin America.

(3) The global population is expected to grow by 36% between 2000 and 2030. Today's population of around 7 billion is expected to increase to about 9 billion by 2050. City dwellers now account for 50% of the total global population.

With about 800,000 new urban residents every week, that proportion is projected to reach 70% by 2050. Over the last 50 years, the cultivated area of land per person gradually declined to less than 0.25 ha. Cultivated land area per person in low income countries is less than half that in high income countries and its suitability for agriculture is generally lower.

(4) Changes in diets in particular in conjunction with rising incomes in emerging economies are a major influence. By 2050, another one billion tonnes of cereals and 200 million extra tonnes of livestock products will need to be produced every year.

(5) Land-intensive biofuel production competes increasingly with food production, putting additional pressure on agricultural land resources. In 2007, an estimated 1.6% of the global cultivated land or 25.1 million ha, was devoted to the production of biofuel feedstocks, mainly sugarcane, maize, cassava, oil palm, rape and soybean. Between 2000 and 2009 bioethanol production has increased fourfold, and biodiesel tenfold.

(6) Production of feedstock for biofuels competes with food production on significant areas of prime cultivated land. Related to that and probably also related to speculation on commodity markets, grain prices soared in 2007 and 2008.

(7) Over the last 50 years, the world's agricultural production has grown between 2.5 and 3 times while the cultivated area has grown only by 12%. In many regions, input-intensity and productivity have been substantially increased – mainly coupled with mechanized agriculture and irrigation. Overall, more than 40% of the increase in food production came from irrigated areas, which have doubled in area.

(8) Agriculture is responsible for 30–35% of global GHG emissions. The energy used to grow, process and transport food is a concern, but the vast majority of emissions come from tropical deforestation, methane released from animals and rice paddies, and nitrous oxide from over-fertilized soils. Converting forests to cultivated land implies substantial increases in GHG impacts and loss of biodiversity.

(9) The land and water systems, underpinning many key food producing systems worldwide, are under in many instances extreme stress. Many groundwater resources are being exhausted because of the enormous freshwater demands of irrigated farming systems. Aquifers are becoming increasingly polluted. In 2025, a third of the world population might be affected by water scarcity. More sustainable land and water management practices have the potential to expand production efficiently to address food insecurity while limiting impacts on other ecosystem values. However, this will require profound changes in the way land and water are managed.

(10) Climate change is expected to exacerbate the pressure on land and water systems – in particular in some key productive areas. The continuation and presumably acceleration of climate change will widen the gap between developed and developing countries, by decreasing production capacity in particular in semi-arid regions. The main influences on land use are warming and related aridity, shifts in rainfall patterns and the growing incidence of extreme weather events. Floods, droughts and landslides further threaten the stability of land and water resources.

The resource intensity and ecological footprint (carbon, water, absorptive capacity, etc.) of western lifestyles has probably been the main influence and driver of past developments. Other important factors are the population growth at global level, the rapidly increasing levels of consumption in emerging economies. In some areas, the accumulation of environmental impacts in key land and water systems has now reached the point where production and livelihoods are compromised. Population growth is aggravating impacts but resource use intensity seems at least similarly important. Policy influences – desired and unintended, direct and indirect – are another area that influences developments to a very significant extent.

AIM OF THIS PAPER

This working paper summarizes some key data and conclusions from a range of analyses and reports related to global level land use change. Emphasis is on publications from the main institutions engaged in this sphere. The idea is to document the common ground in existing studies as well as identifying differing views, should they exist. Often text is taken over from the original publications, where this is the case, the sources are provided.

The focus is on major trends in land use, the main influences and drivers, impacts, and need and broad scope for action. The paper is to complement the analysis based on official land use statistics produced by the Leuphana team (Lutzenberger 2012), and the global scenario/model analysis given in Fritsche (2012).

It is expected that the more informed discussion of land use change will support, and orient, further work around potential interventions and appropriate governance structures.

Major trends in land use

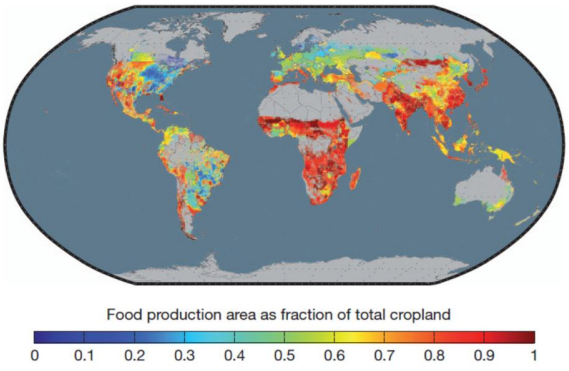
Past and present trends in land use and present situation

Agriculture uses **11% of the world's land surface** for crop production. It also makes use of 70% of all water withdrawn from aquifers, streams and lakes (FAO 2011).

Between 1985 and 2005 the world's croplands and pastures expanded by 154 million hectares (about 3%). But this slow net increase includes significant expansion in some areas (the tropics), as well as little change or a decrease in others (the temperate zone). The result is a net redistribution of agricultural land towards the tropics, with implications for food production, food security and the environment (Foley 2011).

The historical **expansion of cultivated land and pastures** has largely been at the expense of forests (FAO 2011). During the 1990s there has been an average loss of 16 million ha of forests per year. In the last five years the figure decreased to approximately 16 million ha per year. In South America and in Africa alone loss was around 4 million ha per year between 2000 and 2010. Lepers (2005), MEA (2005) and Haines-Young (2009) found that the biggest cause of deforestation – and consequently loss of terrestrial biodiversity – has been agricultural expansion.

Figure 1 Allocation of cropland area to different uses in 2000



SOURE: FOLEY (2011)

Globally, only **62% of crop production is allocated to human food, versus 35% to animal feed** (which produces human food indirectly, and much less efficiently, as meat and dairy products). 3% is used for bioenergy, seed and other industrial products (Foley 2011).

A striking disparity exists between regions that primarily grow crops for direct human consumption and those that produce crops for other uses (Fig. 1). North America and Europe devote only about 40% of their croplands to direct food production, whereas Africa and Asia allocate typically over 80% of their cropland to food crops (Foley 2011).

The **expansion of urban areas and areas used for infrastructure** plays a major role – in the past in particular in the northern hemisphere but now at sometimes extreme rates also in the global south. Currently urbanized areas and areas used for rural settlements and infrastructure occupy an estimated 150 billion ha or 1.1% of the global land mass (excluding Antarctica) (FAO 2011).

Increasing importance of biofuels and energy crop production

Biomass is used as a fuel (firewood, biodiesel, bio-kerosene, and ethanol) and a raw material for the paper and pulp, lumber, furniture, and construction industries.

In the last decade economies based primarily on fossil petrochemicals have started to shift towards more bio-based systems and products.

The increasing competition for woody biomass is a closely related concern. In Europe, triggered by policies to support the shift to renewable energies, traditional industries like plywood manufacturing have been facing increasing prices for raw materials that are also used for heating (Bringezu 2008).

Sweden, although relatively rich in forests, has like other Scandinavian countries become a net importer of bioenergy (Junginger 2008), mainly in the form of pellets imported from Canadian British Columbia, South Africa and Australia. Finland has, from 1991 to 2005, increased timber imports from Russia – due to lower prices – while using only about two thirds of domestic

Figure 2 Increase in bioethanol production between 2004 and 2008

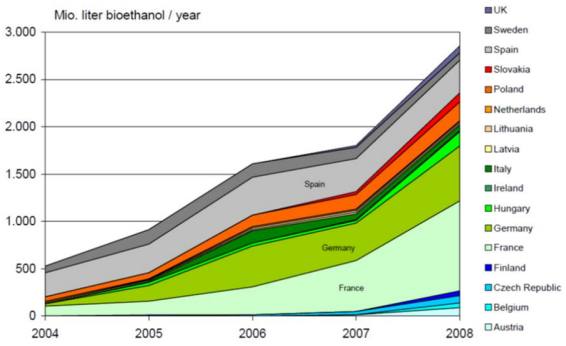


Figure 7. Ethanol production in the EU

Source: Klenk (2010)

annual forest growth (Bringezu 2012).

The increase in bioethanol production between 2004 and 2008 provides another illustration of this trend (Fig. 2).

In 2007, an estimated 1.6% of the global cultivated land or 25.1 million ha, was devoted to the production of biofuel feedstocks, mainly sugarcane, maize, cassava, oil palm, rape and soybean (FAO 2008).

Raskin (2010) and others stress that land-intensive biofuel production competes with food production, putting additional pressure on agricultural innovations to increase yields and stabilize the prices of food staples.

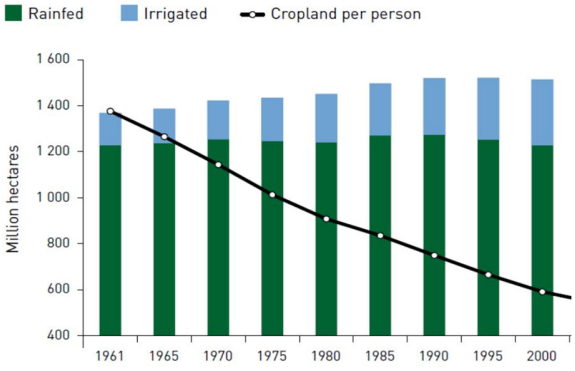
Productivity and input-intensity

Over the last 50 years, the **world's agricultural production has grown between 2.5 and 3 times** while the cultivated area has grown only by 12%. Whereas Africa in particular is confronted with food shortages, globally, the rapidly rising demands for food and fibre were largely met. Cultivated land area per person in low income countries is less than half that in high income countries and its suitability for agriculture is generally lower. This is troubling given that the growth of demand for food production, as a function of population and income, is expected to be concentrated in low income countries (FAO 2011).

In many regions, **input-intensity and productivity** have been substantially increased – mainly coupled with mechanized agriculture and irrigation. Overall, more than 40% of the increase in food production came from irrigated areas, which have doubled in area. Over the last 50 years, the cultivated area of land per person gradually declined to less than 0.25 ha (FAO 2011) (Fig. 3).

The tendency to locate high-input agriculture on the most productive land relieves pressure on land expansion and limits encroachment on forests and other land uses. Much of the

Figure 3 Evolution of land under irrigated and rainfed crops



Source: FAO (2010)

prime agricultural land suitable for irrigation, however, has already been developed (FAO 2011).

The main contribution to future growth in agricultural output is expected to come from **intensification on existing agricultural land**. FAO (2011) and others emphasize that this will require widespread adoption of sustainable land management practices, and more efficient use of irrigation water. What is largely missing in most assessments though, are concrete suggestions in respect of the governance and regulatory frameworks needed to ensure sustainable land management. Past experience indicates that intensification and sustainability cannot easily be reconciled.

The clear trend toward **precision agriculture**[2] and the increasing importance of **organic farming systems** indicate that the private sector and the capacity and orientation of the agricultural knowledge and innovation system also play a critical role.

Anticipated trends

Toward 2050, the **rising population and incomes** are expected to call for 70% more food production globally, and up to 100% more in developing countries (relative to 2009 levels). The rapidly increasing commercialization of all types of food, bioenergy and industrial crops, i.e. introduction or reinforcement of market mechanisms, will add to the demand for land. Increased production is expected to come primarily from intensification on existing cultivated land. Some expansion will still be possible in Sub-Saharan Africa and Latin America. In the longer run, climate change is expected to increase the potential for expansion in some temperate areas (FAO 2011).

Very clearly a continued **shift from fossil petrochemicals towards more bio-based systems and products** is inevitable in the mid-term. Energy supply in particular will more and more rely on renewable energy sources. Based on targets set by individual countries, Fischer et al. (2009) estimate that land used for biofuel

[2] Precision agriculture is a concept that aims to optimize field-level management by matching farming practices more closely to crop needs (e.g. fertilizer inputs); by reducing environmental risks and footprint of farming (e.g. limiting leaching of nitrogen); and by boosting competitiveness through more efficient practices (e.g. improved management of fertilizer usage and other inputs).

feedstocks may increase from current 25 million ha to between 45 and 70 million ha by 2030, or between 3% and 4.5% of current cultivated land (FAO 2011). In view of the major impacts that such shifts may entail, it is widely agreed that a better understanding and management of competing uses of land, water and ecosystem services is needed. Bringezu et al. (2012) and others point to the fact that biofuels are often not produced in the country of consumption and that their import may be associated with unintended side-effects ("interregional problem shifting"). The same authors argue that a key factor is the overall demand of land required for the production of biofuel feedstocks, and the competition for land by all other bio-based products, in particular food, but also biomaterials (including traditional uses of straw and wood).

The **competition between municipal and industrial demands for land and water will intensify** as the scarcity of natural resources increases. Also intrasectoral competition within agriculture – between livestock, staples and non-food crops, including liquid biofuels, will become much more pervasive. FAO (2011) expects that municipal and industrial water demands will be growing much faster than those of agriculture and that they can be expected to crowd out allocations to agriculture. Rising demand for water from agriculture and other sectors will result in increasing environmental stress and socio-economic tensions. In particular any expansion in irrigated land will require tradeoffs, particularly over inter-sectoral water allocation and environmental impacts. Where rainfall is inadequate and new water development is not feasible, agricultural production is expected to be severely constrained. Because of the dependence of many key food production areas on groundwater, declining aquifer levels and continued abstraction of non-renewable groundwater present a growing risk to local and global food production (FAO 2011).

The **expansion of urban areas and land required for infrastructure** is expected to at least keep pace with population growth. The expansion of the built environment is expected to disproportionately affect prime quality and easily accessible land concentrated near urban areas (as has happened historically). An additional 100 million ha of land is estimated to be required for residential, industrial and

infrastructure purposes until 2050, more than 90 % of it in less developed countries (FAO 2011).

Land grabbing is indicative of the increasing scarcity of natural resources

During the last few years, major food importing countries, for example, the Gulf Cooperation Council Countries, China, India, South Africa and South Korea have been buying and leasing farmland (FAO 2011). Sovereign and commercial investors begin to acquire tracts of farmland in developing countries. The increasingly important phenomenon of land grabbing is discussed by Cotula et al. (2009) and Hallam (2009).

The issue is of concern as often the countries targeted by investors are food insecure, especially in sub-Saharan Africa (FAO 2011). The danger is that the fulfilment of basic food needs is endangered as a result of the resource needs of more wealthy investing countries. Hallam (2009) estimates that in only three years, 20 million ha are thought to have been acquired by foreign interests in Africa.

DRIVERS, INFLUENCES AND POTENTIAL CAUSES

The **resource intensity and ecological footprint** (carbon, water, absorptive capacity, etc.) of western **lifestyles** has probably been the main influence and driver of past developments. Other important factors are the population growth at global level, the 'westernising' patterns and rapidly increasing levels of consumption in emerging economies (China, Brazil, Russia, India, etc.) and all the changes and (policy) responses that are related with that. Rising populations and incomes drive the demand for land for agriculture, pasturing, human settlements, forest products, and biofuels (Raskin 2010). It can be expected that the same factors will also be the main determinants of future developments, impacting on land use patterns, intensities and change.

The **global population** is expected to grow by 36% between 2000 and 2030. Today's population of around 7 billion is expected to increase to about 9 billion by 2050. City dwellers now account for 50% of the total global population. With about 800,000 new urban residents every week, that proportion is projected to

reach 70% by 2050 (UNPD 2011).[3] Food demand is growing as a result of population growth. Changes in diets in particular in conjunction with rising incomes in emerging economies are another major influence. By 2050, another one billion tonnes of cereals and 200 million extra tonnes of livestock products will need to be produced every year. However, rates of growth in agricultural production have been slowing, and are only half the 3% annual rate of growth seen in developing countries in the past. Already today, almost 1 billion people are undernourished, particularly in Sub-Saharan Africa (239 million) and Asia (578 million) (FAO 2011).

Production of feedstock for biofuels competes with food production on significant areas of prime cultivated land. Related to that (and probably also related to speculation on commodity markets), grain prices soared in 2007 and 2008. Adequate nutrition is central to human and environmental well-being and the rapid food price increases have hit the poorest hardest (FAO 2011).

Climate change is increasingly influencing land use trends. It is affecting water availability and might cause major shifts in agricultural production. Temperate cereal production in the northern hemisphere will continue to supply global markets and may even see a northward expansion as a result of global warming (FAO 2011). In the dry tropics and subtropics, rainfed production might be more and more affected by erratic precipitation. Unpredictable soil moisture availability in turn reduces nutrient uptake and, consequently, yields (FAO 2011). Climate change has already reduced average crop yields. The continuation and presumably acceleration of climate change will widen the gap between developed and developing countries, by decreasing production capacity in particular in semi-arid regions. Climate change brings an increase in risk and unpredictability for farmers. A higher frequency of extreme weather events will increase food insecurity. Poor farmers in low income countries are the most vulnerable and the least able to adapt to these changes (FAO 2011). The main influences on land use are warming and related aridity, shifts in rainfall patterns and the growing incidence of extreme weather events. Floods, droughts and landslides further threaten the stability of land and water resources. Experts expect an increase in the frequency

[3] United Nations Population Division, http://esa.un.org/unup/, accessed 29 August 2011 (in: Hoff, 2011).

and intensity of droughts and flooding in subtropical areas. Deltas and coastal areas are expected to be impacted negatively by sea level rise. While warming may extend the limit of agriculture in the northern hemisphere, it is anticipated that key agricultural systems in lower latitudes will need to cope with new temperature, humidity and water stresses. Some agricultural systems in higher latitudes are expected to gain net benefits from temperature increases as more land becomes suitable for crop cultivation (FAO 2011).

The **demand for freshwater** is growing fast and is becoming a major determinant of land use patterns, intensities and change. Globally we use an astounding 4,000 cubic kilometers of freshwater per year, mostly withdrawn from rivers and aquifers. Irrigation accounts for 70% of the draw. If we count only consumptive water use—water that is used and not returned to the watershed—irrigation climbs to 80-90% of the total (Foley 2011). Providing adequate freshwater for the maintenance of human and natural systems will become a persistent challenge. Already today, 1.7 billion people live in areas of water stress, i.e., where there is significant competition for water among agricultural, industrial, public, and environmental claims. In addition, several hundred million people endure absolute and chronic shortages of freshwater resources (Raskin 2010).

Unfavourable **socio-economic conditions** (e.g. insecure land tenure, lack of incentives, lack of access to markets or appropriate technologies, use of marginal lands) are sometimes resulting in unsustainable management practices. In some instances, better technology, management practices and policies have arrested and reversed negative trends and thus indicate pathways towards models of, as termed by FAO (2011), 'sustainable intensification'.

Foreign direct investment has already become a major driver of change in many developing countries and it will, with the increasing scarcity of natural resources, become even more important. More than 200 million hectares, or between 2 and 20% of agricultural land in sub-Saharan countries, have been sold or leased over the past few years, or are currently being negotiated over,[4] to help meet the rap-

[4] Friis C, Reenberg A 2010: Land grab in Africa: Emerging land system drivers in a teleconnected world. GLP Report No. 1. GLP-IPO, Copenhagen. Oxfam 2011: Land and Power, Oxfam Briefing Paper 151, Oxford, UK

idly growing demand for food, feed and other bio-resources in particular from China, India and some Arab countries. China now meets half of its demand for wood products from overseas.[5] Investments tend to favour high-input agriculture – including large scale irrigation infrastructure – in the most productive areas, often for biofuel production.[6] Institutional capacity for managing the environmental and socio-economic effects of FDI is developing only slowly.

Policy influences – desired and unintended, direct and indirect – are another area that influences developments to a very significant extent. A relatively large number of studies, at a European level produced above all by IEEP, deal with the very substantial impacts policies have on agricultural and land use change. Agri-environmental policies have been introduced at the end of the 1980s and early 1990s. They play an increasingly important role in reconciling conflicting land use goals and in promoting more sustainable practices. Policy instruments and signals that are much less favourable include agricultural production subsidies and investment support focussed on scale enlargement and the intensification of production. The same can be said for other policy areas, regulatory mechanisms and interventions like energy policy, spatial planning or land use policy.

SIGNIFICANT IMPACTS

Large areas on all continents are experiencing high rates of ecosystem impairment, particularly reduced soil quality, biodiversity loss, and harm to amenity and cultural heritage values. FAO (2011) argues that in some areas, the accumulation of environmental impacts in key land and water systems has now reached the point where production and livelihoods are compromised.

Agricultural expansion has had tremendous impacts on **habitats, biodiversity, emissions and soil conditions**. A wide range of impacts of land use change has been identified and is described in a large number of reports. Foley et al. (2011) estimate that worldwide agriculture has already cleared or radically transformed 70% of the world's prehistoric grasslands, 50% of savannas, 45% of temperate de-

[5] Xiufang S, Canby K 2011: Baseline study 1, China: overview of forest governance, markets and trade, Forest Trends

[6] Cotula, L (2011) Land Deals in Africa: What is in the Contracts?, IIED, London, UK

ciduous forests and 25% of tropical forests. Today, agriculture is mainly expanding in the tropics, where it is estimated that about 80% of new croplands are replacing forests. This expansion is worrisome, given that tropical forests are rich reservoirs of biodiversity and key ecosystem services. Clearing tropical forests is also a major source of GHG emissions (Foley 2011)[7].

Another major influence comes from **agricultural intensification** which has dramatically increased in recent decades. Agricultural intensification has been responsible for most of the yield increases of the past few decades (FAO 2011). In the past 50 years, the world's irrigated cropland area roughly doubled, while global fertilizer use increased by 500%. Of particular concern is that some 70% of global freshwater withdrawals (80–90% of consumptive uses) are devoted to irrigation (Foley 2011).

The following overview only summarizes some of the key information:

- The **expansion of agriculture** into sensitive ecosystems has far-reaching effects on biodiversity, carbon storage and important environmental services. This is particularly true when tropical forests are cleared for agriculture, estimated to cause 5–10 million hectares of forest loss annually. Slowing (and, ultimately, ceasing) the expansion of agriculture, particularly into tropical forests, will be an important first step in shifting agriculture onto a more sustainable path (Foley 2011).

- The **intensification of land uses** is causing water degradation, increased energy use, and widespread pollution. The high inputs of chemicals and irrigation water in intensive agriculture pollute water resources and degrade soil (Raskin 2010). As a result, degradation of water-related ecosystems and salinization are rising. In many large rivers, only 5% of former water volumes remain instream. Runoff from eroding soils is filling reservoirs, reducing hydropower and water supply. The flows of nitrogen and phosphorus through the environment have more than doubled since 1960, causing widespread water pollution and enormous hypoxic "dead zones" at the mouths of the world's major rivers.

[7] For a review of the environmental impacts specifically of "first-generation" biofuels, see Bringezu (2009) and Howarth, Bringezu (2009).

Nearly half the fertilizer applied runs off rather than nourishes crops (FAO 2011).

- Many **groundwater resources are being exhausted** because of the enormous freshwater demands of irrigated farming systems. Aquifers are becoming increasingly polluted and salinized in some coastal areas (FAO 2011). In 2025, a third of the world population might be affected by water scarcity. As a result of excessive consumptive water use, many large rivers such as the Colorado have diminished flows, some have dried up altogether, and many places have rapidly declining water tables, including regions of the U.S. and India.

- Agriculture is responsible for 30–35% of global **GHG emissions**, largely from tropical deforestation, methane emissions from livestock and rice cultivation, and nitrous oxide emissions from fertilized soils (Foley 2011). That is more than the emissions from worldwide transportation (including all cars, trucks and planes) or electricity generation. The energy used to grow, process and transport food is a concern, but the vast majority of emissions come from tropical deforestation, methane released from animals and rice paddies, and nitrous oxide from over-fertilized soils. Converting forests to cultivated land implies substantial increases in GHG impacts and loss of biodiversity. This is recognized by the United Nations in the efforts to implement mechanisms for reducing emissions from deforestation and degradation (REDD). Especially tropical forests hold the world's richest areas of high biodiversity (FAO 2011). Lapola et al. (2010) show for Brazil that indirect land use change induced by the production of energy crops may be associated with worse impacts than direct land use change and over-compensate GHG emission savings.

FAO (2011) provides an excellent summary description of the scale and severity of problems: *"A series of land and water systems now face the risk of progressive breakdown of their productive capacity under a combination of excessive demographic pressure and unsustainable agricultural practices. The physical limits to land and water availability within these systems may be further exacerbated in places by external drivers, including climate change, competition with other sec-*

tors and socio-economic changes. These systems at risk warrant priority attention for remedial action simply because there are no substitutes."

The statement sounds dramatic but it is supported by similar assessments like the recent "Environmental Outlook 2050" published by OECD (2012) or the European Environmental Agency's report "Europe's Environment – The fourth assessment" (EEA 2007). OECD (2012) emphasizes that “the current growth model and the mismanagement of natural assets could ultimately undermine human development […] the costs of inaction could be colossal, both in economic and human terms.”

SOME KEY ACTIONS

There is the urgent need for governments and the private sector, including farmers, to be much more proactive in advancing the general adoption of sustainable land and water management practices. Actions include not just technical options to promote sustainable intensification and reduce production risks, they also comprise a set of conditions to remove constraints and build flexibility (FAO 2011). Some key actions are:

(1) Improving policies, including by reducing the distortions in incentives and regulatory frameworks and gaps.

(2) Supporting a wide use of best practice in land and water management.

(3) Introducing and strengthening of more collaborative land and water institutions.

(4) Improving agricultural advisory services and fostering knowledge exchange.

(5) Supporting adaptive farming systems research and enhancing the adaptive capacity of smallholders.

(6) Providing rural and microfinance, payments for environmental services and establishing carbon markets.

(7) Improving access to local and regional markets and promoting more decentralised, distributed systems.

(8) Addressing agricultural systems at risk as a priority and redressing risks.

(9) Promoting sufficiency concepts, and sustainable production and consumption patterns.

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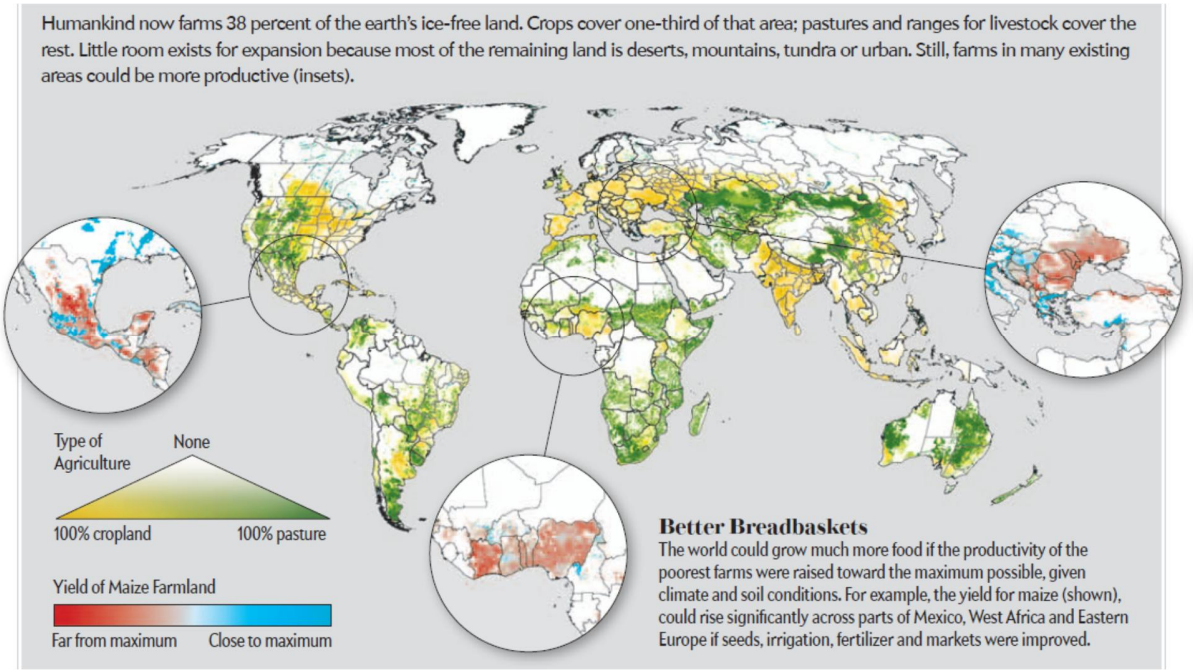
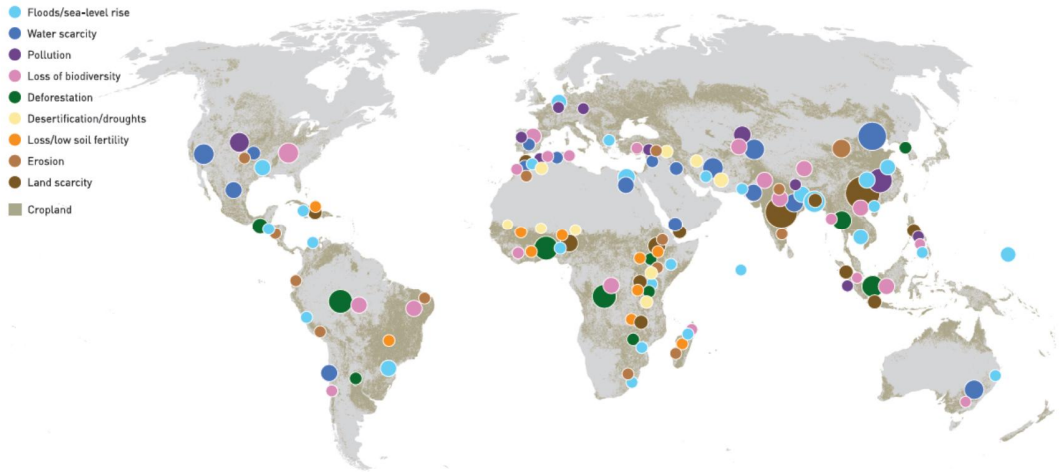
Annex

FIGURE 4 EXPANSION OF LAND USE VS. INCREASES IN PRODUCTIVITY



Source: Foley (2011)

FIGURE 5 AGRICULTURAL SYSTEMS AT RISK



Source: FAO (2011), Map 5

FIGURE 6 MAJOR LAND AND WATER SYSTEMS AT RISK

Global production systems	Cases or locations where systems are at risk	Risks
RAINFED CROPPING Highlands	Densely populated highlands in poor areas: Himalayas, Andes, Central American highlands, Rift Valley, Ethiopian plateau, Southern Africa.	Erosion, land degradation, reduced productivity of soil and water, increased intensity of flood events, accelerated out-migration, high prevalence of poverty and food insecurity.
RAINFED CROPPING Semi-arid tropics	Smallholder farming in Western, Eastern and Southern Africa savannah region and in Southern India; agro-pastoral systems in the Sahel, Horn of Africa and Western India.	Desertification, reduction of production potential, increased crop failures due to climate variability and temperatures, increased conflicts, high prevalence of poverty and food insecurity, out-migration.
RAINFED CROPPING Subtropical	Densely populated and intensively cultivated areas, concentrated mainly around the Mediterranean basin.	Desertification, reduction of production potential, increased crop failures, high prevalence of poverty and food insecurity, further land fragmentation, accelerated out-migration. Climate change is expected to affect these areas through reduced rainfall and river runoff, and increased occurrence of droughts and floods.
RAINFED CROPPING Temperate	Highly intensive agriculture in Western Europe.	Pollution of soils and aquifers leading to de-pollution costs, loss of biodiversity, degradation of freshwater ecosystems.
	Intensive farming in United States, Eastern China, Turkey, New Zealand, parts of India, Southern Africa, Brazil.	Pollution of soils and aquifers, loss of biodiversity, degradation of freshwater ecosystems, increased crop failure due to increased climate variability in places.
IRRIGATED Rice-based systems	Southeast and Eastern Asia.	Land abandonment, loss of buffer role of paddy land, increasing cost of land conservation, health hazards due to pollution, loss of cultural values of land.
	Sub-Saharan Africa, Madagascar, Western Africa, Eastern Africa.	Need for frequent rehabilitations, poor return on investment, stagnating productivity, large-scale land acquisition, land degradation.

Global production systems	Cases or locations where systems are at risk	Risks
IRRIGATED Other crops	RIVER BASINS Large contiguous irrigation systems from rivers in dry areas, including Colorado river, Murray-Darling, Krishna, Indo-Gangetic plains, Northern China, Central Asia, Northern Africa and Middle East.	Increased water scarcity, loss of biodiversity and environmental services, desertification, expected reduction in water availability and shift in seasonal flows due to climate change in several places.
	AQUIFERS Groundwater-dependent irrigation systems in interior arid plains: India, China, central USA, Australia, North Africa, Middle East and others.	Loss of buffer role of aquifers, loss of agriculture land, desertification, reduced recharge due to climate change in places.
RANGELANDS	Pastoral and grazing lands, including on fragile soils in Western Africa (Sahel), North Africa, parts of Asia.	Desertification, out-migration, land abandonment, food insecurity, extreme poverty, intensification of conflicts.
FORESTS	Tropical forest-cropland interface in Southeast Asia, the Amazon basin, Central Africa, and Himalayan forests.	Cropland encroachment, slash-and-burn, leading to loss of ecosystems services of forests, land degradation.
Other locally important subsystems	DELTAS AND COASTAL AREAS: Nile delta, Red River delta, Ganges/ Brahmaputra, Mekong, etc. and coastal alluvial plains: Arabian Peninsula, Eastern China, Bight of Benin, Gulf of Mexico.	Loss of agricultural land and groundwater, health-related problems, sea-level rise, higher frequency of cyclones (Eastern and Southeast Asia), increased incidence of floods and low flows.
	SMALL ISLANDS Including Caribbean, Pacific islands.	Total loss of freshwater aquifers, increased cost of freshwater production, increased climate-change related damages (hurricanes, sea-level rise, floods.
	PERI-URBAN agriculture	Pollution, health-related problems for consumers and producers, competition for land.

Source: FAO (2011), T. 4